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This guide gives educational planners a wealth of up-to-date information and forecasts a technological breakthrough that could help revolutionize education over the next two decades. Whether it actually does so will depend on a number of psychological, economic, and political factors. The new communication satellites have opened extraordinary possibilities for the worldwide spread and enrichment of human learning. These possibilities are not merely theoretical; they have already been clearly demonostrated. Within the lifetime of today's youngsters just entering primary school, millions of TV viewers on several continents have been given front-row seats at great historic events taking place in distant lands and even on the moon. If communication satellites at this early stage can accomplish such extraordinary feats, surely in years ahead they can help give hundreds of millions of children and adults the chance for a better education. Further technical advances hold promise of making such satellites a daily tool for learning even in the poorest nations. This exciting vision, however, calls for sober qualifications. The first qualitification concerns the historic reluctance of educational systems to abandon their traditional practices in favor of more efficient and effective new technologies. Even now, for example, these systems have not come close to tapping the full educational potential of the printed word, not to mention newer instructional media, such as films, recordings, radio, and ground-based television, all of which have been available for a generation or more. The communication satellite offers today's crisis-laden educational systems a chance for a fresh start, but it will take a profound change of customary attitudes and habits to use this new tool on more than a trivial scale.

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AN EDUCATOR'S GUIDE TO COMMUNICATION SATELLITE TECHNOLOGY

by KENNETH A. POLCYN

This document is one of a series of publications intended to provide educators in developing countries with up-to-date information on developments in the use of technology for improving education around the world. The Information Center on Instructional Technology publishes information bulletins in this general area and produces a periodic newsletter which can be obtained by request. The Center, operated by the Academy for Educational Development, is supported by the Bureau for Technical Assistance of the U.S. Agency for International Development. The author has contributed this guide to AID and the Center for limited distribution.

"This is a highly useful compendium of information. It will be of great interest to any educator or planner who thinks he has a satellite in his future. And even if a reader doesn't expect to have a communication satellite or access to one, he will find here the answers to many of his questions about advanced communication technology."

Wilbur Schramm, Director
East-West Communications Institute
University of Hawaii

"The current interest in exploring possible applications of communication satellite technology to education creates the need for a primer and reference book. This easy-to-understand, well-illustrated treatment of the technology provides valuable knowledge and insights to the educational planner, the teacher and the public at large."

Alvin C. Eurich, President
Academy for Educational Development, Inc.

AN EDUCATOR'S GUIDE TO COMMUNICATION SATELLITE TECHNOLOGY

by

Kenneth A. Polcyn

The offering and the acceptance of a satellite, or any other technology for education, should not take place in blind haste but rather in an atmosphere of knowledge, understanding, responsibility and commitment.

Preface	Howard Hitchens
Introduction	Philip H. Coombs
Graphics	Gaynelle Moore
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September 1973

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Portions of this book are based upon previous research conducted by the author for the Academy for Educational Development and which appeared in Chapters I and II of *Broadcast Satellites and Other Educational Technology: Current Status and Associated Issues, Vol. I*, submitted to AID under Contract AID/csd-2829.

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To my sons,
Kent and Lance

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PREFACE

Recent developments in this era of burgeoning communications technology present challenges to the imagination of every educator. In the United States, where most of this very advanced, sophisticated technology is being developed, the challenges to the educational community are particularly crucial. This guide, which is packed full of information about communication satellites, will stir the educator's imagination and focus his attention on these challenges.

Bringing the most beneficial aspects of our technological capability to bear on the educative process has always been a strong imperative. The chalk and slate have been superseded in turn by the lantern slide, radio, audio and video recordings, television, and the computer. Technology applied to education has come a long way in America. Now we are confronted with the challenge of using satellite and other communication technologies to improve and revitalize the educational process in the United States.

Beyond the borders of our own country, however, we are faced with a much wider challenge; that is, to ensure that the technology developed here is available to aid the evolution of other societies. By understanding the educational needs of other nations, perhaps we may strive to assist them in molding the technologies to meet their unique needs.

Members of the worldwide educational community and world statesmen alike will find this guide invaluable as they meet the challenge to use satellite technology to benefit all countries of the world.

Howard Hitchens
Executive Director
Association for Educational
Communications and Technology

INTRODUCTION

This guide gives educational planners a wealth of up-to-date information and forecasts a technological breakthrough that could help revolutionize education over the next two decades. Whether it actually does so will depend on a number of psychological, economic, and political factors.

The new communication satellites have opened extraordinary possibilities for the worldwide spread and enrichment of human learning. These possibilities are not merely theoretical; they have already been clearly demonstrated. Within the lifetime of today's youngsters just entering primary school, millions of TV viewers on several continents have been given front-row seats at great historic events taking place in distant lands and even on the moon. If communication satellites at this early stage can accomplish such extraordinary feats, surely in years ahead they can help give hundreds of millions of children and adults the chance for a better education. Further technical advances hold promise of making such satellites a daily tool for learning even in the poorest nations.

This exciting vision, however, calls for sober qualifications. The first qualification concerns the historic reluctance of educational systems to abandon their traditional practices in favor of more efficient and effective new technologies. Even now, for example, these systems have not come close to tapping the full educational potential of the printed word, not to mention newer instructional media, such as films, recordings, radio, and ground-based television, all of which have been available for a generation or more. The communication satellite offers today's crisis-laden educational systems a chance for a fresh start, but it will take a profound change of customary attitudes and habits to use this new tool on more than a trivial scale.

The second qualification relates to several practical problems of economic, physical and pedagogical feasibility. Costs of satellite broadcasting, as the guide shows, have already fallen sharply and are destined to fall further, particularly as the technology for direct reception is perfected. Even so, the economies of scale and the size of the potential audience will continue to dominate the question of feasibility. The use of educational satellites will be economically justified only for the communication of subject matter that is relevant and useful to a large audience. Locally oriented subject matter, and there is need for much more of this, will have to be dealt with by other means. In short, satellite broadcasting cannot in most instances be a self-contained teaching-learning system; it can, however, be a major component of such a system.

Differences in time zones, in languages, and in national ideologies and purposes will also present difficult problems. These can be partially overcome by storage and playback techniques and by multiple audio channels carrying different languages to fit the same video image. But there are no easy technical solutions to achieving a consensus among separate national and local educational systems on program content or on joint financing of the common enterprise.

A further practical problem, one that has plagued many previous experiments with ground-based educational TV, is how to provide adequate maintenance services for complex equipment and how to ensure a reliable supply of electric power. Again, technical solutions are available for handling these problems, but they all come at a price — sometimes a price so high as to rule many rural

areas out of economic bounds. And these areas, unfortunately, are precisely those most desperately in need of improved educational services.

The third and most troublesome qualification concerns the so-called software of satellite broadcasting, the substance of the message, as distinct from the hardware that distributes it. Here is where so many past efforts to harness modern communication media to the service of education have failed most conspicuously. Typically, the lion's share of attention and available resources has gone to the hardware and logistics of the system, to the fatal neglect of creating good programs, the whole point of the undertaking. The guide presents useful illustrative figures on the costs of good program preparation and evaluation, and properly cautions that, to get good results, at least as much must be spent on software as on hardware.

The foregoing problems have been emphasized not with a view to belittling the potentialities of educational satellites but simply to warn against the tempting notion that this new technology is a miracle medicine for ailing educational systems. It certainly is not. Yet, the communication satellite still remains a promising new means for making high quality, pertinent, and diversified learning opportunities available on a far vaster scale than has ever before been possible.

The central question now is whether educators will be willing and able to make good use of this new tool that technologists have placed at their disposal. Notwithstanding the historic resistance of educational institutions to fundamental innovations, there are grounds for optimism in answering this question.

For reasons that are familiar by now, traditional educational concepts, practices, and institutions are today being more critically and widely questioned and reexamined than ever before. Out of this process fresh insights and perspectives are emerging, along with a new climate conducive to educational innovation. The narrow notion that education equals schooling and that schooling is only for the young is rapidly being displaced by the broader view that education equals learning, regardless of where or how the learning takes place, and that learning is necessarily a lifelong process. This much more realistic view of education is opening the floodgates to a great outpouring of fresh ideas and innovations that are bound to bring radical changes in the whole enterprise of education and human development in coming years.

Even if formal educational systems continue to lag for a time in changing their ways rapidly enough to keep pace with the changing world around them, broadened access to relevant learning will nevertheless be provided by other means, including proliferation of flexible nonformal education programs adapted to the lifelong learning needs of all individuals, regardless of their age, sex, or station in life. Only as innovative developments gather speed will educators and national leaders be able, for the first time, to speak seriously about fulfilling every individual's inherent right to an adequate education.

In this perspective it is particularly significant and encouraging that this guide provides hard information not only about the technology of satellite broadcasting but about several national and international educational ventures now in the planning stage or actually underway which are based on the positive use of this new technology. One hopes that these and similar undertakings will be closely monitored and their progress regularly reported so that all nations may benefit from the lessons learned.

Philip H. Coombs
Vice Chairman
International Council for
Educational Development

Author's Note

The writing of this guide was prompted by the number of domestic communication satellites that are expected to be orbited this decade, and the fact that satellite technology is to be used for extensive social service experimentation during this same period. Specific attention during the experimentation is to be given to educational uses; however, most world educators know very little about satellites or their current uses. Consequently, the purpose of the guide is to provide educators with an awareness and understanding of communication satellite technology, its current uses and some of the tentative plans for educational experimentation. The intent here is to inform educators, not to convince them that the technology has educational merit.

K.A.P.
Washington, D. C.
August, 1973

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CHAPTER I

THE GENERAL NATURE OF COMMUNICATION SATELLITES

Satellites, in general, are of one of two origins: natural or man-made. Natural satellites vary in size and revolve around primary celestial bodies;[1] for example, the moon is a satellite of the earth and the earth, a satellite of the sun.* Man-made satellites are launched into orbit around a celestial body, such as the earth or moon. They are used to:[2]

1. communicate between points on the surface of the earth by such communication media as radio and television;
2. provide a point of reference for establishing locations in space;
3. observe the earth and its environment; and
4. collect and report scientific information.

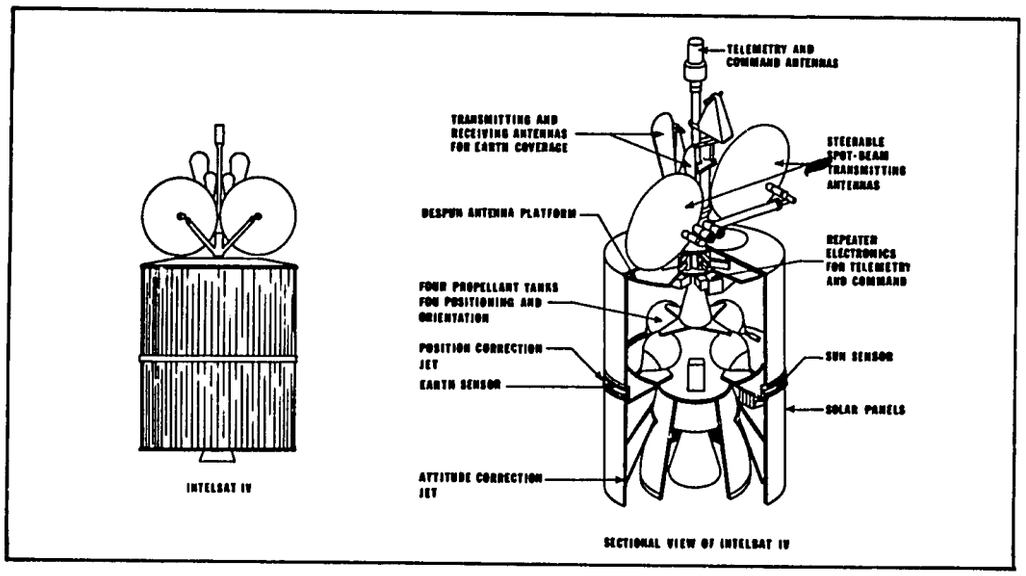
This book is concerned with man-made satellites, specifically those that relay communications between locations on the earth's surface.

COMMUNICATION SATELLITE TECHNOLOGY

Communication satellites receive, amplify and transmit voice, music, television, telephone, telegraph and data signals from one point to another point or points on earth. In other words, the communication satellite is a *repeater* of these signals. How does it function? As is shown in Figure 1, there are a number of subsystems,

Figure 1

Intelsat IV Profile



Adapted from: Hughes Aircraft Company, *INTELSAT IV Handbook*, Culver City, California, (December, 1970), pp. 4, 7.

*A body that rotates about a sun is also called a planet or planetoid.

of which the major ones are:[3]

1. solar panels;
2. spacecraft positioning and orientation controls;
3. telemetry;
4. receive and transmit antennas; and
5. repeater.

These subsystems and others form the satellite communication system; solar cells catch the sun's energy and convert it into the power necessary to operate the various subsystems that control the satellite and relay signals.

The position of the satellite in space is controlled by a "de-spun stabilizing mechanism" and small position and attitude correction jets.[4] First, the satellite must be stabilized in orbit so that it remains in a constant predetermined position relative to the surface of the earth.[5] The position is usually maintained by spinning the satellite about its main axis.[6] Because the antennas must constantly point toward the earth, the part of the satellite carrying the antennas is separated from the main satellite body and de-spun; that is, it rotates at the same rate that the rest of the satellite is rotating but in the opposite direction.[7]

To maintain the proper attitude for the spacecraft relative to the earth, axial jets are located at the base of the satellite; to overcome drift due to the gravitational effects of nearby celestial bodies and the shape of the earth, radial jets are located on the side of the satellite.[8] Sun-earth location sensors provide the information about the satellite position to the telemetry subsystem.[9] The telemetry subsystem is used to keep the satellite in contact with the earth, and responds to correction command signals from earth that activate the positioning and attitude jets.[10]

Information signals are transmitted from an earth station to the satellite receiver antenna, where they are passed on to a communication repeater; the repeater amplifies the signal, converts it to a different frequency and retransmits it to receiving earth stations with either a spot* or earth coverage antenna.

Table 1 lists the various International Telecommunication Satellite Consortium

Table 1

INTELSAT Satellite Characteristics

PROFILE	INTELSAT I	INTELSAT II	INTELSAT III	INTELSAT IV
SIZE	28.4 inches diameter 23.25 inches length	56.0 inches diameter 26.5 inches length	56.0 inches diameter 41.0 inches length	93.7 inches diameter 111.0 inches solar panel height 206.0 inches overall height
WEIGHT (lbs)	150 at launch 85 synchronous	357 at launch 190 synchronous	647 at launch 334 synchronous	3,058 at launch 1,544 synchronous
DESIGNED LIFE	18 months	36 months	60 months	84 months
CAPACITY	240 circuits or one TV channel	240 circuits or one TV channel	1,200 circuits, 4 TV channels or combination thereof	3-9,000 circuits or 12 TV channels or combination thereof
LAUNCH VEHICLE	McDonnell/Douglas, Three Stage, Thrust Augmented Delta	McDonnell/Douglas, Three-Stage, Thrust Augmented Improved Delta	McDonnell/Douglas, Three-Stage, Long-Tank Delta	General Dynamics, Convair Division Atlas/Centaur
SPACECRAFT COST - U.S. $ Millions	6.0	4-4.5	6.0	13.5
SPACECRAFT CONTRACTOR	Hughes Aircraft	Hughes Aircraft	TRW Systems	Hughes Aircraft
INITIAL OPERATION DATE	JUNE 1965	JANUARY 1967	DECEMBER 1968	JANUARY 1971

Adapted from: Communications Satellite Corporation, *Pocket Guide to the Global Satellite System*, Washington, DC: (December 1, 1970), pp. 6-9.

*Spot antennas concentrate signals on a small geographic area.[11]

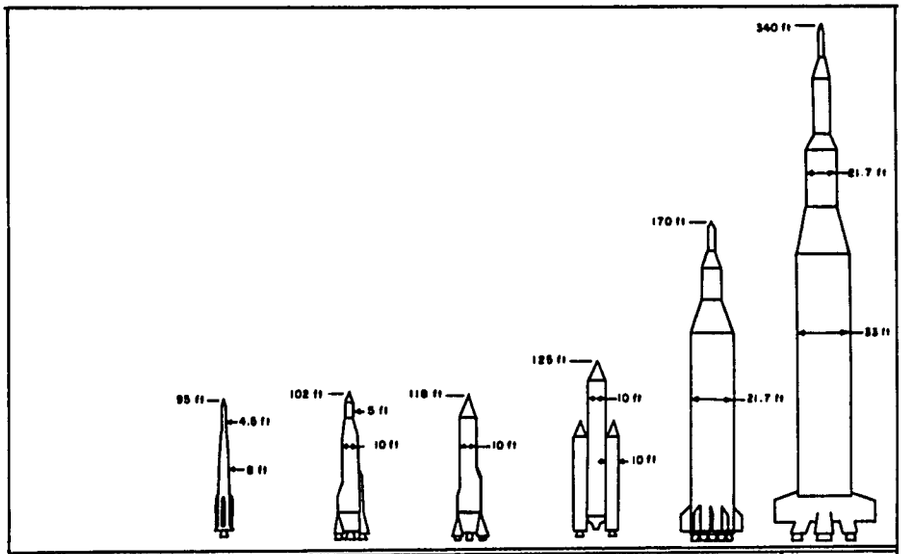
(INTELSAT) satellites that have been or that are operating.[12] Also indicated, their capacity has grown from 240 voice circuits or one TV channel to over 3,000 voice circuits or 12 TV channels. While the general cost of such satellites has increased, the cost per voice circuit has decreased.

Launching and Orbiting a Satellite

A velocity of approximately 25,000 mph[13] is required to launch a man-made satellite. Once this velocity has been attained and the proper altitude reached, a satellite can be placed into an orbit around the earth. Theoretically, a satellite is able to achieve synchronous orbit because its centrifugal force is equal to the gravitational pull of the earth at 22,300 miles above the earth.

The weight and size of the satellite determines the launch vehicle size and cost; some United States launch vehicles, their characteristics and cost, are shown in Table 2.[14] The INTELSAT IVs, heaviest of the communication satellites

Table 2
United States Launch Vehicles and Associated Characteristics



Launch Vehicle	Thor - Imp Delta	Titan 3B Agena	Atlas Centaur	Titan 3C	Saturn 1B/Centaur	Saturn 5
US. $ MILLIONS	5.6 - 7.0	13.0	16.0	25.1	50.0*	200.0*
Payload Volume Constraint	56 inch Diameter	106 inch Diameter	106 inch Diameter	109 inch Diameter	240 inch Diameter	240 inch Diameter
Net Payload (lbs)	343 - 575	1200	1650	3700	17,000	100,000
Broadcast Application	Point-to-Point	Point-to-Point	Point-to-Point, Distribution & Limited Direct Broadcast	Point-to-Point, Distribution & Limited Direct Broadcast	Direct Broadcast	Direct Broadcast

SOURCES: Fred P. Adler, "Broadcast From Satellites," principal address at the Sixth International Television Symposium, Montreux, Switzerland, (May 19, 1969), and information provided by NASA.

*These launch costs are estimates. Further modifications would be required for communication satellite launches. Cost figures include vehicle, launch and other associated items. It should be noted that these launch vehicles can be modified to place more payload into orbit.

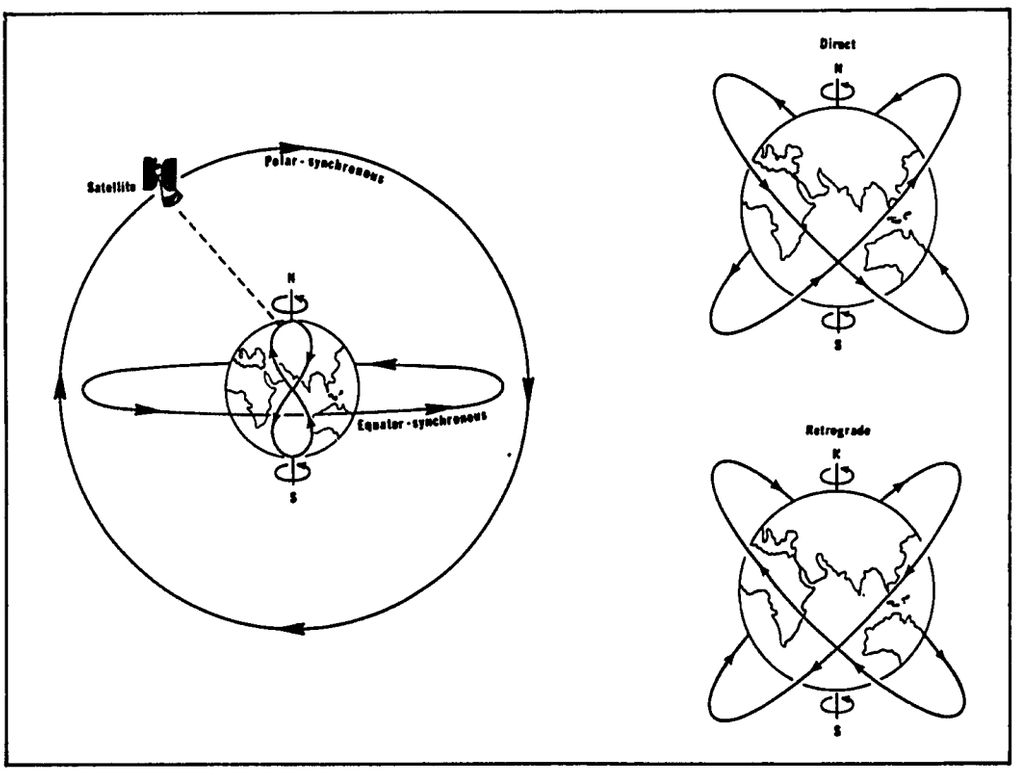
that have been placed into orbit to date, weigh approximately 1,544 pounds; however, the Saturn 5 launch vehicle has the capacity to orbit a 100,000-pound satellite.[15] As shown in Table 2, launching large communication satellites can be quite expensive.

The velocity which a satellite achieves and its angle of ascent determine its orbit. As is illustrated in Figure 2, there are a number of patterns:

1. "Polar (or near-Polar) orbits are inclined at an angle of approximately 90° to the equator. They permit surveillance of all or a major portion of the earth.
2. "Retrograde orbits are those in which the satellite travels from east to west (counter to the earth's rotation). Satellites are put into such orbits to insure that they appear over illuminated areas of the earth at certain times.
3. "Synchronous orbits are 22,300 miles above (the) earth, where a satellite's velocity matches that of a point on the earth's equator. Viewed from the earth, they appear to be stationary in the sky, if they are over the equator; if otherwise 'hung,' they trace a figure 8 on the earth below.
4. "Sun-synchronous orbits have their planes directly in the sun. A satellite in a sun-synchronous polar orbit is ideal for taking pictures of the earth's equatorial and temperate zones with the sun always high in the sky."[16]

Generally speaking, the equator-synchronous (geostationary) orbit is the most effective for communication purposes.

Figure 2
Satellite Orbits



Adapted from: Mitchell R. Sharpe, SATELLITES AND PROBES (c) 1970, p. 111. Reprinted by permission of Aldus Books Limited, London.

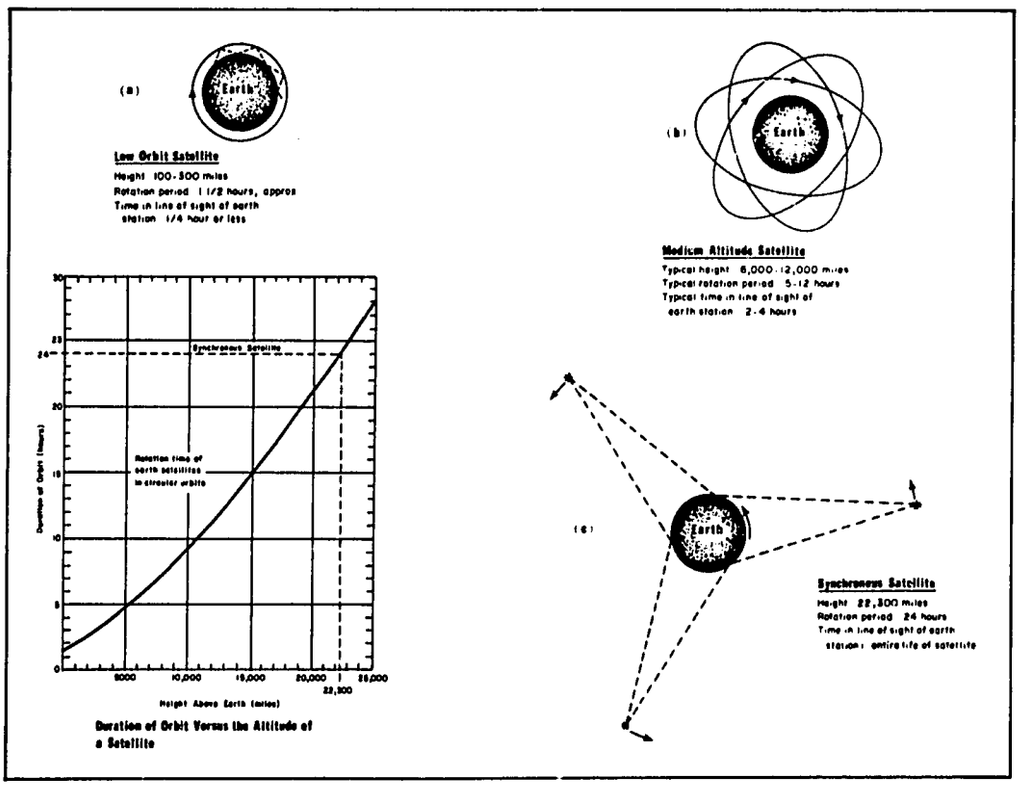
Synchronous versus Nonsynchronous Communication Satellite Orbits

Placing a satellite into a synchronous orbit requires considerable expertise; the launch vehicle initially places the satellite into a long, elliptical orbit having an apogee* of approximately 22,300 miles.[17] The satellite's orbit is then measured and oriented so that it is in the proper attitude for the next step in the process. Then, when the satellite reaches the proper apogee traveling at a right angle to the radius of the earth, the apogee kick motor is fired to place the satellite in a circular orbit at approximately 22,300 miles above the equator and at a velocity (approximately 6,900 mph) synchronized with the rotation of the earth.[18]

Figure 3 illustrates the earth signal coverage by three types of satellite orbits and the relationship between the altitude of a satellite and the duration of time it takes to orbit the earth.[19] (a) and (b) represent nonsynchronous orbits while (c) is a synchronous orbit. The synchronous satellite is favored for communications purposes because it is constantly visible from roughly 40 percent of the earth's surface. As shown in (c), as few as three such satellites, at 120° spacings, can reach the entire surface of the earth, exclusive of extreme northern and southern latitudes. Also, earth stations can continuously receive from or transmit to a satellite in their geographic areas without expensive tracking antennas or complex program scheduling arrangements.[20]

Figure 3

Earth Coverage and Duration of Orbit with Synchronous-Nonsynchronous Orbits



Adapted from: James Martin, TELECOMMUNICATIONS AND THE COMPUTER (c) 1969, pp. 351, 352. Reprinted by permission of Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

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*The apogee of a satellite is the point in its orbit that it is farthest from the earth.

Another characteristic of a satellite in synchronous orbit is its potential for broadcasting signals directly to small, inexpensive receivers by producing powerful signals on the earth's surface. Furthermore, the synchronous configuration makes frequency sharing with terrestrial relay stations feasible, because only a few antenna pointing angles* need to be cleared for possible non-interference with terrestrial communication systems.[21] Consequently, the synchronous satellite orbit appears to be the best means for providing most satellite communication services to most areas of the world.

As was noted above, any satellite orbit less than 22,300 miles above the surface of the earth puts the satellite out of phase (nonsynchronous) with the earth's rotation. Early U.S. nonsynchronous communication satellites, such as TELSTAR and RELAY, circled the earth in relatively low, elliptical orbits. TELSTAR I and II had apogees of 3,800 and 6,200 miles, respectively, and perigees**of 600 miles.[22] They circled the earth in 2 hours and 38 minutes, and 3 hours and 45 minutes, respectively.[23]

When the satellites reached the apogee of their ellipse, they were positioned for sighting by earth stations for the longest possible exposure time for receiving and transmitting signals.

This orbital time period, with its limited signal exposure to the surface of the earth, created problems in telecommunication because the satellites were only capable of communicating with a given tracking station for as little as 30 minutes. If this nonsynchronous orbital pattern had been adopted for use, many satellites would have been required to provide continuous links with a given earth station. The expense for such a system would have been prohibitive to most nations; consequently, the United States pursued the more economical synchronous orbit.

However, nonsynchronous orbital patterns are of value for nations like the Soviet Union, whose landmass and populations lie in the extreme northern hemisphere (55° N); the domestic satellite system of the Soviet Union uses a high, inclined, elliptical, nonsynchronous orbit to meet its communications needs.

Advantages of Synchronous and High Elliptical Nonsynchronous Satellite Orbits

Both synchronous and nonsynchronous satellite orbits have advantages, and it may be that a combination of orbits will best meet the needs of a global communication system. The advantages of synchronous satellites for broadcast purposes are:

1. There is no time restriction on transmission periods.
2. Fewer satellites are required to accomplish true global communications.
3. The construction of ground antennas and their driving servomechanisms is comparatively simple (programming of the computer control devices is also simplified).
4. Satellites are located away from the belts of intensive cosmic radiation which can affect satellite electronic devices.
5. It permits relatively stable signal reception.
6. There is an absence of distortions in the signals from the Doppler effect.
7. A fixed-direction earth satellite reduces the interference between satellite and terrestrial communication systems because there is relative localization of radiated waves.[24]

*The smaller geographic area the signal is concentrated upon, e.g., African Continent vs. the nation of Dahomey, the fewer number of terrestrial broadcasting systems (TV, radio, police, navigation) that must be allowed for when broadcasting to and from space.

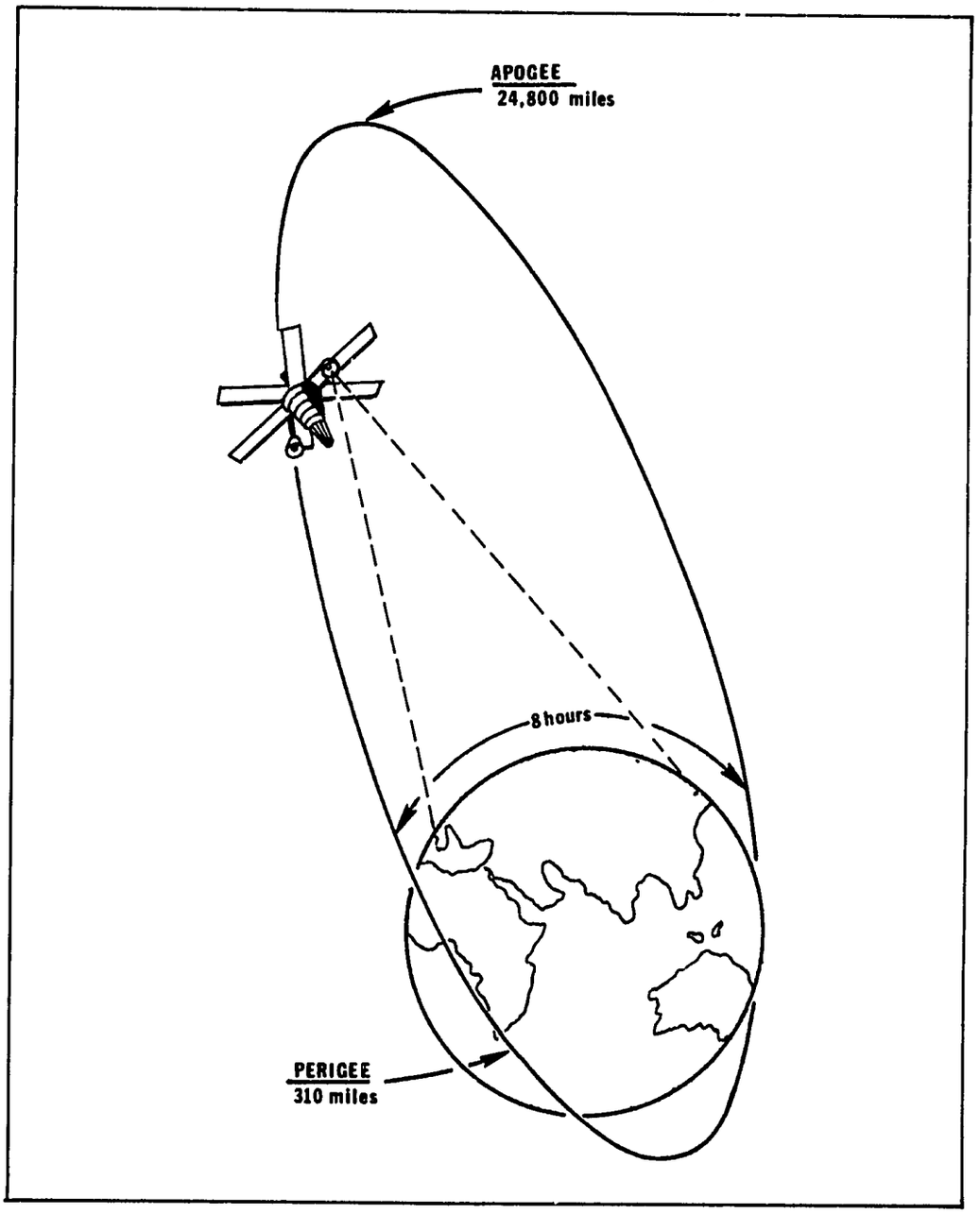
**The perigee of a satellite is the point in its orbit that it is closest to the earth.

The advantages of a high prolonged and inclined elliptical orbit such as that of the Soviet Union's MOLNIYA shown in Figure 4 are:

1. Optimal receiving conditions may be ensured for any ground station of a given country or territory.
2. The same satellite at one hop propagation can be used for program exchange between territories in the eastern and western hemispheres.

Figure 4

MOLNIYA - 12 hour, High, Prolonged and Inclined Elliptical Orbit



Adapted from: Mitchell R. Sharpe, SATELLITES AND PROBES (c) 1970, p. 129. Reprinted by permission of Aldus Books Limited, London.

3. There is comparatively high signal-to-noise ratio reception in high latitudes where synchronous satellites do not give good receiving conditions.
4. It affords simple and economic means for launching of satellites.[25]

It is very possible that as knowledge of, and experience with, satellites and their orbits advance, other nonsynchronous orbits may be found to be useful for broadcast purposes by combining them with those that have been proven to date.

Satellite Lifetime

The excitement with satellite technology and its potential applications sometimes overshadows the fact that satellites are not perpetual motion machines that operate *ad infinitum*; they have life expectancies. The longer the life of a satellite, the more economical it becomes. Lifetimes have increased considerably since TELSTAR I; INTELSAT I, launched in 1965, had an expected life of eighteen months; and the INTELSAT IV series initiated in 1971 has a designed life of seven years.[26] Most communication satellites have greatly exceeded their life expectancies. The increase in the lifetimes of communication satellites over the past few years is highly encouraging; it is anticipated that this trend will continue. Nevertheless, there are still many factors which contribute to satellite system failures, and research is continuing in order to improve the functioning and operational life expectancy of the satellite system. Some of the variables which control the life of the satellite are:[27]

1. "Nature of and variations in the environment;
2. "Consumption of expendables, such as altitude control and station-keeping gas (this is influenced by environmental factors and by tolerances involved in equipment design);
3. "Deterioration of components which eventually causes component failure (this is influenced by choice of component, operating conditions, and by the local environment);
4. "Performance drift, often associated with deterioration, which can eventually cause a system to be outside acceptable limits;
5. "Irreducible risk associated with uncontrollable natural events such as meteorites and solar flares; and
6. "So-called 'infant mortality' caused by poor workmanship, handling accidents, hidden flaws, etc."

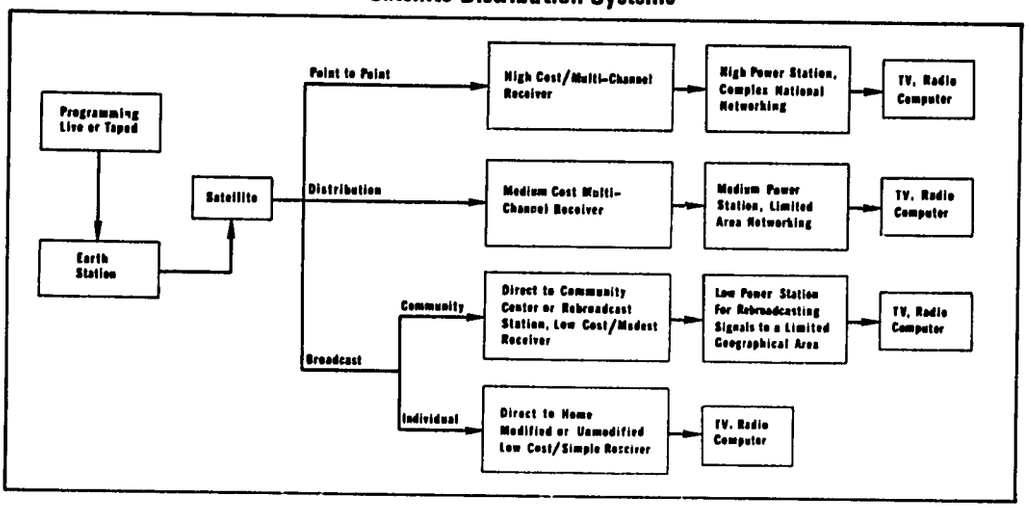
Of course, all of the above are dependent upon the degree of system redundancy, the amount of subsystem sectionalization, the design tolerance, and so forth;[28] but there is little doubt that as man's research and experience with satellites increase, expected lifetimes can be extended well beyond a decade.

Types of Communication Satellite Information Distribution Systems

As Figure 5 illustrates, communication satellite technology evolved various categories of information distribution systems. Three basic system categories were defined: (1) point to point, (2) distribution,[29] and (3) broadcast;[30] however, of the three systems only point to point and distribution are operational today.

Although the three categories of satellite information distribution systems are distinct, their separateness may be more academic than real in the future. A single satellite soon will be able to accommodate all three information distribution modes; even now an INTELSAT IV is capable of providing point to point, distribution, and even some experimental broadcast services.[31]

Figure 5
Satellite Distribution Systems



The *point to point* system uses a relatively low-powered synchronous or non-synchronous satellite to disseminate signals over vast geographical areas.[32] However, because of the limited power, weak signals are emitted as they are relayed from point to point on the earth, requiring large (e.g., 85-feet diameter antenna), sophisticated earth terminals costing in the neighborhood of $2.5 to $4 million.[33] This system serves countries that have a cable and/or microwave system sufficiently well developed to widely distribute the signals. Such a system broadcasted the 1972 Olympic games to the world from West Germany. A point to point system is now used by nations for international communication. The technical and operational standards for this system are established by the International Radio Consultative Committee (CCIR) of the International Telecommunication Union (ITU), as are all international communication standards.

In a *distribution* system a medium-powered satellite relays stronger signals to a limited geographical area.[34] Because the signals from the satellite are stronger, the system uses earth terminals with smaller (e.g., 42-feet diameter) antenna costing between $100,000-200,000[35] for receive-only terminals and $300,000-500,000 for receive-transmit terminals.[36] Since less expensive terminals are possible, their use at certain distribution points can preclude the use of complex interconnective microwave and/or cable systems for signal distribution. Instead, the signals can be received at key redistribution stations via the inexpensive terminal and retransmitted via a limited microwave or cable network to rebroadcast facilities in cities, towns, and villages in a small geographical area. This type of system can be used to limit the transmission-reception to a nation or a world region, but it could be used for point to point transmissions. Both Canada and the Soviet Union have such a system; however, Canada uses synchronous satellites. The United States, India, Brazil, Japan, France, and West Germany are seriously considering a distribution system.

A *broadcast* system uses a highly powered satellite which can provide signals directly to the general public.[37] It is not operational at this time; however, such a system has the potential for broadcasting directly to radio and television sets without the need for an intermediate earth terminal, cable system, or local TV or radio station to distribute signals.

There are two types of reception systems associated with broadcast satellites: community and individual. The *community* system will be able to use a small,

inexpensive earth terminal costing* between $800 and $2,500 (7-16 feet diameter antenna)[38] permitting direct reception at local community viewing centers such as schools, churches, or theaters. Additionally, local broadcasting stations will be able to receive and rebroadcast signals to the surrounding area with terminals costing between $100,000-120,000 (e.g., 16-25 feet diameter antenna).[39] The receive-transmit terminal will cost in the neighborhood of $100,000-200,000. Major emphasis is being placed on the community reception for developing countries to upgrade and extend education training to the masses, but such systems also may be useful to developed countries. Since development of the technology is in advanced stages and the operational costs appear to be reasonable, an operational system will be possible in the next three to five years.

Individual distribution systems will be able to provide signals directly to TV and radio sets located in the home; however, this is *not* expected to be possible in the foreseeable future. The power that would have to be generated by a satellite to relay a television signal directly to a television set is beyond the capability of any satellite existing or planned. Scientists believe this would require a very large satellite and an expensive launch vehicle. In any case, regardless of any political, economic, and technical considerations, the practical application of such a system still remains to be fully conceptualized.

Nevertheless, *augmented* reception soon will be possible; theoretically, any individual who can afford the price of the small community type receiver will be able to receive signals. However, the CCIR has not provided the necessary technical and operating standards, nor has the World Administrative Radio Conference (WARC) of the ITU provided frequencies for its operation.[40]

In summary, of the three information distribution systems discussed above, only *point to point* and *distribution* systems are currently operating. Community reception from the *broadcast* system is expected to be operating within the decade, but individual reception with or without augmented receivers cannot be expected in the near future.

Satellite Communication Frequencies

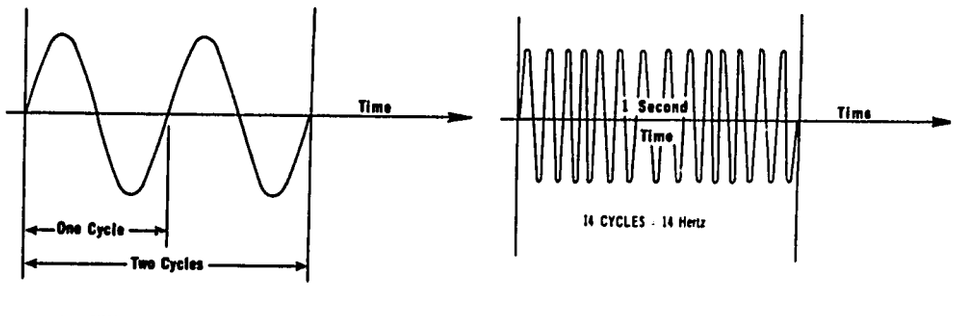
The information relayed via a communication satellite travels to and from the satellite by means of electrical or radio waves*,[41] in the same way that terrestrial radio and television programs are transmitted to the home. Carrier waves, upon which audio and video signals are superimposed, deliver these signals to radio and television receivers. The drawing at the top of Figure 6 illustrates a radio wave that has completed two cycles. The number of cycles, or times that it repeats itself over a given period of time, is called a radiowave frequency.[42] The middle illustration shows a series of cycles. Wave cycles are measured in seconds; one cycle per second is called a hertz,[43] or fourteen cycles per second would be called 14 hertz. The last illustration at the bottom of Figure 6 lists the common frequency terminology; for example, a kilohertz is 1000 hertz or 1000 cycles per second. In general, no more than one piece of information can be carried on each cycle or hertz.

The source of the information—whether it is an individual speaking or a computer transmitting data — is the key element in the system, for it determines the frequencies and bandwidth to be used for transmission. Both are associated with the rate at which information is produced by the source. For example, if the source is a teleprinter that punches holes in a paper tape using a binary

*All costs are estimates and they will vary according to the country manufacturing them, frequency used and the quantity desired. These do not include installation, housing of equipment, etc; quoted prices are U.S. estimates.

**Radio waves refer to all media-carrying waves; waves that carry television, radio, and telephone signals.

Figure 6
Frequency Terminology



OLD TERM	ABBREVIATION	NEW TERM	ABBREVIATION	DEFINITION
Cycles per Second	cps or c/s	Hertz	Hz	.....
Kilocycles per Second	kc or kc/s	Kilohertz	kHz	1000 Hz
Megacycles per Second	Mc or Mc/s	Megahertz	MHz	1,000,000 Hz
Gigacycles (Kilomega-cycles) per second	Gc or Gc/s (kMc or kMc/s)	Gigahertz	GHz	1,000,000,000 Hz

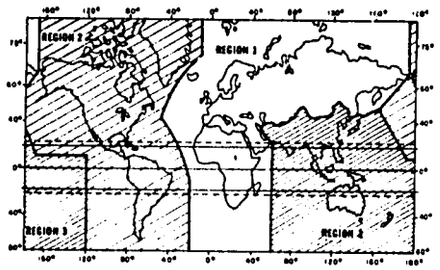
Adapted from: James M. Moore, RADIO SPECTRUM HANDBOOK (c) 1970, p. 22. Reprinted by permission of Howard W. Sams & Co., Inc., Indianapolis.

information coding procedure which consists of holes or the absence of holes, and if the printer codes up to ten consecutive binary symbols (holes/no holes) per second, and if the tape is used for transmitting the symbols at that rate, the bandwidth necessary for transmission is *at least* 10 cycles per second.[44] Consequently, there is a radio frequency spectrum on which different media can be transmitted. For example, to transmit the human voice requires from 300 to 3,000-4,000 hertz; color television requires 4.5 million hertz (4.5 Megahertz).[45] Therefore, some information sources, such as voice, can be generated and transmitted more efficiently and effectively on lower frequencies than other information, such as television. Further, as the above discussion suggests, a given bandwidth can be allocated for various types of signals, or the transmission of the same type of signals, each having a bandwidth that is less than the total. For example, the INTELSAT IV satellite is equipped to handle 12 TV channels, with each channel having a 36 Megahertz (MHz) bandwidth; however, all 12-36 MHz bandwidths can be divided into 3,000 or more voice channels with 3 to 4 Kilohertz (KHz) bandwidths or other bandwidths to carry other information such as computer data.[46]

In order to protect those portions of the carrier frequency spectrum which are best suited for certain types of transmissions, it has been divided into frequency bands and allocated to different types of services.[47] The ITU, through WARC, allocates carrier frequencies according to three geographic regions shown in Figure 7. Once frequencies have been determined and allocated, the nations within the regions attempt to divide the allocated frequencies among various

services, such as maritime, amateur radio, police, and aircraft transmissions. Figure 7 also shows the communication satellite frequency allocation decided upon at WARC in the summer of 1971. Note how the frequencies have been allocated according to regions, and for specific purposes. "Shared" frequencies are used by both terrestrial and satellite information distribution systems.

Figure 7
ITU Regions and WARC Frequencies



ITU FREQUENCY REGIONS

Adapted from: James M. Moore, RADIO SPECTRUM HANDBOOK (c) 1970, p. 12. Reprinted by permission of Howard W. Sams & Co., Inc., Indianapolis.

Region I Eurasia and Africa	Region II The Americas	Region III Australiaa
620 - 790 Broadcasting Satellite (Footnote)	620 - 790 Broadcasting Satellite (Footnote)	620 - 790 Broadcasting Satellite (Footnote)
2500 - 2690 BROADCASTING SATELLITE (Shared)	2500 - 2535 FIXED-SATELLITE (Space-to-Earth) BROADCASTING SATELLITE● (Shared)	
	2535 - 2655 BROADCASTING SATELLITE● (Shared)	
	2655 - 2690 FIXED-SATELLITE (Earth-to-Space) BROADCASTING SATELLITE● (Shared)	
	6625 - 7125 FIXED-SATELLITE (Space-to-Earth) (Secondary Basis) Brazil, Canada, and USA	
10950-11200 FIXED-SATELLITE (Shared) (Space-to-Earth and Earth-to-Space)	10950-11200 FIXED-SATELLITE (Shared) (Space-to-Earth)	
11450-11700 FIXED-SATELLITE (Shared) (Space-to-Earth)		
11700-12500 BROADCASTING SATELLITE (Shared)	11700-12200 FIXED SATELLITE (Space-to-Earth) BROADCASTING SATELLITE (Shared)	11700-12200 BROADCASTING SATELLITE (Shared)
12500-12750 FIXED-SATELLITE (Shared) (Space-to-Earth and Earth-to-Space)	12500-12750 FIXED-SATELLITE (Shared) (Earth-to-Space)	
14000-14500 FIXED-SATELLITE (Shared) (Earth-to-Space)		
17700-19700 FIXED-SATELLITE (Shared) (Space-to-Earth)		
19700-21200 FIXED-SATELLITE (Space-to-Earth)		
22500-23000 BROADCASTING SATELLITE (Shared)		
27500-29500 FIXED-SATELLITE (Shared) (Earth-to-Space)		
29600-31000 FIXED-SATELLITE (Earth-to-Space)		
40000-41000 FIXED-SATELLITE (Space-to-Earth)		
4100-4300 BROADCASTING SATELLITE		
60000-61000 FIXED-SATELLITE (Earth-to-Space)		
84000-86000 BROADCASTING SATELLITE		
92000-95000 FIXED-SATELLITE (Earth-to-Space)		
102000-105000 FIXED-SATELLITE (Space-to-Earth)		
140000-142000 FIXED-SATELLITE (Earth-to-Space)		
150000-152000 FIXED-SATELLITE (Space-to-Earth)		
220000-230000 FIXED-SATELLITE (Transmission Direction Unspecified)		
266000-275000 FIXED-SATELLITE (Transmission Direction Unspecified)		

● For Community Reception Only.

WARC Communication Satellite Frequency Allocations (MHz)

Further, the frequencies chosen to transmit and receive information signals are very significant. At frequencies above 10 Gigahertz (GHz) there is substantial signal attenuation due to atmospheric absorption of the signal as it travels to and from the satellite.[48] Fifteen GHz is currently the maximum practical opera-

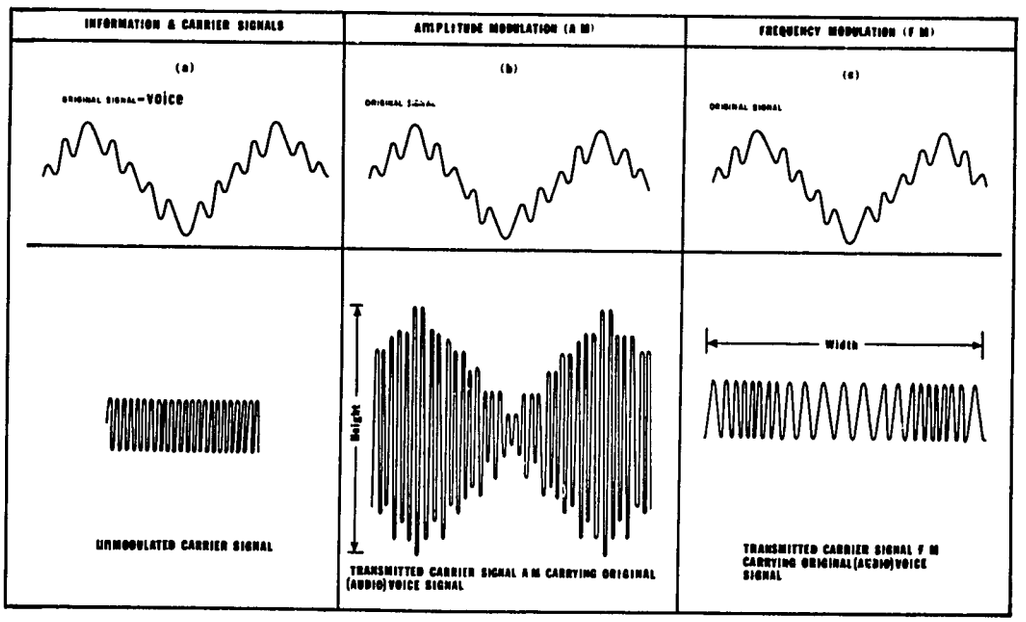
tional frequency.[49] Most civil communication satellites receive signals at frequencies in the neighborhood of 6 GHz and relay at frequencies around 4 GHz.*[50]

In addition, as the frequency allocations point out, certain frequency bands have been set aside specifically for earth-to-space and space-to-earth transmissions. The primary reason for using different frequency bands for the up- and down-links is to avoid interference between ascending and descending signals.[51] The reason the down-link transmission signal is of a lower frequency is because it is less subject to distortion or attenuation.[52]

Why are carrier signals or frequencies used? Carrier signals are used because originating audio and video signals are of such a nature that it is uneconomical and inefficient to feed them directly into an antenna for transmission. At lower frequencies tremendously large antennas are required to transmit the signals; additionally, there is no way to separate desired and undesired signals.[53] In other words, using this approach there are only a very limited number of communications channels.

The solution to the problem was the carrier signal that could be *modulated* to effectively carry the original audio, video, or other types of signals. To modulate a signal means to vary or modify a stream of uniform carrier waves to represent the desired audio or video signal it carries.[54] Figure 8 illustrates AM (amplitude modulation) and FM (frequency modulation) carriers. AM was the first to be developed.[55] Panel (a) shows voice and carrier signals in their original states. Panel (b) shows an AM signal wave varied or modified to represent the desired audio signal it carries. It takes the form of the signal wave; consequently, the up-and-down oscillation of the AM carrier wave is modified. AM signals are

Figure 8
Amplitude and Frequency Modulation



*Currently, there is research being conducted to determine the feasibility of using 18 GHz (up links) and 30 GHz (down links) for high density telephone traffic for a U.S. domestic satellite system.

subject to many sources of noise or interference.[56] For example, noise is generated by electrical storms, the aurora borealis, the sun or other radio signal-emitting objects in space, and earth electrical devices.[57] As a result, FM was introduced. Panel (c) in Figure 8 illustrates that FM directly alters the width of the carrier wave; consequently, to achieve the desired results, an FM radio signal must have a bandwidth several times as wide as an AM signal.[58] In effect, FM trades bandwidth for noise. To increase the amplitude of modulation requires a proportional power increase; however, frequency of modulation can be increased without any increase in power.[59] This is the basic difference between the AM and FM.*

In addition, it should be noted that all AM signals are converted to FM before they are relayed to the satellite, because the power level of the signal transmitted from the satellite can be reduced, thus increasing the communication capacity of the satellite by the power reduction factor.[60]

Frequencies are the key to information transmission, whether information is being relayed over the surface of the earth by microwave towers or relayed via a communication satellite. And, it is the efficient and effective use of the frequency spectrum assigned to these systems that contributes to their financial success. There are other factors which justify the use of earth or space information distribution systems, and these factors are discussed next.

THE BASIC ECONOMICS OF COMMUNICATION SATELLITES

Since 1965, communication technology has grown so rapidly that most countries now utilize satellites either directly or indirectly. The primary justification for their use is the economies of such a system as compared with other distribution systems.

Satellite Distribution Cost Theory

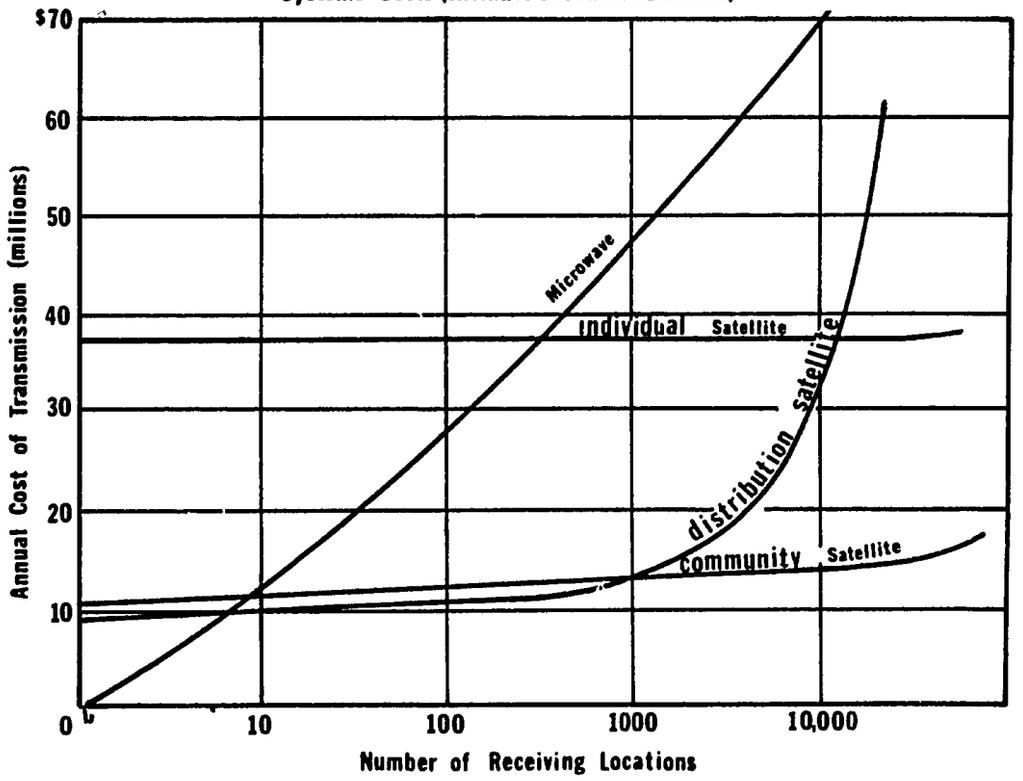
The advantage of satellite communications increases with the size of the area to be serviced and amount of information to be transmitted.[61] This advantage is due to the satellite's capability to use multiple information transmission and reception routes**, as opposed to the single route capabilities of earth communication systems.[62] Earth communication systems have inter-connecting links that follow specific routes along the surface of the earth, and their cost increases with the number of locations they connect.[63] The volume of information between any two points justifies the cost of the link; further, the cost per information-circuit diminishes as the number of circuits increases. It is the anticipation of heavy increases in information volume that justifies the investment in additional circuits and links.

In a satellite system, the expense of a communications link between a satellite and an earth station is the cost of the transmitting or reception station, and this cost is generally uniform.[64] Consequently, the basic cost to link two earth stations, using a satellite, does not depend on the distance separating them.[65] In addition, since the same satellite can transmit to or receive from many stations simultaneously, the basic investment per communication route diminishes as the number of such routes increases on a per-station basis. It would be misleading, though, not to point out that variable costs for satellites and earth stations increase with the number of routes served. As is indicated by Figure 9, the number

*There are other modulation processes such as pulse amplitude modulation (PAM) and pulse code modulation (PCM), but they are not within the scope of this discussion.

**As noted above, a single satellite can transmit signals over approximately 10,000 square miles and any receiver in the area can pick up the signal.

Figure 9
Hypothetical Comparison of Satellite and Microwave Distribution Systems' Costs (Includes Broadcast Stations)



Adapted from: Panel 10, *Broadcasting*, National Academy of Sciences, Washington, DC, 1969, p. 75.

of routes has less impact on the total cost because the satellite system does not require numerous duplications along the transmission path. Walter Hinchman[66] has pointed out that:

> To determine total cost of satellite service, one must add to these basic costs the per-circuit costs of both satellite and earth station facilities. Since both these facilities serve multiple routes, the volume of traffic over a given route has little effect on per-circuit costs. The total volume of traffic through each facility — satellite or earth station — like that of terrestrial systems reduces per-circuit cost as the number of circuits increases. Thus, per-circuit costs of satellite inter-connection within a given coverage zone are largely independent of the number of routes or individual route traffic volume but inversely proportional to the total traffic volume over all routes served.

Therefore, satellites do present cost advantages for long, low-traffic routes, particularly when several routes are being served by one satellite and one earth station. But an earth system will be a competitor for high-volume, short route information transmission, especially if only one route is needed for a specific location.

Some Hypothetical Configurations and Costs of Direct Broadcast Satellite Systems

What will a communication satellite information distribution system cost?

Estimates for point to point and distribution systems can be made; however, a direct broadcast system is another matter since limited cost data exists upon which accurate predictions can be made. Nevertheless, this system *could* have the greatest impact because it may eventually permit the reception of signals with an unmodified or inexpensively-modified receiver (e.g., television, radio, computer terminal and telex). Consequently, it is this system, with its community or individual reception, which will be discussed.* And, many of the factors which will affect the system cost can be generalized to other communication satellite systems.

Five factors have a bearing on system cost:[67] (1) information desired; (2) the numbers and types of receivers; (3) frequencies to be used; (4) satellite transmitter power; and (5) area to be covered by the satellite signal.

Type of Service

Services greatly influence the cost of the satellite system. Satellite radio, like terrestrial radio, is less expensive than television because radio signals require less transmitting power, less bandwidth, and less expensive receivers. Regardless of the difference in the cost of the two radio systems, the questions that have to be answered are: What results are desired? What is the desired geographic coverage area? And what media can produce the desired results most efficiently, effectively, and in the allotted time?

The Receivers

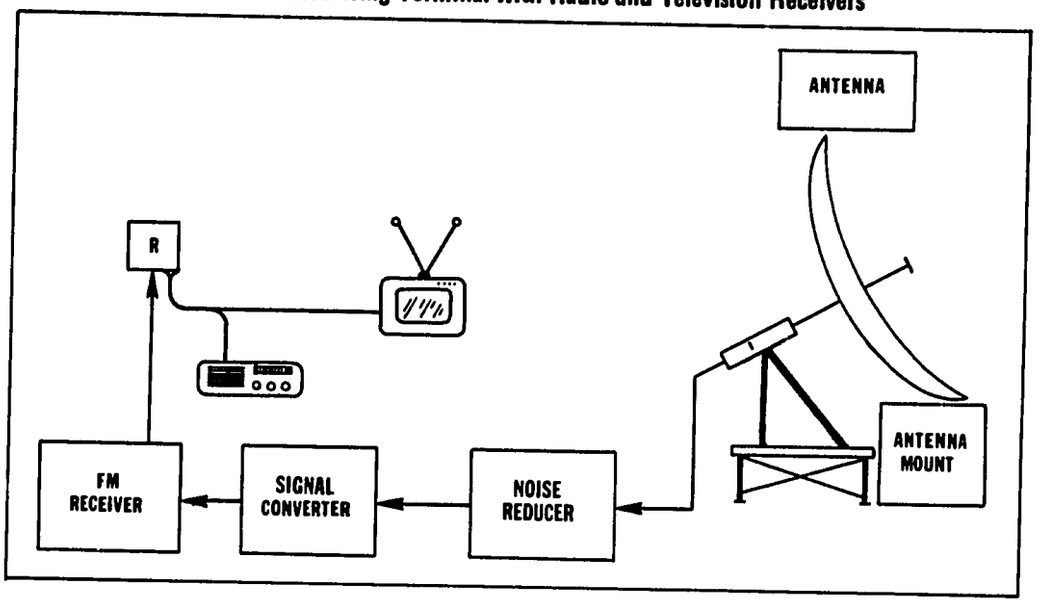
In developing countries in particular, the type of reception and coverage area are significant because most of the people cannot afford to purchase receiver terminals, radios, or television. And, the greater the area covered, the greater the number of receivers required to justify the signal distribution. In most developing countries $50 to $100 is very expensive. Purchase of most of the receivers would fall upon developing country governments.

It is important to distinguish between the *receiving terminal costs* and the *television or radio receiver costs*. As is shown in Figure 10, if signals are to be received directly at a community center or at home, a receiving terminal is needed, which is attached to a television or radio receiver. A receiving terminal consists of a small (7-16 feet) antenna and adaptor. Depending on the service quantity and receiving frequency, the antenna and adaptor components can vary in price. For example, receiving terminals (if bought in 100,000 lots) capable of handling one television channel or 100 radio channels at 2.6 GHz would cost approximately $200 each plus an installation charge of $200,[68] assuming installation at 100,000 sites.

The costs of radio and television sets vary, but in classroom quality and size, sets purchased in quantity might cost approximately $150 each; radios probably could be purchased for less than $15 each. For example, in Brazil[69] 76 domestically-manufactured, conventional-powered 23-inch television sets have been purchased for a proposed satellite experiment for $141 each. Two hundred and fifty 12-inch battery-powered television sets were purchased for $157 each. Three hundred and seventy battery-powered AM radios cost $15 each. Of course, purchase of television and radio will be of little concern to developed countries because most people own sets; rather, purchase and installation costs of the receiving terminal component will receive greater attention.

***The development of a broadcast satellite that can broadcast to *modified* receivers is now possible. The technology exists; however barring political interference, approximately three to five years would be required to put such a system into operation.**

Figure 10
Simplified Block Diagram Showing Major Components of a Hypothetical Small Receiving Terminal with Radio and Television Receivers



Options open to developing and developed countries are (1) using a community receiver terminal at a school or (2) installing a reception station to rebroadcast or distribute signals via a cable. To justify the establishment of a satellite rebroadcast facility costing $200,000 it would take a reception area with over 1,000 reception points.[70] Of course, in large urban areas such facilities are justified. The community center (school or meeting house) concept could reduce the number of receiving terminals and television or radio receivers needed; but the rebroadcast facility could still require a considerable financial outlay for radio or television receivers. Again, this is really of little concern to the developed countries.

Frequencies

The frequency bands available for use help dictate system cost by influencing the cost of the receiver. Terminals working with the 2.5 to 2.6 GHz bandwidth are less expensive than those working with the 11.7 to 12.5 GHz bandwidth.[71] Antennas working at higher frequencies such as the 12 GHz bands have to be parabolic and precisely aimed to receive intelligible signals.

Some estimates cost a receiver terminal for 2.6 GHz in quantities of 1,000* at approximately $450 per unit; however, to bring the cost of a receiver terminal for 12.0 GHz to $600 per unit, 10,000* would have to be purchased.[72] Continued research probably will produce receivers that are more economical in the high GHz frequencies. In the meantime, the assignment of frequencies for broadcast satellites is an important economical consideration.

Satellite Transmitting Power

The transmitting power of the satellite or space segment is inversely related to the cost of the receiver or earth segment. Generally speaking, as the power

*These figures do not include an estimated installation cost of $200 per site.

of the satellite increases, the sophistication and cost per unit of the receiver decrease. However, the amount of power needed to produce desired signals depends upon the frequency and service. For example, transmitting at 12 GHz requires more power than transmitting at 2.6 GHz. In addition, one television channel requires more power than 100 radio channels in both frequencies.

Satellites can produce a small amount of "prime power," through solar cells. Prime power is the maximum wattage* which can be generated to operate the satellite's subsystems and transmit radio, television, and other signals. Not all of the power can be used for signal transmission. For example, as shown in Table 3, the prime power of the Hughes Aircraft satellite, HS-336, is estimated to be 220 watts.[73] Only 88 watts of the power can be allocated to radio frequency power at any one time. However, the transmitter power can be allocated accordingly as more or fewer television or radio channels are needed. Table 3 is fairly representative of costs of systems that are commercially available from the United States.

Table 3
Satellite Capabilities and Launch Costs

Satellite	Total RF Power	Prime Power	Cost	Launch Vehicle	Cost	Total
HUGHES HS-336	88w	220w	$ 6.3M	THOR-DELTA	$ 7M	$13.3M
INTELSAT IV	120w	740w	$13.5M	ATLAS-CENTAUR	$16M	$28.0M
MCI-LOCKHEED	672w	4.4kw	$21.0M	TITAN IIID-AGENA	$23M	$44.0M

SOURCE: Daniel C. Smith and James M. Janky, "Direct Broadcast Satellites" in *A Direct Broadcast Satellite for Education and Development in Africa*, Institute for Communication Research, Stanford University, Stanford, California, (February, 1972), p. 120.

Transmitting Power Versus Coverage Area

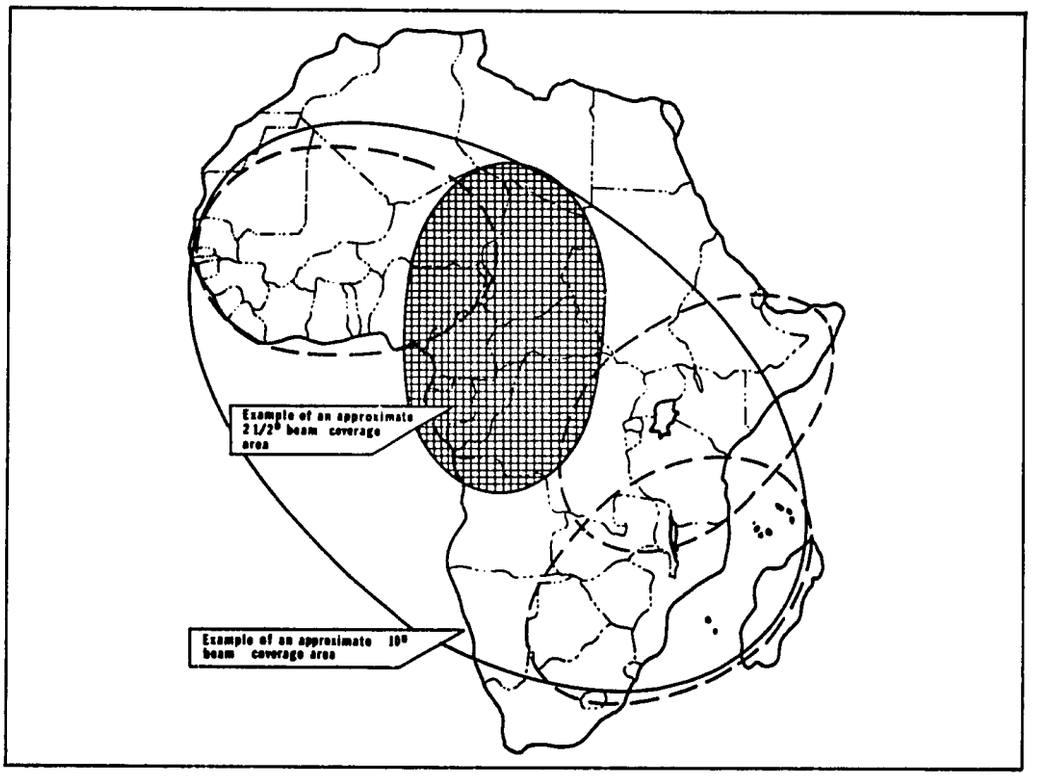
Coverage area can be traded for transmitting power. By reducing the coverage area by three quarters, that is, from a 10° beam to,say, a 2.5° beam, the required transmitting power can be reduced to roughly one quarter.[74] Figure 11 illustrates 10° and 2.5° beam coverage areas superimposed on Africa. As is indicated, covering a smaller geographic area may limit the waste of satellite transmitting power. Four 2.5° beams appropriately placed could cover most of sub-Saharan Africa

*A watt is a unit of energy. Heat energy depends on the amount of current flowing through a resistor. Heat energy in watts=(current in amps)^2 x (resistance). This is referred to as power.

with little wasted power.

Some satellite costs increase when smaller geographical areas are covered. Larger and more sophisticated antennas are needed to focus the signal beam on the desired area.[75] The smaller the beam focus, the larger the satellite transmitter antenna. The antenna required for a 5° beam at 2.6 GHz is about 5 feet 5 inches in diameter.[76] This is approximately the size of the INTELSAT spot beam antennas which produce a 4.5° beam. More research is needed to develop satellites with numerous antennas capable of meeting the needs of many nations.

Figure 11
Satellite Beam Coverage Area for African Continent



Adapted from: Daniel C. Smith and James M. Janky, "Direct Broadcast Satellites" in *A Direct Broadcast Satellite for Education and Development in Africa*, Institute for Communication Research, Stanford University, Stanford, California, (February, 1972), pp. 113, 114.

Some Hypothetical Systems and Costs

The complexities of costing communication satellite systems are readily apparent. The variable most important to costing is the earth segment. For example, when the ground segment includes 100,000 radio and 100,000 TV reception terminals, 500,000 AM radios, 500,000 TV sets and 50,000 small electrical power generators, the reception component of the system exceeds the cost of the satellite and 30 transmitting earth stations.[77]

Table 4[78] shows the cost of two broadcast satellite systems based on the parameters that already have been presented. These systems do not include the cost of software, i.e., radio, television, or computer programs. Of course, it is assumed that radio and television receivers must be bought by the people and/or the

Table 4
Two Broadcast Satellite Systems and Costs

System I Parameters	System 1	Capital Cost	Annual Operation & Maintenance*
	Satellite and launch	$14.0	$1.0
100 Watts	7 ground stations and studios	14.0	1.4
2.6 GHz	25,000 radio terminals—100 channels	5.0	1.3
400 radio channels to 5° area	125,000 AM radios	2.5	0.6
	12,500 power sources	1.5	1.3
	Engineering	5.0	–
	Total U.S. $ Millions 47.6	$42.0	$5.6

System 2 Parameters	System 2	Capital Cost	Annual Operation & Maintenance*
	Satellite and launch	$28.0	$1.0
300 Watts	3 ground stations	6.0	0.6
	10,000 radio terminals—100 channels	2.0	0.5
2.6 GHz	50,000 AM radios	1.0	0.3
400 radio channels to 5° area or	20,000 TV terminals—2 channels	5.0	1.3
2 TV channels to each of two	100,000 TV sets	10.0	2.5
2½° areas	5,000 power sources	0.6	0.5
	Engineering	10.0	–
	Total U.S. $ Millions 69.3	$62.6	$6.7

*Management only. Operating costs do not include programming. These two systems are receive only, but a limited two-way capability could be added for a small additional investment.

Adapted from: Daniel C. Smith and James M. Janky, "Direct Broadcast Satellites" in *A Direct Broadcast Satellite for Education and Development in Africa*, Institute for Communication Research, Stanford University, Stanford, California, (February, 1972).

government. The cost is not pertinent to developed nations, so it can be omitted. In addition, the power source cost for developed countries can be subtracted. It is assumed that in developing countries power generators of some sort will be required to provide the necessary power for some receivers and transmitters.

The two systems that are presented in Table 4 are for the 2.6 GHz band, but they do represent two different coverage areas with different earth segments. As illustrated, television capability will require more power and cost more; however, the major contribution to the cost difference is the variance in the amount and kinds of earth equipment.

Software

All too often software — that is, the radio, television, computer programs that must be developed for transmission — is ignored or given low priority in system development. Software, the most important element in the communication system, is the most difficult to produce and the most costly item of a system.

The average cost for the production of an instructional/educational television or radio program has been estimated at $5,000 and $1,000 per hour respectively.[79] Using this average for 300 days of educational programs, six hours a day, the cost would be $9 million for television and $1.8 million for radio. This is no small investment.

Of course, costs vary depending upon where the programs are produced and their quality, sophistication, and complexity, among other things. An ETV program in El Salvador costs approximately $1,300 per hour; a similar Japanese program costs approximately $2,500.[80] In contrast, the per-hour production cost for "Sesame Street" is approximately $48,000, and the "French Chef" television program costs approximately $17,000.[81]

In sum, the cost of direct broadcast satellite systems depends on many variables, such as type of service, receivers, frequencies, satellite power, satellite coverage area, and software. The above cost figures are based on limited data, but they provide insight into the potential costs of a broadcast satellite system. Continued research and development efforts will undoubtedly introduce cheaper ways to produce the hardware components. Unfortunately, there is little hope that software development costs will be reduced.

THE EVOLUTION OF COMMUNICATION SATELLITES

Man's first communication satellite was the moon. In the early 1950s the U.S. Army used it for radio contact between Washington, D.C., and Honolulu, Hawaii; then in 1958 voices were first relayed, via the moon, from Holmdel, New Jersey, to Goldstone, California.[82]

From Echo I to INTELSAT IV

The first artificial communication satellite which relayed radio and TV signals* was launched by the U.S. on August 12, 1960. "Echo I," a gas-filled plastic balloon 100 feet in diameter, orbited the earth at altitudes ranging from 945 to 1,049 miles.[83] The satellite was passive; that is, it served as a reflector.

Courier 1B, launched on October 4, 1960, was the first U.S. active or repeater communication satellite.[84] However, TELSTAR I, the first commercially built

*SCORE, launched December 18, 1958, was the first U.S. communication satellite; however, it carried a taped message on board which was used to transmit signals back to earth. It was not used for relaying signals.

active communication satellite, was launched into a low-altitude elliptical orbit on July 10, 1962[85] and transmitted telephone messages, facsimile, telephotos, and the first live monochrome and color television between Europe and the United States.[86] TELSTAR I stopped functioning less than a year later because of a technical error. Drawing upon TELSTAR I technology, RELAY I was launched December 13, 1962[87] and, on May 7, 1963, TELSTAR II was orbited.[88] This was followed by RELAY II on January 21, 1964.[89] The TELSTAR program showed that commercial satellite networks were just around the corner.

The RELAY* program demonstrated two-way transmission of long-distance color television and other types of communications via satellite.[90] The RELAY program pioneered satellite communications between North and South America, provided the first trans-Pacific television transmission from the United States to Japan, and provided transmission of electroencephalograms to specialists in the United States.[91] RELAY I was also used to telecast the events surrounding President Kennedy's assassination to viewers in Europe, Japan, and the Soviet Union, thus proving the utility of satellites for international networking. The RELAY satellite program established the feasibility of low and medium altitude communications satellites, and provided the impetus for development of satellite communications earth terminals throughout the world.[92]

However, the high cost of a satellite communication system using a nonsynchronous orbit added impetus to explore the feasibility of synchronous satellite orbits for relaying signals. On February 14, 1963, SYNCOM I achieved the correct synchronous orbit, but it failed within minutes.[93] In July of the same year, SYNCOM II successfully demonstrated the practicality of synchronous communications satellites.[94] SYNCOM II was not designed for television transmission, but it was used to conduct an experiment in audio-video quality.[95] Television network officials judged the quality satisfactory for rebroadcast and SYNCOM III, launched in August, 1964, was orbited over the Pacific Ocean in time to relay portions of the 1964 Olympics from Tokyo to California.[96] The program was distributed from California throughout the United States and to Canada, Mexico, and Europe. RELAY II was used to retransmit live portions directly to Europe, thus demonstrating the feasibility of simultaneous global television distribution.[97] It was the SYNCOM satellite program that provided the basis for an international telecommunication satellite system.

The U.S. formally initiated the international communications satellite concept in 1964. Shortly thereafter, to foster the development of a single international system, the International Telecommunications Satellite Consortium (INTELSAT) was formed.[98] By 1967 the consortium orbited four satellites, and added three more within the next two years.

INTELSAT I (Early Bird) was orbited over the Atlantic Ocean on April 6, 1965. It relayed signals to the northern Atlantic basin via 240 voice circuits or 1 TV channel.[99] The INTELSAT II series was initiated in 1967 containing the same number of circuits, but covering larger geographical areas than INTELSAT I.[100]

INTELSAT III, with 1,200 voice circuits or 4 TV channels and a mechanically-de-spun earth coverage antenna, represented a new generation of satellites. Eight of the III series were launched, beginning in September, 1968;[101] three were unsuccessful. In January, 1971[102] the first of eight INTELSAT IV satellites was launched with a unique antenna system that could transmit search-light beams

***Shortly after launch of RELAY II, the U.S. launched Echo II, a passive satellite, to conduct joint communication experiments with the USSR.**

of concentrated power onto small geographic areas. INTELSAT IV satellites can handle 3,000 or more voice circuits or 12 TV channels.

The INTELSAT V series is scheduled for launch in 1978, but in the interim, to help with the increasing use of the consortium satellites, the INTELSAT IV is being modified (designated the IV A) and is scheduled for launch in 1975.[103]

The European Communication Satellite*
Research and Development Effort

Of course, the United States is not the sole promoter of satellite technology. In 1965, the USSR launched the versatile MOLNIYA I satellite which handles voice, television, teletype and facsimile information.[104] And in 1967 a domestic system designated Orbita was established.[105] Noted previously in Figure 4, the Orbita system does not use synchronous satellites; the orbit is elongated and elliptical, permitting the satellites to be within broadcast distance of the USSR for a major portion of the orbit. Three MOLNIYA satellites are required to provide continuous twenty-four hour service to all areas of the country. A new satellite takes over the duties of the predecessor as the predecessor disappears over the electronic horizon.**[106]

The system has been expanded to an international system, INTERSPUTNIK, similar to INTELSAT. So far, the system has not been as widely accepted as the INTELSAT system, primarily because of its expensive tracking earth stations and incompatibility with INTELSAT.[107]

The nations of Europe, moving to check Soviet and American domination of space technology and the prohibitive costs for challenging that domination, established the European Launch Space Vehicle Development Organization (ELDO), and the European Space Research Organization (ESRO).[108] Member countries have divided development work. For example, development of their launch vehicle has been the responsibility of the United Kingdom (Stage I), France (Stage II) and the Federal Republic of Germany (Stage III). Italy has been responsible for constructing the satellite test vehicle, including its electronic equipment. The Netherlands has been in charge of the development of long-range telemetry links, and Belgium has been developing and constructing equipment for the downrange guidance station. Range and support facilities for developmental tests have been provided by Australia. To date, major difficulties with the launch vehicle have impeded progress. All launches have been unsuccessful.[109]

In addition, Germany and France have been working on "Symphonie," a joint communication satellite experiment.[110] The Symphonie project is scheduled to launch a satellite in early 1974. The satellite will be used to conduct television experiments between France and Germany.*** An ELDO launch vehicle is to be used.

However, each is studying the feasibility of a domestic system. The French National Space Agency is considering three separate satellite systems:[111] 1) Retelsat, a communication satellite that would be used to link France, French-speaking Africa, and French foreign departments; 2) Memini, to broadcast to

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*Information about all nations' activities was not available to the author at the time of this writing. For information about UNESCO and other nations' efforts contact: Director, Mass Communications, UNESCO, place de Fontenoy, Paris, or the International Telecommunications Union, Geneva.

**The Soviet Union plans to place a communication satellite in synchronous orbit. It is to be designated Statsionar.

***Satellite capacity: three audio and one service channel; or one hundred and ninety-two telephone channels, plus twelve channels for each carrier, or eighteen radio broadcast channels, with one service channel.

Quebec; 3) Socrate, the proposed educational satellite system which would provide educational television to French-speaking Africa. France may use an ELDO or a USSR launch vehicle.

The Federal Republic of Germany initiated a research project in 1970 to explore the possibility of a domestic broadcast satellite system. In 1972 contracts were awarded to design an experimental system, which is to provide TV and other signals to community and augmented individual receivers.[112] The experimental system is scheduled for launch (U.S. or ELDO vehicle) in 1977 and is to be used for educational and scientific experiments over a five year period.[113]

The Asian Communication Satellite Research and Development Effort

Japan has been developing an extensive satellite capability, launching three of its own small scientific satellites in the past four years and planning to launch ten additional satellites over the next five years.[114] Two of these are to be communications satellites; one is to provide for domestic telecommunication, the other is to provide broadcast services which will cover Asia.[115] The Japanese may launch their own communication satellites or rely on the U.S.*

Working with the United Nations, the U.S., the Soviet Union, and other nations, India has been planning a domestic broadcast satellite system since the late 1960s.[116] Initially, experimentation is planned for 1975 and 1976 using a U.S. built and launched Application Technology Satellite (ATS-F).[117] This is to be followed by the foreign procurement, and a 1976 launching, of a domestic broadcast satellite; by 1981 India plans to have the capability to build and launch its own communications satellites.[118]**

The South American Communication Satellite Research and Development Effort

Brazil has been conducting communication satellite studies since the mid 1960s. Initial efforts were education oriented; however, a multipurpose concept has emerged. Some educational experimentation has taken place with the U.S. ATS-3, and some has been planned for other U.S. experimental satellites.[119] If a domestic satellite is forthcoming, current development plans point to the foreign procurement and satellite launch for sometime in the late 1970s, both probably provided by the U.S. There are plans for domestic manufacturing of communication satellites but not for developing a launch capability in the foreseeable future.

With the aid of UNESCO and the ITU, Argentina, Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela are conducting a joint feasibility study.[120] The joint team is exploring the possibility of a regional information distribution system for education, cultural exchanges, and information exchange and development. The value of a satellite information distribution system is being compared with various terrestrial distribution systems. Being studied are the formal and nonformal educational applications of broadcasting; the need for curriculum revision, program content, television and radio production, and training;

*Currently Japan does not have the capability to launch large communication satellites into synchronous orbit. To develop this capability may delay a launch for a number of years.

**The Philippines, Indonesia and Australia have also expressed an interest in a domestic satellite and Indonesia and Australia have been conducting studies to determine the feasibility of the system for education and other services.

the optimum means for the transmission and distribution of information; and the overall economic, financial, legal and organizational aspects of such a system.[121]

The Middle East-African Communication Satellite Research and Development Effort

To determine what contribution satellite communication systems can make to education and development, UNESCO in cooperation with the ITU has conducted preliminary studies or surveys for the Arab States and for African nations south of the Sahara.[122] The Arab State survey was completed in 1970, and more extensive studies have been undertaken. UNESCO is to conduct additional studies.[123]

The Government of Iran has been exploring the possibility of an Iranian domestic satellite system since 1969.[124] An initial survey was conducted in 1969 culminating in 1970 and 1971 proposals[125] to develop an operational system primarily for educational purposes. A decision was made not to pursue the matter for the time being.

The sub-Sahara survey was conducted in 1972,[126] and the results indicate that a regional satellite system will be difficult to establish due to the diverse cultures and languages of the region. Further, the costs of a domestic system appear prohibitive for all of the nations.[127]

The Canadian Communication Satellite Research and Development Effort

Canadian satellite efforts date back to the early 1960s when the Defense Research Board built ALOUETTE I and II which were launched by NASA in 1962 and 1963 respectively.[128] Since this initial undertaking, Canada has designed and supplied many satellite components for other nations. Further, it has established an extensive communication satellite R&D program, a portion of which is being conducted with the United States.[129]

Canada was the second nation to initiate a domestic communication satellite system, and the first to use the synchronous satellite orbit. The first of three satellites (ANIK I)* was launched in November of 1972; ANIK II was launched in April of 1973; the third remains on the ground as a reserve.[130]

Each satellite can handle 12 simultaneous colored TV channels or 11,520 one-way voice channels, or some combination of TV and voice channels.[131] The system provides information services which complement the existing terrestrial communication services and provide services to remote areas where terrestrial communications are poor or nonexistent. The ground portion or earth segment is to be comprised of 70 earth stations with the majority being capable of receiving TV only; some are equipped to receive TV and to receive and transmit telephone, data, etc.

The Canadian experience is providing valuable information to both the developed and developing countries. Canada is illustrating how a communication satellite system can be used in conjunction with a well-developed terrestrial communication system in Southeastern Canada and at the same time demonstrating how the communication needs of the underdeveloped, remote areas of Canada can best be served. Further, the system is being used to address the diverse linguistic requirements of the nation; this is providing other nations with similar multilinguistic requirements with insights into how to approach such needs.

*ANIK means brother in Eskimo language.

The United States Communication Satellite Research and Development Effort

While other nations have developed, or are developing, communication satellites, the United States has had the most ambitious and extensive research, development, and application programs in the field. Table 5 summarizes past, present, and projected U.S. satellites and their launching years.

Table 5
U.S. Experimental Communication Satellites

Satellite	Year										
	1958	1960	1962	1963	1964	1966	1967	1968	1969	1974	1978
SCORE	▼										
ECHO I		▼									
COURIER		▼									
TELSTAR I			▼								
RELAY I			▼								
SYNCOM I				▼*							
TELSTAR II				▼							
SYNCOM II				▼							
RELAY II					▼						
ECHO II					▼						
SYNCOM III						▼					
ATS-1							▼				
ATS-2							▼*				
ATS-3							▼				
ATS-4								▼*			
ATS-5									▼*		
ATS-F **										▽	
CTS											▽

LEGEND:
▼ launched
▽ to be launched

* Partial or total failure for technical reasons.
** Prior to launch, experimental satellites are identified by letter. After launch, they are identified by a number.

Adapted from: Leonard Jaffe, *International Experimentation with Communication Satellites*, United Nations Conference Paper No. A/Conf. 34/VIII.2, (June 3, 1968.)

After SYNCOM III, NASA initiated the multi-purpose Application Technology Satellite (ATS) program to provide the basis for new operational systems capabilities.[132] The ATS-1, launched in December, 1966, demonstrated the feasibility of using electronically de-spun antennas on geostationary, spin-stabilized spacecraft and also demonstrated VHF signals exchanges with aircraft.[133] In 1967 the ATS-3* satellite demonstrated a mechanically de-spun antenna, improved beam concentration, and high-power transmitters, permitting television signals to be transmitted to terminals considerably smaller than those used in the INTELSAT system.[134]

*ATS 2, 4, and 5 were partial or total failures due to technical problems. For an explanation of failures see Executive Office of the President, National Aeronautics and Space Council, *Aeronautics and Space Report of the President*, Washington, D.C.: United States Government Printing Office, (January, 1971), p. 109.

In June, 1967, the ATS-1 coupled with two INTELSAT II satellites was used to broadcast a worldwide, two-hour television program sponsored by the European Broadcasting Union (EBU). The satellites connected Europe, the Americas, Japan, and Australia. Both the ATS-1 and 3 satellites have been made available to foreign governments and U.S. organizations for experiments demonstrating new applications and providing experience in the applied uses of satellites. For example, Alaska and Hawaii have conducted independent educational experiments with the ATS-1 and the ATS-3 has been used by Stanford University and Brazil for similar experiments.[135]

Satellites launched in the near future will experiment with improved satellite communication capabilities. The ATS-F (ATS-6) is being developed to test the deployment of an antenna 30 feet in diameter, which is to permit a signal beam pointing accuracy of 0.1°.[136] The antenna and associated multiple-frequencies are to be used to transmit powerful, highly directional television signals to relatively small, inexpensive community receivers.[137] Among other things the satellite will be used to test the feasibility of improving mass instructional broadcasting in developing and developed regions of the world. Actually, the ATS-F satellite is the forerunner of the direct broadcast satellites of the future. The ATS-F is to be the last satellite in the ATS series.[138] Table 6 summarizes the past, present, and future ATS experiments.

Table 6
Applications Technology Satellites
Educational Communications Experiments

STATUS	DATE	SATELLITE	PURPOSE
COMPLETED:	CONCLUDED		
Corporation for Public Broadcasting	March 1970	ATS 1,3	Transcontinental Interconnection
Stanford University	Summer 1971	ATS 1	CAI Distribution
NPR / Alaska	Fall 1972	ATS 1	Educational Radio
NLM / OE / Alaska	Fall 1972	ATS 1	Medical / Public / Educational Communications
CONTINUING:	STARTED		
University of Hawaii	March 1971	ATS 1	Pacific Interconnection
Stanford University / Brazil	April 1972	ATS 3	Lecture, Seminar Data Exchange
APPROVED:	ESTIMATED START		
NASA / CPS / HEW / RME / ARC / Alaska / Brazil	Summer 1974	ATS F	Medical / Public Educational Communications
NASA / INDIA	Spring 1975	ATS F	
PENDING:	REQUESTED START		
Numerous Organizations, States, and Industry	1975	CTS	Multipurpose

Adapted from: Donald Silverman, "Summary of Past, Present and Future Educational Experiments Involving Advanced Technology Satellites." Paper presented at Washington University Conference on Satellites for Education, St. Louis, Missouri, (July 20, 1971).

In April, 1971, NASA and the Canadian Government's Department of Communications signed a formal agreement to jointly build and test a Communications Technology Satellite (CTS). Shortly thereafter, ESRO signed an agreement to provide a number of components for the CTS.[139] The satellite is to be tested in 1975. Objectives of the cooperative effort are to advance the state-of-the-art in spacecraft and related ground technologies for future educational broadcasting and remote-area communication, and to develop technologies in the 12-14 GHz band.[140] The satellite will provide one or two-way color television and one or

two-way audio channels, and permit wide-band data exchange as well. This will be the last of the U.S. experimental communication satellites for the foreseeable future.

Commercial interests have begun to use the results of the NASA R&D efforts and are expected to continue to advance the state-of-the-art. The United States is expected to have several domestic satellite systems by 1976, owned and operated by private corporations.

INTELSAT: AN EXAMPLE OF AN OPERATIONAL COMMUNICATION SATELLITE SYSTEM

The development of the communication satellite led to the U.S. Communication Satellite Act of 1962, providing for the establishment of a communication satellite corporation to work toward a global satellite-supported communication network.[141] The Communication Satellite Corporation (COMSAT) became a legal entity on February 1, 1963.[142] A year later, the U.S. Government, COMSAT, and other nations negotiated two agreements which established the International Telecommunications Satellite Consortium (INTELSAT).[143] The first or Interim Agreement, signed by eleven countries, established the structure of the proposed organization and set forth its basic goal: a single, world commercial communication system owned jointly by all members of the International Telecommunication Union (ITU), and available for every nation to use.[144] Each member nation was to designate a telecommunication authority or entity to ". . . undertake the requisite financial commitments for and share in the ownership of the 'space segment"[145] . . . share costs and revenue, and establish charges for satellite use, procurement policies and procedures, and rights in inventions and technical data.[146]

Because most of the technology for such a system was concentrated in the United States, COMSAT was designated interim INTELSAT manager, responsible for the design, development, construction, establishment, operation, and maintenance of the hardware and related software of the space segment components of the system. In addition, the United States controlled over 50 percent of the votes in the organization.

This arrangement was renegotiated in May, 1971. Under the agreement, the governing body consists of representatives or signatories known as the Board of Governors headed by a Director-General.[147] Each governor has a voice equal to that part of the investment share of a signatory or group which he represents, which is based on the use of the system.[148] No governor may cast more than 40 percent of the total votes.[149] Thus U.S. control is reduced. For the time being COMSAT is continuing to provide technical and operational management but answers to the Director-General and the Board of Governors.[150]

The INTELSAT system has two distinct parts:[151] the space segment and earth segment. The space segment consists of the satellite and the ground equipment needed to track, control, and command the satellites. The earth station segment is composed of reception and transmission systems, usually constructed, owned, and operated by a government-approved entity.

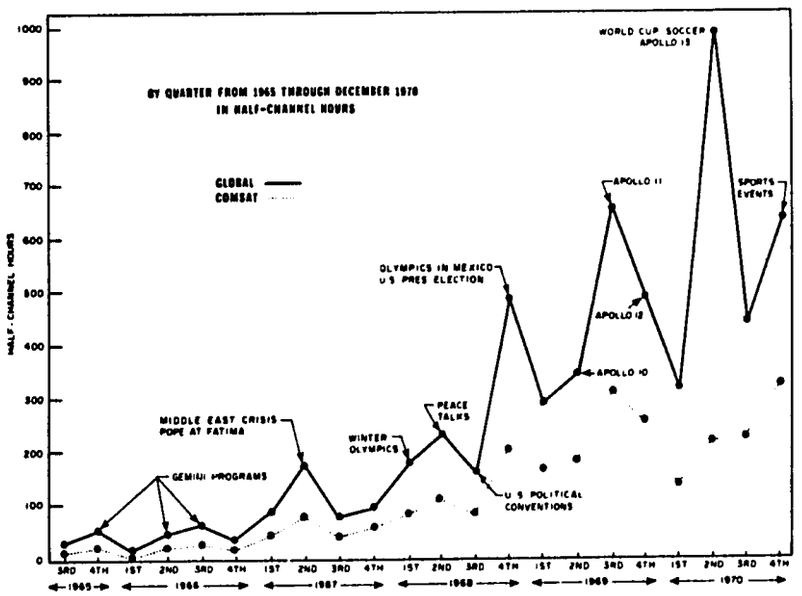
At the outset, $200 million was estimated as the cost of the space segment, but actual expenditures by 1970 had reached only approximately $80 or $90 million.[152] The earth station segment, on the other hand, has cost much more. Each station costs $2.5 to $4 million to build, and $1 million annually to operate and maintain.[153] There were 71 earth station antennas operated by 44 countries as of August, 1972.[154]

The Growth of the INTELSAT System

All of the full-time operating INTELSAT satellites are in geostationary orbits, which INTELSAT I (Early Bird) proved satisfactory for *commercial* communications. INTELSAT I was launched in 1965 with a capacity of 240 telephone circuits or one television channel linking North America and Western Europe. The satellite's basic characteristics did not permit simultaneous television and voice; consequently, all voice circuits had to be given up to transmit television signals. In 1967 three INTELSAT II satellites were orbited — one over the Atlantic and two over the Pacific, each having the same telephone and television capabilities as INTELSAT I.[155] In 1968-69 the INTELSAT III series was launched with 1,200 telephone circuits or 4 television channels.[156] One of the III-series satellites was sited above the Indian Ocean to complete the space segment portion of the system. In effect, the INTELSAT I, II, and III series were the first steps toward tying the four corners of the globe together with a reliable and fast communication system.

While only about one half of the circuits on Early Bird were in operation when INTELSAT II was available over the Atlantic, the anticipated growth of overseas communications seemed to justify its existence. In a report to a Congressional committee in 1962, a NASA spokesman estimated that Americans would make more than 20 million overseas phone calls in the 1970s and 100 million by the 1980s.[157] It now appears, as Figure 12 indicates, that television

Figure 12
Television Trends: Global and COMSAT



SOURCE: *COMSAT Annual Report to the President and Congress*, Communications Satellite Corporation, (May 31, 1971), p. 89.

may contribute to the use of a considerable part of the available INTELSAT satellite capacity. In 1970 television via satellite averaged one hundred transmissions a month compared to five a month in 1965 when INTELSAT I was the only satellite. Global satellite television increased by 33 percent during 1970.[158] In 1971 it increased by almost 50 percent over 1970.[159]

As a consequence of the anticipated use of the communication satellite circuits, the INTELSAT IV system was developed. It has between 3,000 and 9,000 voice circuits, or as many as 12 television channels; the first of these was launched January, 1971.[160] Because of the power of the system (five times that of INTELSAT III) and its antenna-focusing capability, the costs of future ground stations are expected to decrease. Current systems have relatively weak transmitters which require elaborate ground equipment to receive and amplify signals when they reach the earth.

The Operational Status of the INTELSAT System

As of July 30, 1972, seven INTELSAT satellites were in service; one is on standby.[161] One INTELSAT II satellite (F-6) and two INTELSAT IVs (F-2, F-3) are in service in the Atlantic area; in the Pacific area, two INTELSAT IIIs (F-3, F-4) and one INTELSAT IV (F-4) are in service; and in the Indian Ocean area, one INTELSAT IV (F-5) is operating. The one standby satellite is INTELSAT I; the other satellites are inoperative. In all, nearly 40,000 satellite voice circuits are available for use in the INTELSAT system.

The Use and Cost of INTELSAT

The INTELSAT system is a commercial venture, and it leases "units of satellite utilization."[162] A unit of satellite utilization is called a half-circuit. A half-circuit is a two-way communication path suitable for voice exchange between one earth station and a satellite. When it is matched with a corresponding half-circuit between the satellite and another earth station, a through two-way voice circuit or full circuit is provided.[163]. The price of a half-circuit is an annual rate designed to cover depreciation of the space segment and its operating costs and to yield a return on the capital invested.[164]

In fixing the half-circuit charges, INTELSAT views the space segment (Atlantic, Pacific, and Indian Oceans) as an entity, and accordingly levies a uniform half-circuit price, reflecting rapid depreciation of the space segment, research and development costs, operating costs, and continuing investment in the space segment.[165] Until 1966 the charge was $32,000 per half-circuit per year, but this since has been reduced, first to $20,000 then to $15,000 in January, 1971 and $13,000 in January, 1972.[166] This price is expected to continue to decline. The INTELSAT base price is a constant with no variance for time of day or demand rate.*

The satellite communication entity of a nation, such as COMSAT in the United States, leases half-circuits from INTELSAT and then makes them available at specified rates (which include costs and a profit) to communications carriers like AT&T or Western Union. These companies then charge a specific rate to individuals or companies who use the system. These rates also include costs and a profit. For example, the user, a person making a trans-Pacific telephone call via an INTELSAT satellite, is charged at a basic rate which includes a portion of the $13,000 plus the lessee's costs and profit. Generally speaking, the pieces in the communication system that must be paid for include the link from an individual's telephone to an earth station, the transmission of the signal from an earth station to the satellite, the relay via the satellite, the links down from the satellite

*Th. price does increase if a smaller than standard INTELSAT earth station is used because more satellite power is required; accordingly, the increased power is expressed as a greater number of half-circuits in use.

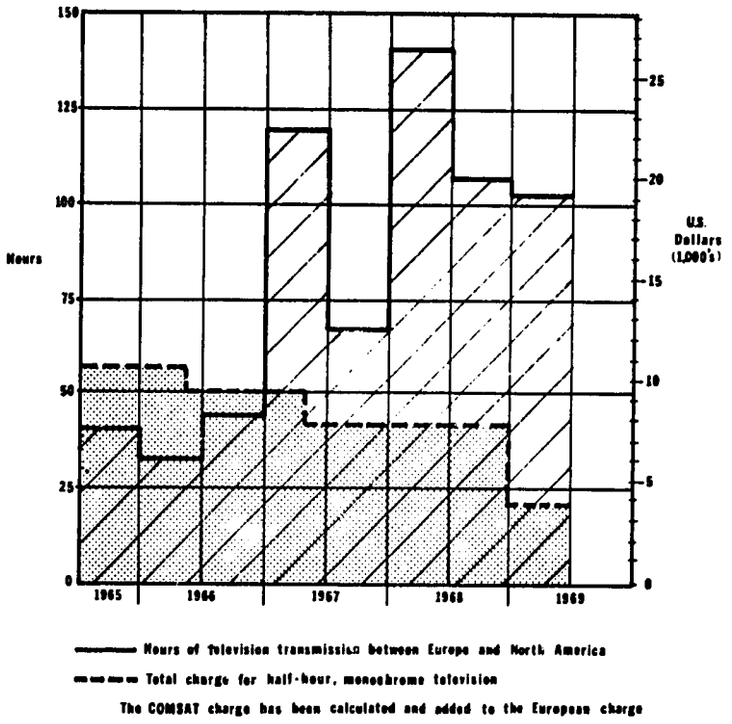
to another earth station, and then the link to the telephone of the party being called. However, the charge for the up-link from an Australian earth station to satellite may differ from the charge for the down-link from satellite to, say, a Kenyan earth station. The rate for a satellite-to-earth link is not always the same among countries. Two fundamental reasons for this, although they are not the only reasons, are: the extent to which the total circuit capacity of an earth station is utilized, and the practice among nations of subsidizing their domestic communications with international communications profits.[167]

INTELSAT: The Cost and Growth of Television Service Between Europe and the United States

It was noted previously that Early Bird provided either 240 voice circuits or one television circuit. One result was that television rates were mainly based on loss of telecommunication revenue. Of course, television rates varied according to time of day, with the highest costs coming during peak telephone usage hours.[168] As is common practice, each end of the circuit sets its own charge, and the overall charge is payable to whichever end is required to supply service or establish the circuit.[169] In light of the "eitherflor situation" with Early Bird, the cost per half-hour of monochrome television was approximately $11,000 for U.S.Europe transmissions.[170]

Figure 13 illustrates declining international television broadcast costs and increasing broadcast hours since 1965.[171] As a result of the additional satellites

Figure 13
Satellite Television Cost



Adapted from: Piero Fanti, "European Satellite Rates for Television Service" in *EBU Review*, (Vol. 118 B, November, 1969), p. 36. Reprinted by permission of the Administrative Office of the European Broadcasting Union.

that have been orbited, the dramatic increase in television use as soon as INTELSAT II was available shows how much television demands had been restricted by Early Bird. Thus, with the introduction of the INTELSAT II series the overall cost of a satellite link between the United States and Europe was reduced. In 1967, the second year of commercial service, the hourly use of satellites for television nearly tripled.[172] This same ratio was maintained in 1968 relative to 1967, but despite this, television transmission was still restricted by the characteristics of the INTELSAT II satellite.[173] The advent of the INTELSAT III satellite series in December, 1968 meant a prodigious improvement in broadcast service. Television was given a permanent capacity in the satellite sufficient to meet television video and audio requirements without imposing minimum use constraints on other services. Consequently, in 1970 the hourly charge for a 30-minute transatlantic color television program was $3,000 plus earth station-network link charges of approximately $1,250.[174] There is little doubt that the costs per circuit will continue to decline as the use of satellites increases.

The New INTELSAT Domestic Service[175]

Under a recent arrangement, INTELSAT is specifically authorized to provide space segment facilities for domestic communications services. For example, Australia could *transmit and receive* its own daily television program by renting a portion of the satellite bandwidth or transponder (36 MHz). This was not possible before September, 1971. At its 55th meeting in September, 1971, the Interim Committee on Satellite Communications (ICSC) of INTELSAT established guidelines for signatories in ascertaining their prospective television requirements. The charge for a *full-time* INTELSAT IV global beam 36 MHz transponder for television use was set at $4.6 million. The committee stated that these charges might require review after study of the possibility that a full-time television channel could be provided via a spot beam.

It is important to note that, based on the forecasted decrease in charges, a TV distribution system going into service in the near future (one-year transponder lease) is expected to cost approximately $3.2 million. By 1980, the cost of equivalent capacity on whatever satellite is then in service is expected to fall to about $1.4 million. A further decrease to about a half a million dollars is expected by 1988 as steadily growing traffic continues to benefit from greater economies of scale on larger, more efficiently utilized generations of INTELSAT satellites.

While most earth stations accessing the INTELSAT system for international communication are the large "standard" type costing from $2.5 to $4 million, it is possible *today* using an INTELSAT system to establish a domestic TV system using smaller stations costing from $100,000-$200,000; this could mean considerable cost, operational, and other advantages over separate domestic satellite systems. One of the advantages of the INTELSAT system is that it is technically feasible to use a small, relatively inexpensive earth station for a domestic television network in conjunction with a country's present or planned standard INTELSAT earth station operating with the INTELSAT system.

Initially, small earth stations could be equipped for TV reception only, but they can be upgraded for telephone service by the addition of the necessary transmission and channel equipment. For example, minimum-cost ground stations, capable of delivering a single video signal of fine quality using the global beam antenna of an INTELSAT IV, can be built in quantity for about $100,000 each. Additional equipment required for receiving a second and third TV channel

can be installed for about $20,000 per channel. Additionally, a basic station could be modified to receive and transmit twelve telephone channels for about $35,000 if such capability is desired at a later time.

In summary, INTELSAT has demonstrated that communication satellite information distribution systems can be useful to mankind and economical to operate. The growing demand has led to decreasing service costs and an increase in the services that can be provided. Whether nations will take advantage of the domestic satellite service offered by INTELSAT or opt for their own domestic systems remains to be seen.

CONCLUSIONS

Evidence to date favors the utilization of satellite systems for some types of communication; however, caution should be taken not to represent the communication satellite as a boon to education. Currently there are no satellite systems being used for educational purposes; consequently, no definite conclusions can be drawn about a satellite's value to the educational community. This remains to be demonstrated, it is hoped, through extensive experimentation over the decade. But it must be remembered that the type of service and the quality of programming will be the determining factors, not the satellite technology.

Looking at communication satellite systems in general, it is possible that the real economic advantage of satellite distribution systems will be related to doing something new or providing better or hitherto nonexistent services in areas where terrestrial distribution systems are either limited, nonexistent, or else not geared to providing a desired service. Consequently, satellite distribution systems may be justified by developed and less-developed countries on the basis of offering education and other social services that could not be offered as efficiently and effectively and in the desired time via terrestrial distribution systems.

Of course, it may be that factors such as geography, population density, and educational objectives may serve as major determinants in choosing between terrestrial and celestial information distribution modes. For example, in locales where the population is concentrated in a few areas, microwave, cable, or video tape could prove a more practical solution to the communication problem. However, such large countries as India, Brazil, or Sudan, where populations are scattered and terrestrial communication and transportation almost nonexistent, might find a satellite system helpful in filling missing links in the communications network.

Because of the potential of satellite technology for rapidly modernizing developing countries, the less-developed countries are the prime target for proving the value of *broadcast* satellites. However, broadcast satellite systems present many political, economic, and social considerations for world leaders, for rarely, if ever, do social institutions evolve as rapidly as technology does. Marriage of the technologies of the future with the institutions and technologies of the present and past has always been difficult.

FOOTNOTES

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CHAPTER II

PRESENT AND FUTURE COMMUNICATION SATELLITE EDUCATIONAL EXPERIMENTATION

The Soviet Union and Canada have domestic communication satellite systems. Two international satellite systems currently exist, INTELSAT and INTERSPUTNIK. The United States, India, Brazil, West Germany and Japan are to have domestic communication satellite systems within the decade. Further, many other nations are seriously considering regional or domestic satellites. This boom in satellites is occuring with only limited notice and understanding by the general public, yet the proponents of the technology are predicting that many facets of everyday life, from mail delivery to education, will be changed.

A considerable amount of discussion has been and is taking place about the use of satellite technology, with particular emphasis on its usefulness to developing and developed countries in educating their citizens. Whether the technology is of value for educational purposes still remains to be seen.

In April of 1974 a serious effort will be made to begin to demonstrate some of these possible social services with the launch of the ATS-F, the sixth and final communications satellite in the NASA program. Initially the satellite will be used by the United States for medical and educational experimentations in the Appalachian and Rocky Mountain regions and in the State of Alaska. Then in 1975, the satellite will be moved for use by India to determine its possible value for national integration, health and family planning. As was noted in Chapter I, in North America social service experimentation is to continue throughout 1976 and 1977 with the CTS, a satellite sponsored jointly by Canada and the United States.

The commitments to these experiments will exceed a quarter of a billion dollars; this indeed is a serious effort and promises to be a major event in this decade. What societal institutions, roles, and functions will be altered or replaced by the technology remains to be seen. But the fact that domestic communication satellites are expected to quadruple this decade, and extensive social service experimentation is to be conducted, calls for an understanding of the technology by the public in general and educators in particular.

From these experiments, educators should receive some inkling of the educational potential of satellite technology. It is these experimental efforts that world educators should be interested in. More important is their participation in such experiments or their monitoring of the results. As a consequence, when the time comes to make decisions about the use of satellite technology for social development in general and education in particular, decisions based on knowledge and experience can be made.

CURRENT EDUCATIONAL SATELLITE EXPERIMENTATION*

Educational experiments are currently being conducted with the Applications Technology Satellites (ATS) 1 and 3. While basically audio in nature, these experiments can provide educators with some new insights into the potential of the

*This section, an article by the author, appeared in *Audiovisual Instruction (c) Vol. 18, No. 2, February, 1973, pp. 32-35, and is entitled* "Current Educational Satellite Experimentation: An Overview."

technology and its associated problems, the personnel, facility, and financial requirements, and the necessity for comprehensive planning. This section provides a brief overview of these experiments. The three separate experiments currently in progress are being executed mainly in the United States by the State of Alaska, the State of Hawaii, and Stanford University.

The State of Alaska Satellite Experimentation

The Alaskan experiment was initiated in 1969 when the State of Alaska submitted a proposal to the National Aeronautics and Space Administration for use of the ATS-1.[1] NASA approved the proposal; however, the cost of the earth stations ($200,000) for receiving television via the ATS-1 was prohibitive. So, at the suggestion of the Department of Health, Education, and Welfare, radio experimentation was agreed upon, with television experimentation being relegated to the high-powered ATS-F satellite, for which receivers were to be considerably less expensive.[2]

The experiment has three objectives:[3]

1. to demonstrate how medical services might be delivered to remote areas;
2. to demonstrate the effect of real-time National Public Radio programs from the 48 contiguous states; and
3. to demonstrate how educational services might be delivered to remote areas by satellite technology.

Three projects were initiated in 1971 with medical services being provided through a "biomedical" project using the ATS-1 to link 21 village health aides with a Public Health Service doctor who provides medical counseling and diagnostic services; additionally, health education programs are being transmitted to village inhabitants.[4] A public service program is being provided from the "lower" 48 states by National Public Radio;[5] the University of Alaska radio station in Fairbanks, KUAC-FM, receives and rebroadcasts "All Things Considered" daily to residents of the Fairbanks area.[6] The educational component is provided by the state-operated schools with the purpose of providing subject-matter programs to the classroom, as well as using the satellite to provide two-way communication between teachers and their administrators.[7] To date, these projects have just begun to provide insights into how to proceed to meet the needs of the populace in health, education, and public service broadcasting.[8]

VHF satellite audio receivers have been developed, costing about $30 to $40, excluding the antenna.[9] "The two-way transmitter-receivers used in the Alaskan experiment are, in fact, modified taxicab radios."[10] The receiver-transmitters are being used to permit two-way voice communication among 26 Alaskan locations.[11] While reduced satellite power has led to some signal problems, in the main, it is a better communication link than the short-wave radio, which is subject to extensive atmospheric noise and communication blackouts.[12]

The project involves NASA, the Lister Hill National Center for Biomedical Telecommunication, Bethesda, Maryland, the United States Office of Education, and the various interest groups of the State of Alaska.

The total fund commitment for the various projects, primarily from HEW, slightly exceeds $700,000.[13] The funds were drawn from the "Elementary and Secondary Education Act of 1965, Title III ($56,474) and Title V ($21,900); Educa-

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***For further information about the experiment contact ATS-1 Project Director, 650 International Airport Road, Anchorage, Alaska 99502.**

tion Professions Development Act, Part D ($15,615); and Manpower Development and Training Act ($300,000 administered by the Office of Education). In addition to the operation of the ATS-1 satellite, NASA is providing financial support ($35,000) for systems studies. And additional support of $274,000 came from HEW's Lister Hill National Library of Medicine."[14]

The State of Hawaii Satellite Experimentation[15]

Hawaii has a very successful satellite experiment underway called the Pan Pacific Education and Communication Experiments by Satellite (PEACESAT). Using the ATS-1 satellite, the experimental project ties together selected educational institutions in the Pacific basin in order to provide experience and knowledge that will be useful in the design of future educational telecommunication systems. The three general objectives of the PEACESAT project are:

1. to increase the quality of education in the Pacific by facilitating the sharing of scarce, costly resources;
2. to improve professional services in sparsely populated areas through telecommunication support; and
3. to assist in applying the potential of satellite technology for peaceful world development.

Operations began in April, 1971, tying together the University of Hawaii's Hilo Campus on the island of Hawaii, and the Manoa Campus on the island of Oahu, using university-constructed earth terminals. It was expanded in January, 1972 to an international network. Thus far, the system includes the Hawaiian colleges and University; the University of the South Pacific in Suva, Fiji; Wellington Polytechnic in New Zealand; the Department of Education, Pago Pago, American Samoa; Papua New Guinea Institute of Technology, Lae, PNG; University of South Pacific Centre, Nuku'alofa, Kingdom of Tonga; and Saipan and Truk in the Trust Territory of the Pacific Islands.

The satellite is available 12.5 hours a week to relay voice and facsimile signals to and from each site, with slow-scan television and teletype signals transmission reserved for selected locations.[16] The format and content of information exchanges are determined by the users. More specifically, the Hamilton Library on the Manoa Campus of the University of Hawaii uses the system to demonstrate exchange of materials with Hilo College, the University of the South Pacific, and Wellington Polytechnic. Doctors of the Pacific Research Section of the National Institutes of Health consult with doctors of the Bethesda, Maryland, National Library of Medicine. The Hawaii Agricultural Experiment Service uses the system to conduct seminars with its offices and agents throughout Hawaii. In addition, the system has been used effectively in marine research, teacher education, and international student debates.[17]

The communication network is made possible by small, inexpensive ground terminals designed and developed at the University of Hawaii. The two types of terminals cost approximately $1,500 and $7,000. Eleven or more such terminals are used in the network, with each educational institution providing its own operational staff; furthermore, each institution has its own staff to develop exchange programs.

The project, which is administered by the University of Hawaii under the Governor's Committee on Pan Pacific Educational Communications, was initiated with a grant from the University of Hawaii's Innovative Program. In April of 1971, the state legislature appropriated $75,000 for the project. In April, 1972, the National Library of Medicine provided the project $50,000 to develop a medical

network in the Pacific, incorporating demonstrations of library and professional exchanges.

The project is an excellent example of what a university and a state have done and what others can do to learn about satellite technology and its potential application without major Federal assistance or large sums of money.*

The Stanford University-Brazilian Experiment[18]

The Stanford-Brazil experiment is part of a three-phase Brazilian plan aimed at gaining the appropriate skills, knowledge, technical expertise, and the training of key personnel in preparation for its own domestic satellite to be launched sometime during the mid-1970s. Phase I, which involves the reception of selected voice, slow-scan, and teledocumentation broadcasts from Stanford University and the transmission of Brazilian cultural programs to Stanford via the ATS-3, is discussed here; Phase II is discussed later in the chapter.

The experiment has three general objectives:

1. to test equipment;
2. to train personnel; and
3. to determine the value of exchanging educational programs.

The experiment began in January, 1972, and all transmissions and receptions are confined to the two institutions; the information is being exchanged from three to six hours a week, with actual use of the system for education programs being initiated with the Stanford University 1972 spring semester. The voice element provides two-way communication capability and is being used for seminars and lectures; the image element provides for one-way communication where video signals in slow-scan form are received from Stanford and are projected on a special screen with a telebeam projector; the teledocumentation element provides communications where documents are transmitted and received using special equipment developed by Xerox Corporation. This also uses the slow-scan capability.

The earth segment portion of the experiment is under the control of Brazil and Stanford University;** however, NASA manages the satellite. While no cost data are available, the fact that both institutions have their own earth stations and each is using existing software greatly minimizes the cost of the experiment.

FUTURE UNITED STATES EDUCATIONAL SATELLITE EXPERIMENTATION ***

The emphasis of educational satellite experimentation will shift to television in 1974 and 1975 with the ATS-F, a satellite configured to transmit powerful, highly directional television signals to relatively small and inexpensive ground receivers.[19] Two countries are planning major experimentation with the ATS-F, which is scheduled for launch in April, 1974;[20] they are the United States and India. Brazil is also planning to use the satellite while it is available for the

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*For further information, contact Director, PEACESAT, University of Hawaii, 2560 Campus Road, Honolulu, Hawaii 96822.

**For further information contact The School of Engineering, Stanford University, Stanford, California 94305.

***This section, an article by the author, appeared in *Educational Technology (c) Vol. 13, No. 8, August, 1973 pp. 46-52, and is entitled* "Future United States Education Satellite Experiments: The Rocky Mountain Region Experiment."

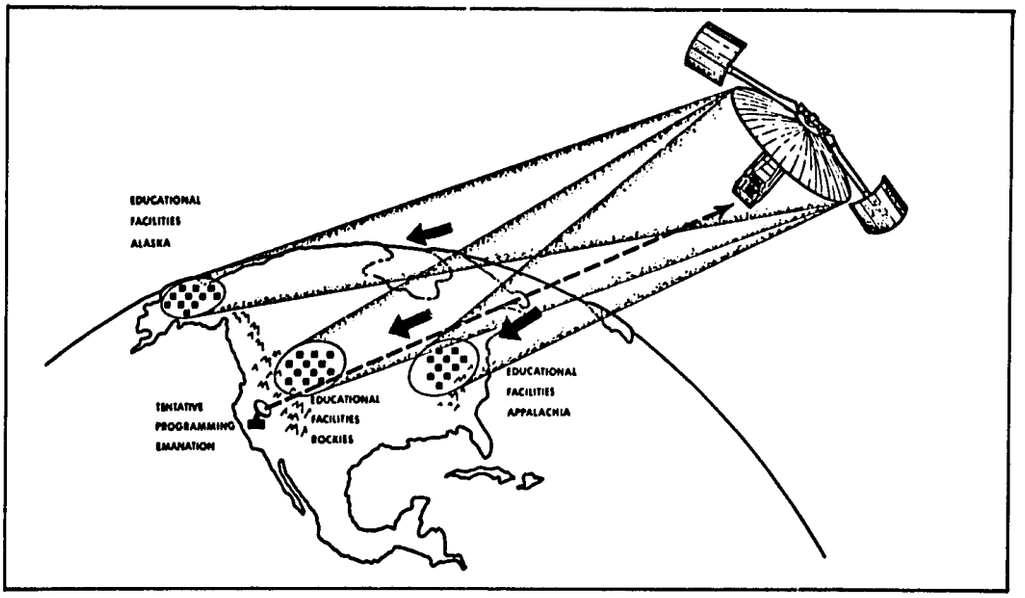
U.S. experiments, but on a limited basis. This agreement has been reached only recently.

The Indian Department of Atomic Energy (DAE) and NASA signed a Memorandum of Understanding on November 18, 1969 to conduct jointly an instructional/educational television experiment using the ATS-F.[21] Under the agreement, the satellite will be placed in orbit to cover a portion of the United States for approximately one year and then be repositioned for use by India.[22]

The proposed U.S. experiments are the result of the Applications Technology Satellite Program of the National Aeronautics and Space Administration of the United States, and efforts by the Corporation for Public Broadcasting (CPB) and the Department of Health, Education, and Welfare (HEW) to explore possible social improvements through the use of new technologies.[23]

With the advent of satellite technology, CPB conducted several studies to gain insights into problems that might be associated with "frequency allocation, interference and required transmission quality in addition to prototype design work on low-cost communication equipment."[24] At the same time, HEW was exploring the value of electronic communications relative to medical and educational services.[25] The results of these studies, along with past experience, promoted the planning of a joint medical-educational experiment to be conducted with the ATS-F system. Figure 14 illustrates the areas to be covered by the satellite.

Figure 14
Possible ATS-F Coverage Area U.S. Experiments



Rocky Mountain Federation Experiment*

As a consequence of the NASA-HEW-CPB effort, the Federation of Rocky

*The information contained herein reflects the status of the experiment as of early 1973. To obtain more current information about the experiment contact Director, Educational Technology Experiment, Suite 300B, 2480 W. 26th Avenue, Diamond Hill, Denver, Colorado 80211.

Mountain States, Inc., submitted a proposal for experimentation with the ATS-F satellite that eventually resulted in a series of planning documents which described the Rocky Mountain region's requirements for the use of a broadcast satellite; this led to a $500,000 planning grant from the Office of Education which was awarded early in 1972.[26]*

Objectives

The major portion of the educational experiment is scheduled to concentrate on remote areas and emphasize early childhood education and career development.

The general objectives of this portion of the experiment are:[27]

1. to aid a child's social, intellectual, physical and emotional development by providing training to regular and foster parents, early childhood center personnel and day care home personnel; and
2. to aid adolescents in making career decisions by providing them with social and career information necessary for sound career decision making.

The Experiment

The experiment is scheduled to begin in the spring of 1974 and last for approximately one year, with the satellite relaying educational programs directly to schools, and learning centers; and to cable television head ends and broadcast stations for redistribution.** Target sites are to receive the signals using a newly designed 10-foot diameter parabolic antenna. The satellite is to be configured to relay audio, video and digital (maximum two TV channels with four audio channels each) signals in the newly-allocated 2.5-2.69 GHz band using two focus feeds or boresights.[28] The media mixes to be used are "one-way video, one-way audio/digital; one-way video, two-way audio/digital; two-way video and two-way audio/digital."[29]

Figure 15 provides an example of a signal field that is possible in the Rocky Mountain region with the satellite at 94°W longitude. The transmission of signals to the other two experimental areas (Alaska and Appalachia) will require a boresight shift.*** However, shifting the focus of the satellite so that one of the other two experimental areas can receive signals will take approximately twenty minutes.[30]****

The groups which are to be involved in the experiment are within an eight-state region — Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Utah and Wyoming — and include Indians, Chicanos, Blacks and Anglos.[31] The target groups are to represent the urban and rural areas and include reservation domiciled Indians and migrants.[32] The purpose is to provide educational services to areas that have not been served, or that have been served inadequately in the past by such services.

Sixty sites located throughout the eight-state region are to be used for the experiment.[33] The target audiences are to be composed of individuals with different cultural and ethnic backgrounds, who are either adults involved with preschool

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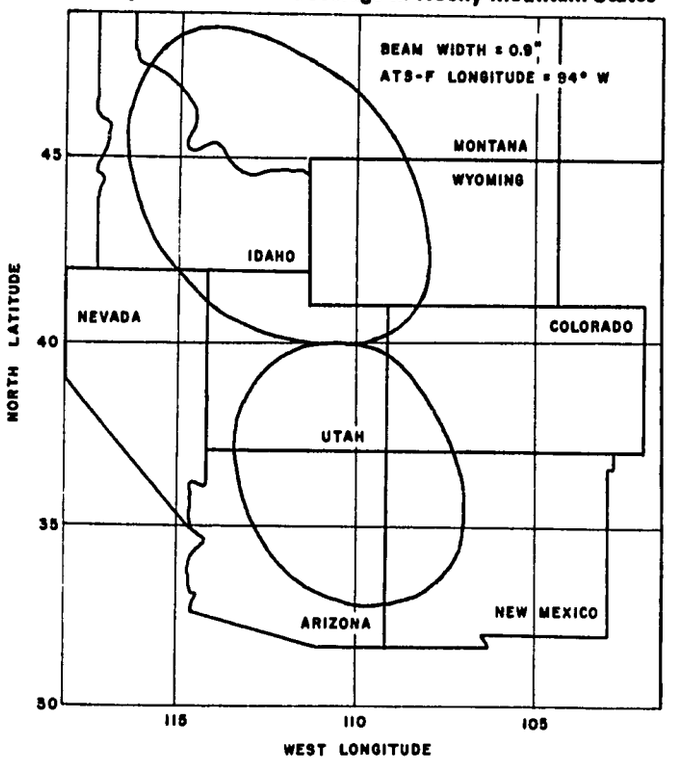
*No discussion of the medical portion of the experiment is provided here. For information, contact Director, Lister Hill National Center for Biomedical Communications, Bethesda, Maryland 20014.

**The Satellite was orginally scheduled for launch in 1973 but was changed to 1974.

***Large receivers, of INTELSAT quality, will be able to pick up all signals from a weak global (C Band) beam that is to be transmitted from the ATS-F.

****The ATS-1 and ATS-3 may be used in conjunction with the ATS-F to execute the experiment.

Figure 15
"Footprints" of ETV Coverage in Rocky Mountain States



SOURCE: *NASA, The ATS-F and G Data Book,* Greenbelt: Goddard Space Flight Center, (October, 1971), p. VII-37.

children or adolescents with a personal interest in choosing a career.[34] There are to be two basic cultural/linguistic population categories:[35]

1. *Specific* — all members share the same cultural and ethnic identity with (a) English as the sole or primary language or (b) a language mix with little or no English spoken.
2. *General* — not all members share the same cultural and ethnic identity, but all speak and understand English at a functional level.

There are to be fifty General and ten Specific sites which are to be divided equally between urban and rural areas.[36] The satellite is to provide thirty of the General sites with a one-way video and a one-way audio/digital media mix; an additional ten will receive a one-way video and a two-way audio/digital, and the remaining ten sites are to receive a two-way video and a two-way audio/digital media mix.[37] The ten Specific sites are to receive a one-way video and a two-way audio/digital mix.[38] It has been estimated that approximately 300 broadcast hours[39] are to be used to achieve the desired outcome.

During the course of the experiment, the Federation will attempt to find the answers to such questions as:[40]

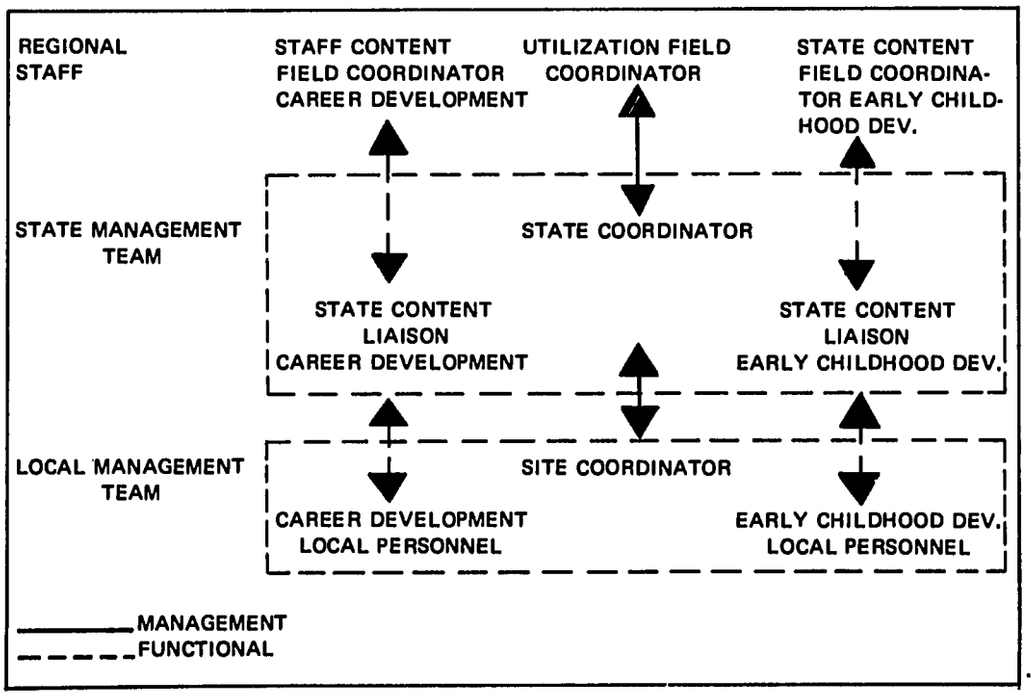
1. What degree of learning is facilitated in each target audience by the various media mixes, associated programming and support patterns?
2. Which media mix, associated programming and support patterns solicited what degree of participation by the various target audiences?
3. What are the costs associated with questions 1 and 2, and what are the implied cost-effective alternatives and tradeoffs?

Experiment Management

The experiment is primarily under the control of the Federation of Rocky Mountain States, an organization created in 1965 to represent the educational, economic and other social interests of the region.[41]* It is responsible for the design, development, execution and evaluation of the experiment. HEW's Office of Telecommunications Policy is the national coordinator; the National Center for Educational Technology, (NCET), Office of Education, is providing guidelines and financial support for the project; the Lister Hill National Center for Biomedical Communications is responsible for the medical portion of the experiment along with providing some of the hardware. NASA is providing for the construction and launching of the ATS-F, and its Office of Space Science and Application has been providing technical advice about the communication capability of the satellite, receiver requirements and so on.[42] In addition, NASA is coordinating the time allocations for the other 23 scientific experiments[43]** scheduled for the satellite.

To ensure the involvement of key organizations and personnel and the coordination of their efforts, the Federation plans to establish a tri-level management and participation structure, which would include regional, state and local components.[44] As Figure 16 shows, at each level there is to be an early childhood

Figure 16
Field Support Management Structure



SOURCE: Federation of Rocky Mountain States, *Abstract of a Proposal: Educational Technology Demonstration Federation of Rocky Mountain States,* Denver: Submitted 1972, p. 25.

*Nevada and Arizona do not belong to the Federation.

**For more information about other experiments, see *The ATS-F and G Data Book* published by the Goddard Space Flight Center, Greenbelt, Maryland 20771.

and career development element responsible for all content activities associated with their respective areas. The Site Coordinators are to be responsible for such things as local involvement, the match of program content to audience, logistics needs, the efficient and effective use of instructional and other materials, project monitoring, and data collection.[45] State Coordinators are to be responsible for guiding and supporting the experimental activities of sites within their respective states, as well as serving as a communication interface between individuals, agencies, organizations and so on within and outside of their state.[46] While they are to be the chief decision-makers for their respective states, their decisions may be reviewed by the regional staff.[47] At the regional level, the Utilization Field Coordinator is to be responsible for the coordination of the total experimental effort, ensuring that there is no unnecessary duplication of effort or expenditure.[48] Some of his main activities are to be the coordination and provision of support for the design, development and functioning of the delivery and communication systems; the design, development and testing of software; the recruitment and training of personnel; the design, development and implementation of a data collection system, and the evaluation of the results of the experimentation.[49] Therefore, it is through this field-support structure that the Federation hopes to minimize its problems and maximize communications on the way to achieving the objectives of the experiment.

*Software**

Each content area is to be responsible for its own software development, working within the context of its respective objectives. Initially, a needs assessment is to be conducted and behavioral objectives structured accordingly. Based upon this information, programs are to be developed taking into account the media mixes available for information dissemination. A software feedback and revision loop is to be built into the system so that software can be developed, tested, used, evaluated and revised before and/or during the experiment.[50]

It has been estimated that approximately three hundred, 45-minute programs[51] may be required to meet early childhood and career development needs, one hundred and fifty for each learning area. An additional three hundred 15-minute programs have been estimated for adult orientation.[52]

As was noted above, the early childhood content is to be geared to an adult population, those who care for preschool children, emphasizing how to "facilitate and enhance" the physical, social, emotional and intellectual development of preschool children.[53] Tentative adult behavioral objectives have been developed and are in the process of being refined so that programs and supplementary materials can be modified or developed for field testing.[54] Some software may be available from Head Start, Early Childhood Development and other such USOE programs. Care II, a computer program, is an example. It was developed to aid early childhood teachers develop teaching strategies and techniques.[55] However, a number of these training materials would probably need to be modified to match Federation objectives and the language requirements of the target audience.

Television is to be the main medium supplemented by and coordinated with radio, computer and printed materials. Additional support is to be provided by "on site" personnel such as the Site Coordinators. While formal programming

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***Most of the TV and radio programming is to be developed under the management of the FRMS's Telecommunications Council by CPB and KRMA-TV in Denver, Colorado; the University of Utah and KBTU-TV, Provo, Utah; and the University of New Mexico and KNME-TV, Albuquerque, New Mexico.**

may consume a considerable portion of the satellite time, thought is being given to permitting two-way audio and/or video demonstration and discussion.[56] For example, the interactive video system may be used for adults in remote sites to demonstrate what has been learned, and permit immediate feedback about their performance from Denver, Colorado. Additionally, the two-way communication capability may be used for sites to have general discussion or to address specific problems with experts.

The Career Education-Development area may be comprised of four or more content components which would, among other things, (1) create an awareness and understanding of work in society; (2) provide insights into how individuals select occupations; (3) provide information about and some experience with various occupational fields; and (4) indicate the employment opportunities in the Rocky Mountain region.[57]

Television is to serve as the main medium supported by the computer through Computer-Assisted Instruction (CAI); furthermore, Educasting* may be used.[58] The television programs would provide basic information relative to occupational fields, e.g., agribusiness, natural resources, public service. CAI may be used to provide interactive programs that would permit students to explore occupational fields, and associated employment opportunities, plus provide some instructional programs.[59] The Federation may use the Educasting system so students can receive programmed instruction, coupled with audio and printed materials, to explore various occupational fields.

Obtaining computer programs appears to be no major problem since a considerable amount of work has been done in the career field. Career orientation programs for testing and counseling are available from sources such as the Honeywell EDINET System and the Pennsylvania State University CAI Laboratory.[60]

Additionally, the *Index to Computer-Assisted Instruction* lists numerous thoroughly tested programs for career guidance.[61] But, all CAI interactive programs are in English and may have to be modified for the various language audiences.[62]

Much remains to be done before the experiment; the most useful, existing programs must be selected and modified and original programs must be developed, and all must be field tested. Additionally, related supportive software such as manuals, books, tests and so on must be designed, developed and also field tested.

Evaluation

Evaluation considerations were originally provided to the project by Arthur D. Little Corporation, and these guidelines eventually led to a concerted effort on the part of NCET to ensure that a well-thought out planning effort take place prior to the experiment. This culminated in a grant to Stanford University to provide assistance to the Federation of Rocky Mountain States in developing an operational and evaluative plan that would take into account all the components of the experiment that needed to be thoroughly evaluated.[63]

More specifically, the Federation is to be responsible for the internal formative and summative evaluation, while Stanford is to be the external evaluator.[64] However, Stanford and the Federation are working together to develop an overall project plan including measurable objectives which are to serve as a basis for

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*Educasting is a programmed student response learning system, and in its simplest form requires five separate audio channels. For example, one channel can be used to present lecture material and the remaining four channels can be used to provide multiple choice testing of the students during the lecture.

operational decisions and both types of evaluation.[65] In the content areas, the Federation, with the aid of Stanford, is to define software development objectives also to be used for formative and summative evaluation; finally, Stanford has the sole responsibility for the administrative history of the experiment.[66]

While the effectiveness of the hardware and its implications for a U.S. domestic satellite system may have to be determined, the major thrust of the evaluation is to be centered around the effectiveness of the various media and associated software relative to the diverse audiences taking part in the experiment.

To ensure that the appropriate evaluation takes place, Table 7 shows that an experimental design dividing the fifty General sites into ten primary sites,

Table 7
Tentative Rocky Mountain Experimental Design

CULTURE-ETHNIC	USER SUPPORT SERVICES						NUMBERS OF SITES			MEDIA MIXES
	Low		Medium		High		Primary Sites	Matching Sites Per Primary Site	Total Sites	
	Rural	Urban	Rural	Urban	Rural	Urban				
GENERAL	X	X	X	X	X	X	6	5	30	one-way video one-way audio/digital
					X	X	2	5	10	one-way video two-way audio/digital
					X	X	2	5	10	two-way video two-way audio/digital
SPECIFIC					X	X	10		10	one-way video two-way audio/digital
							TOTAL		60	

Adapted from: Federation of Rocky Mountain States, *Abstract of a Proposal: Educational Technology Demonstration Federation of Rocky Mountain States,* Denver: Submitted 1972, pp. 15-17.

each having five matching sites, may be used; major emphasis is to be placed on the one-way video and one-way audio/digital mix. The matching concept is to be used to permit the use of site summary or individual data and help to guard against internal and external validity problems. None of the ten Specific sites are to have matching sites because of, among other things, the audiences' diverse characteristics which make matching an extremely difficult, if not an impossible, task.[67]

The Federation is aware of the difficulties and problems of setting up, conducting and evaluating the experiment; consequently, model or prototype sites are to be established and are to serve as field test facilities prior to and during the experiment. These sixty sites are also to be selected in accordance with the design delineated in Table 7, and they are expected to yield information that would permit adjustments and/or corrections in plans, programs (software), procedures, personnel and hardware, prior to and during the experiment.[68]

A key ingredient in the experiment will be the populace. Without their participation in and support for the endeavor there will be no chance for success. Therefore, a priority item in the field test period is to be the determination of means to create favorable awareness, acceptance and participation. Interviews and surveys are to be used to measure public acceptance and variance in participation, either as a supporter or target audience.[69]

The formative and summative evaluation approach described above is extremely important in an undertaking as extensive as the one being planned for the Rocky Mountain region. However, while all of the above steps are being taken to

ensure a successful experiment, the fact that the satellite is to be available for U.S. experimentation for roughly twelve months beginning in late spring could contribute considerably to experimentation and evaluation problems.

Experiment Costs

Excluding hardware, the estimated three-year cost is approximately $13 million,[70] but the actual cost, in large part, will depend upon the required amount of receiver hardware, hours and types of software required, personnel requirements, and the depth and scope of evaluation. The following discussion touches only briefly upon some of these costs since a total cost accounting was not available at the time of this writing.

Total receiver cost is difficult to determine because it is dependent upon the number of sites to be used and the number of locations within sites to be involved; furthermore, the actual price of the antenna-adaptor is in question since it is still in the R&D stages. However, an estimate of $2,000* has been made for approximately 300 receive-only receivers.[71] Based on these figures, receiver costs would be in the neighborhood of $600,000. The hardware cost for an installation that will receive television, and receive and transmit voice and digital information, plus serve as a rebroadcast facility, has been estimated at $13,600,[72] but the number to be used still remains to be determined.** Additional costs would be associated with modification of Public Broadcasting Network (PBN) stations for use in the experiment, plus providing a large, Rocky Mountain earth station to receive and transmit signals; the station could cost anywhere from $200,000 to $1.5 million.

Program production costs could be quite expensive. Table 8 illustrates educational television software production costs in various areas of the world as well

Table 8
Some Instructional Program Costs
(dollars/hour)

Program or System	Cost
El Salvador	$1,300
Nippon Hoso Kyokai, Japan	2,500
Bavaria	12,000
Samoa	2,300
U.S. Costs:	
PBS, in general	40,000
"Sesame Street"	48,000
"World Press Review"	4,500
"The Advocates"	50,000
"The French Chef"	17,000

SOURCE: Daniel C. Smith and James M. Janky, "Direct Broadcast Satallites" in *A Direct Broadcast Satellite for Education in Africa*, Stanford University, (February, 1973), p. 131.

*In lots of 5,000 units, Hewlett Packard has estimated the cost to be $800 per unit.

**The receiver costs do not include installation, maintenance, housing, power, etc.

as for specific programs. For example, if original materials of "Sesame Street" caliber were developed, 150 program hours would cost $7.2 million. However, program modification costs have been estimated at about $200 per minute[73] or $12,000 per program hour. Assuming that there are 150 program hours of modification, the cost would be $1.8 million. But the actual cost will depend upon the extent and type of program modification needed, and this will depend upon the nature of the original program and the intended audience. An additional cost may be the use of multilinguistic supplementary materials that would be used in conjunction with the television programs. Finally, software pilot-testing costs must be added. Given modifications in computer and other software, costs could well exceed $3 million.

Personnel costs for the first 18-24 months were originally estimated at approximately $775,000,[74] but this figure appears to be low due to the fact that eight states are to be involved with an estimated 120* sites. This will require a considerable number of personnel, many with specialized skills. Consequently, the magnitude of the experiment in terms of sites involved, training needs, hardware management-maintenance, and community involvement, among other things, will dictate personnel requirements and associated costs, and many of these decisions still remain to be made. Therefore, personnel costs probably could be in the neighborhood of $2.5 million.

Evaluation may cost from $400,000 to $600,000.[75] An initial grant of $100,000 has been awarded to Stanford University to aid the Rocky Mountain Federation in developing a comprehensive evaluation plan.[76] The uniqueness of the experiment and its implication for future systems demand a careful in-depth evaluation. If properly executed, the evaluation of the experiment will probably cost more than a-half-million dollars.

The Alaskan Educational Telecommunications Consortium Experiment**

Alaska is the only proposing ATS-F experimenter with previous experience in satellite experimentation.

Although limited in nature, the ATS-1 experiment has provided Alaskans with invaluable experience, which is now being put to use in planning for the ATS-F. From the experience, they found that three factors are critical for success:[77] extensive planning, involvement of community members and teachers in the planning, and a sufficient quantity of high-quality programs.

Using this experience and information from a study[78] sponsored by NCET that explored the potential of telecommunications and educational technology in solving some of Alaska's educational problems, the Alaskan Educational Telecommunications Consortium (AETC) under the direction of the Office of Telecommunications, Office of the Governor, is developing a plan for a unique and innovative experiment which will determine the value of a satellite information distribution system like the ATS-F in meeting some of Alaska's pressing communication needs. And, there are many such needs — Alaska is *communications poor*.

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*There are to be sixty pilot-test and 60 experimental sites.

**The information and data for this section are based on 1972 and early 1973 documents. For more current information contact the Satellite Experiment Coordinator, Office of Telecommunications Policy, Office of the Governor of the State of Alaska, Juneau 99801.

The Setting

The population of Alaska (302,172)[79] is scattered over an area larger than the northeastern part of the forty-eight contiguous states. More than 50,000 live in areas where there is no year-round land transportation, and another 50,000 or so live where waterways serve as their only route of transportation.[80]

One hundred and seventy-five villages contain about three fourths of the native population (52,000 — mostly Eskimos, Indians and Aleuts), of which the majority have no roads or railroads that interconnect them or provide access to the major communities.[81] Boats, aircraft, snowmobiles or dog sleds serve as their mode of transportation and shortwave radios as their mode of communication, but at times communications are severely curtailed by adverse atmospheric conditions.[82] Consequently, most natives are far from being an integral part of the political, economic, and social fabric of Alaska.

A closer look at the life of the natives reveals some startling facts:[83] Most adults have little or no formal education — in the main, the local educational system provides schooling only through the sixth grade; primitive subsistence practices prevail with limited monetary income provided through public assistance and seasonal employment; and information from the world outside of the villages is minimal.

In addition, Alaska as a state has the highest accidental death rate and the highest per capita alcohol consumption of any state, has the sixth highest homicide rate, and also ranks sixth in forcible rape.[84] Here it must be remembered that the total population of the state is involved in these statistics; *not* just the natives.

The urgency of reaching the natives with the education and information essential to their growth and integration into modern Alaskan society has been heightened by the 1968 discovery of oil in the Prudhoe Bay area and the United States Government's enactment of the Alaska Native Claims Settlement in 1971. These two factors alone can have tragic implications for the Alaskan natives if they are not prepared to deal with the people, problems, and politics that are bound to accompany such a boon.

Objectives

The general purpose of the educational portion of the experiment is to determine those communication services that are desirable and will meet the educational needs of the populace by exploring some of the alternative services that can be provided by broadcast satellites such as the ATS-F.*

There are to be five experimental areas, aimed at determining the value of and problems associated with:[85]

1. providing training and consultation opportunities for remote area teachers, and providing students and adults with culturally relevant curricula and information;
2. providing interactive health education programs to children, adults and paraprofessionals;
3. assisting classroom instruction by using a computer-linked teletypewriter;
4. delivering television programming defined to be relevant by the Alaska native viewers; and

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***The ATS-1 may be used in conjunction with the ATS-F for the Alaskan portion of the experiment.**

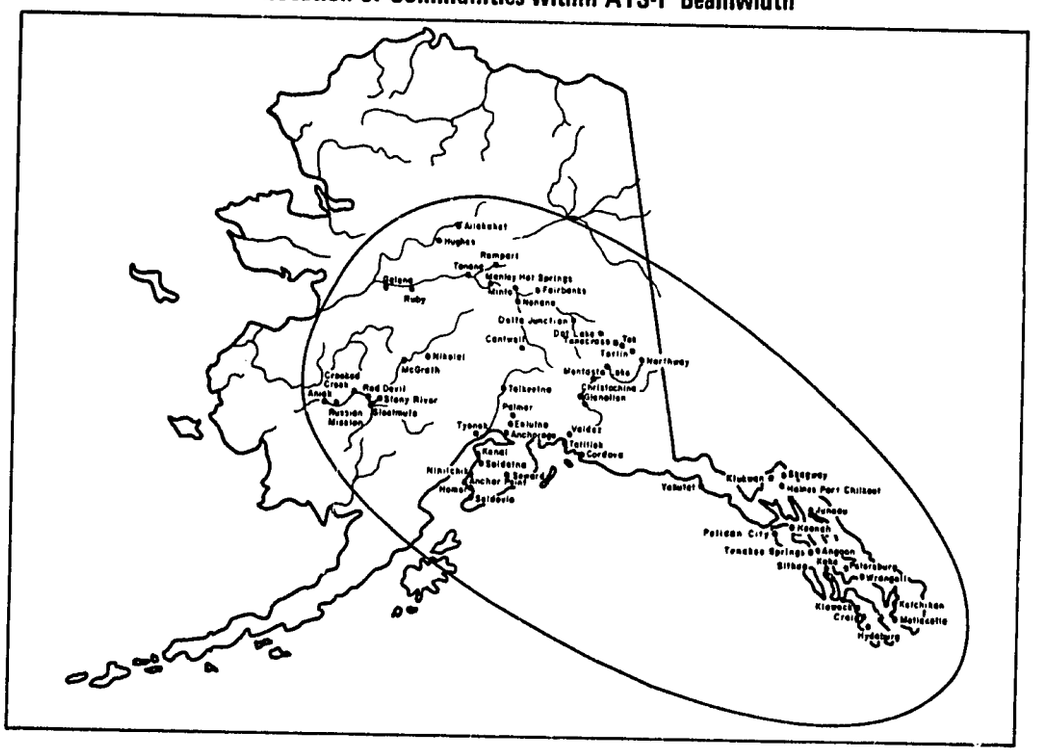
5. transmitting real-time public broadcasting programming from the lower 48 states to Alaska and vice versa.

These objectives are based on needs that have been identified by the rural residents.

The Experiment

The Alaska experiment is scheduled to begin at approximately the same time as that of the Rocky Mountain Federation and to last for about eleven months, addressing those communities where Eskimos, Aleuts, and Indians are the main inhabitants. However, the villages to be involved are to be limited by the ATS-F signal pattern. With a geostationary orbit location at 94° W longitude, a long, narrow signal pattern will be produced. Unfortunately, as Figure 17 indicates, only 63 out of 265 communities can be covered by this pattern — and these

Figure 17
Location of Communities Within ATS-F Beamwidth



Adapted from: Alaska Educational Broadcasting Commission, *Alaska/ATS Health/Education Telecommunications Experiment Program Plans*, Anchorage, (December, 1970), p. 10.

are not necessarily representative of remote Alaskan communities. Nevertheless, 17 communities have been selected to participate in the experiment.[86] Fairbanks, Juneau, and Anchorage are the key receive-transmit locations. Fairbanks is to service Allakaket, Galena, Minto, and Nenana; Juneau is to provide services to Angoon, Craig, Petersburg, and Yakutat; and Anchorage will service Aniak, McGrath, Nikolai Russian Mission, Sleetmute, and Valdez.[87]

Of the 9.5 broadcasting hours to be used, 5.5 are to be allocated to the educational portion of the experiment and will consist primarily of one-way video and two-way audio transmissions.[88] This is to include health education. It should be noted

that provisions for in-service training are included in each experimental area.

The instructional programming experiment is to satisfy the requirement of the first objective noted above. It is to focus on four audiences: teachers, students, pre-school children and adults, and is to take up 2.0 hours of the weekly broadcast time. There are to be four parts to this experimental area: two parts are to concentrate on pre-school children, emphasizing the development of their English language skills; another is to permit inter-cultural exchanges between junior high school students; and the fourth part is to provide in-service training for teachers and their aides.[89]

The interactive health education component is to use 1.0 hour of program time per week, concentrating on administrators, teachers, aides and students.[90] The topics to be treated are sex, drugs, health and sanitation.

No time has been specified for the CAI portion of the experiment.[91] Nevertheless, CAI is to be used to teach math and language skills to students in grades 1 through 6, and prepare adults and high school dropouts for the high school equivalency examination. Two teletype terminals are expected to be installed at each of six sites.[92]

The viewer-defined programming service is to take up 1.0 hour of program time a week, and is to be designed and managed by the natives.[93] It is to explore the feasibility of consumer-determined and consumer-controlled programs.[94] This unique service is to revolve around a program entitled "The Alaska Native Magazine."[95] Once a week the service is to provide interactive audio and video programs with built-in "pause points" to permit viewers to express opinions, ask questions, and suggest additional topics to be covered.[96] This information is to be used for the development of future programs.

The Public Broadcasting System (PBS) and National Public Radio (NPR) service is to provide "live" radio and television programs to Alaska. Alaska is also to provide programs to the lower 48 states.[97] This is to take up 1.5 hours a week.

Currently, on occasion, live radio programs are received; however, live television from the lower 48 states is virtually nonexistent.[98] Normally, programs are taped and flown to Alaska to be rebroadcast; consequently, radio and television news programs from the rest of the states are delayed as much as seven or more hours and entertainment programs are delayed considerably longer.[99] Therefore, the purpose of this portion of the experiment is to determine. . . "the public reaction to live programming as contrasted to that received after delays of 12 hours to one month."[100]

Answers to the following four fundamental questions are to be sought from the five experimental areas:

1. How did the satellite technology enhance the quality of service previously provided by other means?
2. Are the new services provided via satellite desirable and useful?
3. Is there a relationship between service support broadcast time and target group achievement time?
4. Does a one-way communication capability have a different effect on the target group than a two-way capability?

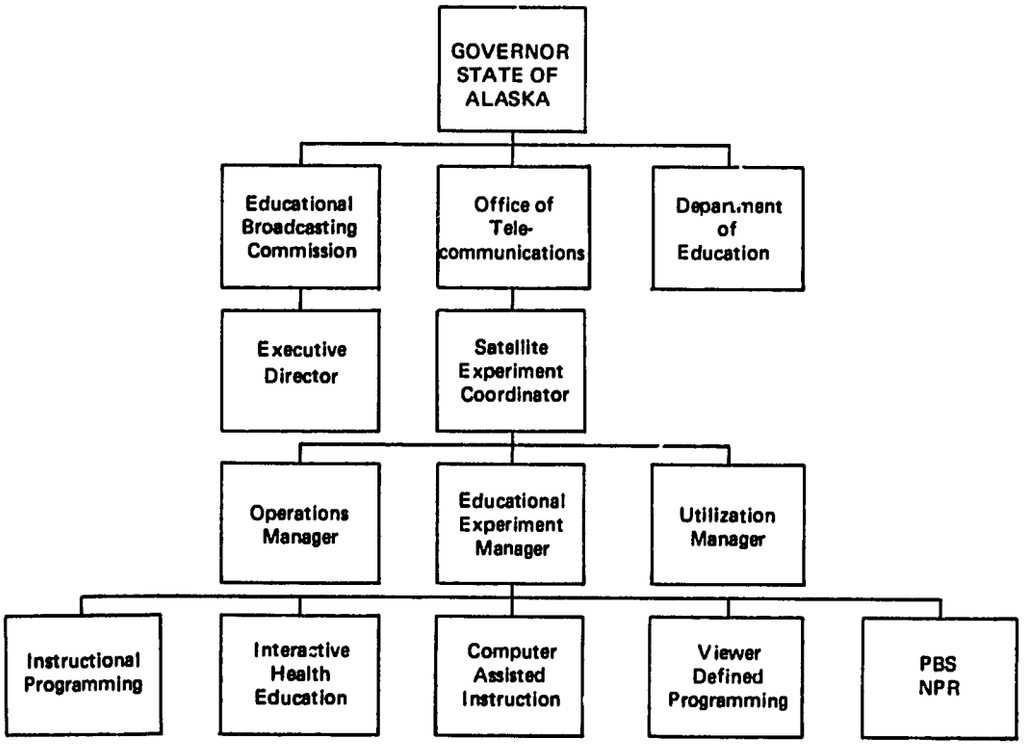
Experiment Management[101]

The Alaskan experiment planning and management rests mainly with the Office of Telecommunications within the Office of the Governor of Alaska. Some planning input comes from the Alaskan Educational Broadcasting Commission, a citizen group appointed by the Governor of Alaska. HEW's Office of Telecommunications

Policy, NCET and NASA are all playing similar roles as in the Rocky Mountain Experiment; Lister Hill is to provide financial help for the earth stations plus conduct the medical portion of the experiment, coordinating its activities with the organizations responsible for the educational experiments. And CPB is to provide aid for low-power transmitters, which are to be used to rebroadcast signals received at the earth stations, and help with the development of some of the software.

As Figure 18 depicts, there is to be a Satellite Experiment Coordinator responsible for the general design and associated planning for the experiment. Further,

Figure 18
Alaska ATS-F Program Organization



SOURCE: Office of Telecommunications, *"Alaska ATS-F Health/Education Telecommunications Experiment Program Revisions*, Office of the Governor, State of Alaska, (February, 1973), p. 39.

he is to serve as the key interfacing agent with outside entities coordinating their activities with those of the State. An Educational Experiment Manager is to work for the Coordinator and be more directly responsible for the operational activities, including operational planning, experiment execution, and evaluation of the results. Also responsible to the Coordinator will be a Manager for Utilization and a Manager for System Operations.

The use of a Utilization Manager is the direct result of the experience with the ATS-1 experiment where, in many instances, the populace was inadequately prepared to participate. For example, failure to involve local groups during the planning phase or to explain the purpose of equipment has plagued the experiment, resulting in few objectives being achieved. For each of the experimental service areas, the Utilization Manager is to be responsible for keeping individuals in the target sites informed about the experiment and ensuring their participation.

In addition, it is his responsibility to make sure that the software is properly used, plus making the results of the experiments known to the sites.

There are to be Field Representatives to help in carrying out the utilization functions. Each is to be responsible for overseeing the activities at a given number of sites; they are to know the language(s) and key personnel in their area of responsibility. In addition, each site is to have a part-time Community Assistant who is to see that services are provided as intended.

The Operations Manager is to be responsible for the ground segment or hardware component, which is to include planning for, installing, operating and maintaining the earth station and ancillary equipment. Moreover, he is to be the Alaskan liaison with engineering and broadcast personnel at the Federation of Rocky Mountain States (FORMS), NASA and others.

Each of the five service areas is to have a Project Manager who is to develop the detailed operational plan, mold a strong supportive organization, maximize the potential for success of the operational phase and aid in the evaluation.

Software[102]

As the discussion of the experimental areas indicated, there are to be a number of unique programming requirements which will preclude, to a great extent, the use of existing or prerecorded programs; in the main, the audio portion is to be spontaneous. The use of existing software is primarily to be associated with the CAI and interactive health education areas.

The computer programs which are expected to be used for CAI were developed at the Institute for Mathematical Studies in the Social Sciences, Stanford University, and provide mathematics and language arts lessons.[103] The mathematics program covers the complete range of elementary mathematics (grades 1-6), providing five levels of difficulty. The language arts program provides instruction in the basics of the English language. Both programs have been field tested, with the mathematics program having extensive use. The high school equivalency preparatory CAI program also exists and has been field tested; however, it is anticipated that the course materials of all three subjects will need to be adapted to the native culture.

The interactive health education programs are to address the. . . . "high rate of illegitimate births and VD; the spiraling drug abuse problems in rural as well as urban areas; the marginal health conditions of natives; and the lack of proper health and sanitation knowledge and standards in rural and isolated areas."[104] Some of the programs that may be used are from a series developed by National Instructional Television and include: "All About You," a program for children which describes and explains the nature of human growth and development; "Inside/Out," also for children, which treats coping with social, emotional and physical problems; "Health: Your Decision," a program for teenage and adult audiences, providing facts and expert opinion about drugs, emotional stability and human sexuality. In addition to these programs, 36 hours of television programming are expected to be developed in Alaska and aimed specifically at indigenous health and sanitation problems.

The viewer-defined program experimental area is a unique undertaking and is to require original programs centering around timely issues, such as the Alaskan pipeline, and cultural activities such as native dances. This program, which is entitled "The Alaska Native Magazine," is to be hosted by natives, and they are to present thirty-minute television programs (video tape, live, films) that are to be broadcast to the villages. Viewers are to have thirty minutes of inter-

spersed response time to indicate their likes and dislikes and to make suggestions for new programs. The majority of the responses are to be audio; however, some video feedback may be used. This information fed back from the viewers is to be used in the development of programs for future weeks.

The PBS-NPR experimental area is primarily to concentrate on the transmission of programs to Alaska, with only occasional programming originating from Alaska. Consequently, the majority of the burden for programming is to be on PBS and NPR in Washington, D.C. This should pose no problem, since it is anticipated that regularly scheduled programs are to be used for the endeavor. Programs originating from Alaska may be original.

Programs for the instructional experimental area are to be original, with the in-service education part being primarily preparatory for use of the program and materials associated with the other three parts. Using the objects and activities associated with the home, the early childhood development programs are to concentrate on the form and structure of the English language. The studio set is to represent a home, and audience activities are to be the manipulation of objects, listening and oral responses. Programs are to be presented by teachers representing each of the native dialects.

The basic English oral communication skills part is to teach English as a foreign language in order to improve the production and conceptual ability of Alaskan native children in the English language. The program content is to concentrate on oral English language patterns through the use of dialogues, games, songs and other activities. The programs are to be concluded with an animated dialogue to reinforce the learning. Here also, teachers who represent each of the native dialects are to be used as program personnel.

The intercultural exchange part of the experiment is to afford junior high school students an opportunity to know something about their peers and life in other parts of Alaska. In communities where receive-transmit sites are to exist, community members and school faculty are to provide content from which students are to develop social studies units. The units are to portray community life in ways that are similar to and different from other Alaskan communities. Then students are to use the units to develop television programs which they are to produce, direct and narrate; programs are to be exchanged the last 18 weeks of the experiment. This part, as well as the other parts of the instructional programming experiment, is to provide a two-way audio link to permit teachers and students to interact with personnel at the originating site.

The Alaskan programming effort should be watched closely because an attempt is to be made to determine some of the unique services that communication satellite technology has to offer. Creative efforts such as these must continue, if the value and place of the technology are to be determined and capitalized upon.

Evaluation[105]

Action research is to be emphasized and formative rather than "product" evaluation is to prevail. Consequently, throughout the experiment a continuous feedback of information is to be provided so that problem areas can be identified and adjustments made accordingly.

During the course of the experiment an effort is to be made to determine the receptivity of the various audiences to the programs, the effectiveness of the interactive audio transmissions, and the effects of the programs' content

on the audiences. Comparative analyses, for example, may be made between one-way audio-video versus one-way video and two-way audio; real-time versus delayed video; and limited coverage audio-video versus wide-spread coverage audio-video.

It should be noted that the diversity of the audience (Eskimo, Aleut, Indian), its small size, and the fact that it must be selected from a geographic area dictated by the ATS-F footprint may limit the conclusions that can be drawn as well as the generalizations that can be drawn from those conclusions.

Experiment Cost[106]

The Alaskan experiment is expected to cost slightly over $1.67 million for the period January 1, 1973 to July 1, 1975. If the planning and preparation costs up to January, 1973 were included, the total cost of the experiment would probably come close to $2 million.

Table 9 summarizes the cost for each of the experimental areas, the program management, the educational experiment management, and the operations, utili-

Table 9
Estimated Cost For Alaska ATS-F Experiment

COST CATEGORY	ESTIMATED COST (THOUSANDS)
Program Management	$155.5
Educational Experiments Management	137.7
Instructional Programming	171.4
Interactive Health Education	127.1
Computer Assisted Instruction	155.8
Viewar Defined Programming	334.2
PBS/NPR	140.0
Operations	247.0
Utilization	166.6
Evaluation	36.0
Total	$1,671.3

Adapted from: Office of Telecommunications, *Alaska ATS-F Health/Education Telecommunications Experiment Program Revisions*, Office of the Governor, State of Alaska, (February, 1973).

zation and evaluation functions. The most single costly part of the experiment is to be the viewer-defined programming at $334,000; however, it is interesting to note that the least costly item is the evaluation effort — $36,000.

Looking at a more detailed breakdown of costs in these categories, personnel costs are to consume approximately $717,000 of the budget with approximately $221,000 going for equipment or hardware. Software production excluding labor is estimated at around $72,000; computer time is to cost in the neighborhood

of $15,000, communications are estimated at $65,000. The location of Alaska relative to the rest of the U.S., its size, and limited terrestrial transportation system can start to be appreciated by merely looking at the travel budget for the experiment — $178,000.

The Appalachian Region Experiment*

The Appalachian region experiment was the last to be initiated. In 1972 the United States Office of Education provided the Appalachian Regional Commission (ARC) with $45,000 to conduct a survey of needs and identify some fruitful areas for experimentation. With the aid of the Pennsylvania State University, and Washington University (St. Louis), ARC undertook the basic planning.

The Setting

The Appalachian region stretches over thirteen eastern states — from southern New York to northeastern Mississippi.[107] For decades many of the inhabitants have been held incommunicado from the rest of the world by the mountains. The area has been described as having "pockets of affluence amidst poverty."[108] Appalachia is a poverty-stricken area containing a large number of people who have inadequate food, housing, education and employment.[109] In the 1960s there were over 3,000,000 illiterate adults in the region.[110] Because they are uneducated and unskilled, finding employment is next to impossible and as a result, they become permanent wards of society depending on welfare to live. Further, parents do not encourage their children to stay in school. Consequently, the teachers, who are usually cut off from the mainstream of the educational community, have a difficult task.

Objectives[111]

The experiment is to concentrate on in-service education relative to career education and elementary reading. The objectives are:

1. to use and improve the effectiveness and reach of the Appalachian region's education service agencies for delivering quality in-service education programs, through the use of telecommunications and educational technology, to elementary and career education teachers;
2. to demonstrate the feasibility of improving classroom teaching techniques by providing hitherto nonexistent or improving the existing in-service programs in career education and elementary reading; and
3. to demonstrate the feasibility of directly involving the faculty and administration in the development of career education (K-12) and elementary reading curricula for use in their school.

The most important activities would appear to be the attempt to demonstrate the value of centralized educational program development and distribution, the development of a means for attacking and solving educational problems common to *several* states, and connecting satellite and terrestrial communication systems.

The Experiment[112]

The operational phase of the experiment is to begin in April, 1974 and last

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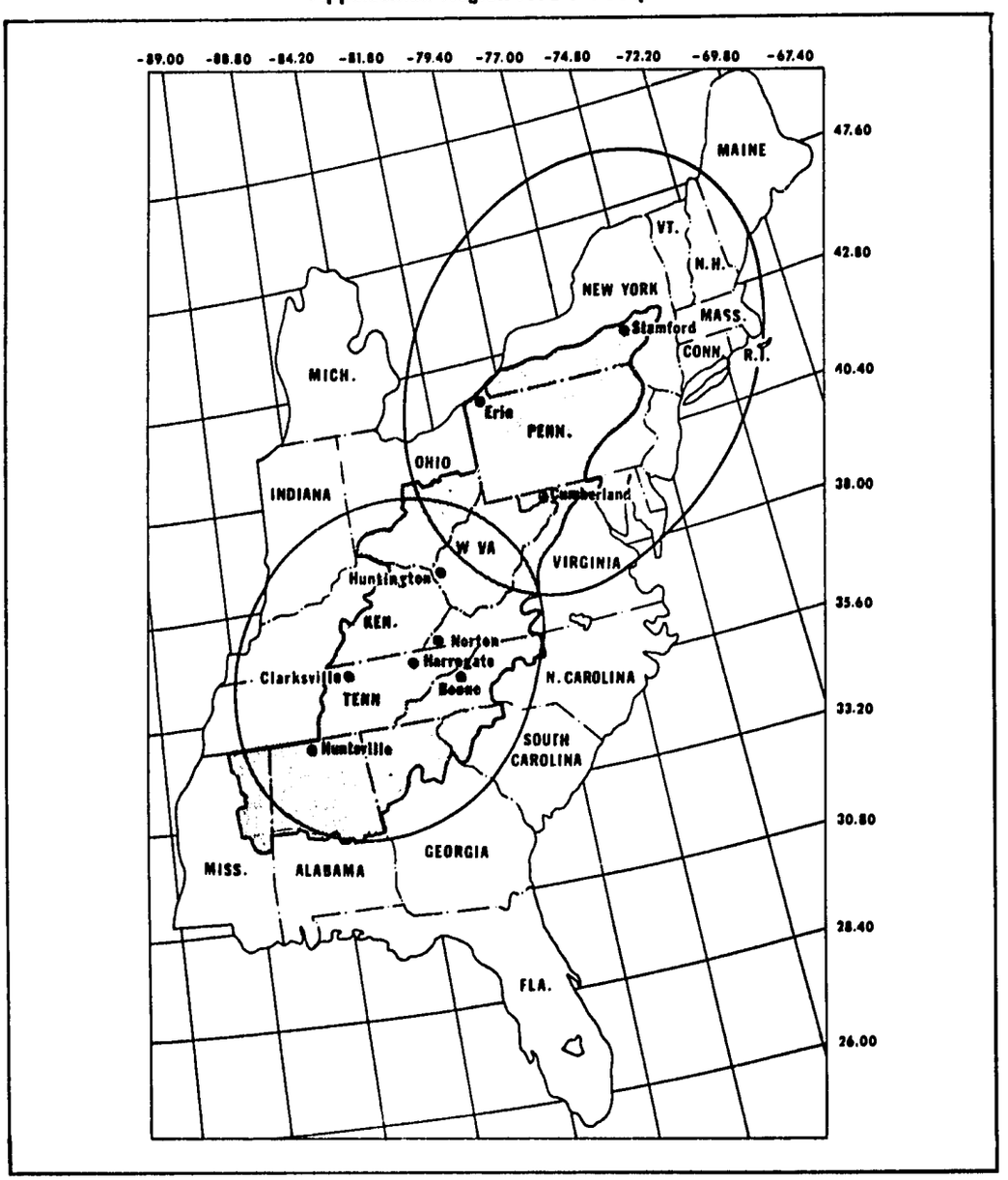
***Information in this section is based on early 1973 information. For more current information contact Project Director, Appalachian Region Satellite Experiment, 1666 Connecticut Avenue, NW, Washington, DC 20036.**

through June, 1975. As Figure 19 illustrates, the ATS-F footprint* is to cover the total Appalachian region, but the areas and individuals to be involved are to be limited by the Regional Education Service Agencies (RESA) to be selected to participate in the experiment and the limited number (possibly five each) of elementary and secondary schools that surround these sites. Five RESAs are to be selected from the following eight: Human Resources Program.

Figure 19
Appalachian Region ATS-F Footprint



Adapted from: Appalachian Regional Commission *Request for Proposal: Educational Component of the Appalachian ATS-F Experiment*, Washington, D.C., 1973.

*The ATS-3 may be used in conjunction with the ATS-F for the Appalachian portion of the experiment.

Huntsville, Alabama; Dilenowisco Education Co-operative, Norton, Virginia; Office of Federal-State Relations, Charleston, West Virginia; Rural Supplementary Education Center, Stamford, New York; RITEC, Erie, Pennsylvania; RESA of Maryland, Cumberland, Maryland; State Department of Education, Raleigh, North Carolina; Upper Cumberland Development District, Cookeville, Tennessee; and Clinch Powell Education Co-operative, Harrogate, Tennessee.

The media mixes to be used are primarily to be one-way video and two-way audio (digital), with approximately 100 hours of ATS-F time being allocated to accommodate these transmissions. Signals are to be transmitted to the ATS-F from a Resource Coordination Center (RCC) located in the region; RESAs are to receive the signals which in turn are to be retransmitted to the schools via cable, Wide-Area-Telephone Service (WATS) or other means. The schools are to serve as centers for educational activities. Using television, voice, computer and telecopy as the main communication modes, three basic in-service courses are to be offered: career education, occupational counseling, and reading.

Beginning June 1, 1974 and lasting for 3 months, teachers are to receive their initial in-service training in career education or basic reading. In both instances one-way video and two-way digital transmissions are to occur; the digital aspect, among other things, is to permit access to documents at the RCC and provide for the dissemination of supplemental materials to the experimental sites. Further one-way video and two-way audio are to be used to conduct live seminars in career education. Some computer familiarization work is to begin in the third month.

The last six months of the experiment are to be devoted to the continuation of in-service training, but with an expansion in the use of media and their applications. The computer is to play a major role during this period, along with Educasting. Computer terminals are to be located at each site for two-way communication with the RCC computer. The computer is to be used in the career education area to help the teacher determine and meet individualized student needs; one program is to help diagnose student needs and help develop associated curriculum study plans, and another program is to serve as a resource or data bank which is to provide information about the location (regional or national) of materials, etc., geared to the needs defined above. In addition, means for obtaining the materials are to be provided. The computer is also to be used to diagnose individual reading problems and to provide the teacher with prescriptions for overcoming them. Throughout the experiment, Educasting is primarily to be used as a programmed instruction tool.

Experiment Management[113]

The Office of Telecommunications Policy of HEW, NASA, and USOE are to be responsible for the same activities noted in the discussion of the other U.S. experiments; however, USOE is also to provide consultation on career education concepts, curriculum and programs. ARC has the overall management responsibility for the experiment and is developing the framework and guidelines for its conduct. Further, ARC is to select the RCC and RESAs, monitor their activities and serve as liaison with the Rocky Mountain Federation.

Major responsibility for the operational part of the experiment rests with the RCC. Among other things, it is to detail the objectives of the project; aid in the selection of the RESAs; produce, validate and distribute the software; establish and continue contact with RESA Coordinators and site teachers; and conduct the evaluation of the experiment.

The RESAs' primary responsibilities are to be the planning of their educational activities based on RCC software, selecting the individuals to participate in the experiment, executing the educational activity throughout the experiment, and aiding in the final evaluation. The RESAs are also to gain professional support for the in-service training program and secure approval for the participants to receive graduate credit.

The Federation of Rocky Mountain States is to be responsible for providing technical assistance to the experiment, aiding in the site planning and preparation, and providing the necessary personnel and information.

In order to reduce unnecessary duplication of effort, information exchanges are to occur between RESAs. Further, the exchanges are to be used to permit RESA Coordinators to seek solutions to common or unique problems, or provide ideas on how certain functions can be better performed.

Software[114]

The software requirements for the experiment are quite varied and are to consist of such things as computer programs, films, video tapes, slides and printed materials. While some software exists, a considerable amount will need to be developed to meet the objectives of the experiment.

The teacher in-service career education course is to provide teachers with the knowledge and skills necessary to incorporate the career topic into the curriculum. The software is primarily to consist of video tapes and supplementary materials, e.g., printed matter, films and games, and is to be developed by the RCC; some materials are to be available from the Federation. Once the lessons have been developed and scheduled, the video portions, and where possible the supplementary materials, are to be transmitted to the RESAs and then relayed to the schools. While the video portion is being used for class, it is to be recorded at the RESAs and stored for use in future in-service training.

The teacher occupational counseling course, which is to be broadcast simultaneously with the career education course, is to provide rural teachers with the capability to assist students in identifying the Federal and state financial assistance programs for which they qualify, and the postsecondary educational and vocational opportunities that exist within and outside of the region. Most of the programs for this course are to be original; however, some supplementary materials are available.

The reading course, which is to be broadcast at a different time than the above courses, is to provide the teacher with the knowledge and skills to attack the reading problem that is rife in the region. The program material for this course is to be based upon an in-service reading program developed by ARC and the New York State Department of Education in early 1970; however, some modifications are anticipated.

Three computer systems are to be used to support these courses, two of which focus on career education. The career education *diagnostic* system is a retrieval system which aids the teacher in planning individual vocational and academic curricula. The basic computer package that is to be used was developed by RITEC in Erie, Pennsylvania, and is known as VAULT. The career education *resource dissemination* system is to supplement VAULT by providing teachers with an annotated list of available and useful films, video tapes, books, pamphlets, and journal articles. Further computer programs are to be developed to match materials to student age, year in school, career education cluster and so on. Desired materials are to be ordered through the computer; they are to be transmitted

via the satellite or mailed. Some of the data for the dissemination system are to be provided by the Federation.

The primary education *reading diagnostic* computer system is to provide teachers with a tool to determine student reading problems and prescribing methods and materials for overcoming them. This system is to be based upon a computer program known as EDUTEK which was funded by USOE and developed in Nebraska. Taking into account student achievement, abilities and interests, the system provides the teacher with materials to improve the student's reading.

The Educasting system is also to be used to supplement the three basic courses by providing teachers with programmed instruction lessons, which are to sharpen their ability to help students make decisions about possible careers. Software to support the system is limited, so considerable original program development is anticipated.

The live career education seminar is to provide video programs from the RCC, to which teachers are to be able to respond during and after the presentation. The teacher feedback is to serve as the basis for the next week of programs. Consequently, a considerable amount of original programming is to be required each week.

The software requirements for the experiment are far from modest. Just the requirement for developing new and modifying old computer programs is a major undertaking. It may be difficult to develop and field test all of the software necessary for initiating the experiment.

Evaluation[115]

The RCC has the major responsibility for the formative and summative evaluation of the experiment. No definitive experimental design had been developed to date, but the RCC is to ensure that a comprehensive evaluation plan is designed to include a research methodology, data collection system, data analysis and documentation guidelines.

Throughout the experiment the RCC is to monitor the RESAs' activities, evaluate their progress and make recommendations for improvements. Specific attention is to be given to frequency and quality of participation, adherence to course and program scheduling and so on.

Participants in the in-service courses are to be evaluated during and at the conclusion of the two phases. Criteria developed by the RCC are to serve as the basis for RESA and credit-granting institutions' evaluation. Specific summative evaluation plans are to be developed by an institution other than the RCC. It may be Stanford University, since it has been responsible for such endeavors for the Federation.

Experiment Cost

The estimated cost of the experiment is to be somewhere in the neighborhood of $1.5 to $2.0 million.[116]

The United States Domestic Satellite System

The United States initiated a serious look at a domestic satellite with President Johnson's 1967 Task Force on Communications Policy.[117] In January, 1970, the

Nixon administration recommended to the Federal Communications Commission (FCC) that private companies be permitted to build and operate communication satellites on an open competition basis.[118] The FCC solicited communication satellite proposals and eleven major proposals were submitted.[119] Three proposals offered *free* educational television channels — Western Union, Hughes Aircraft, and MCI-Lockheed.

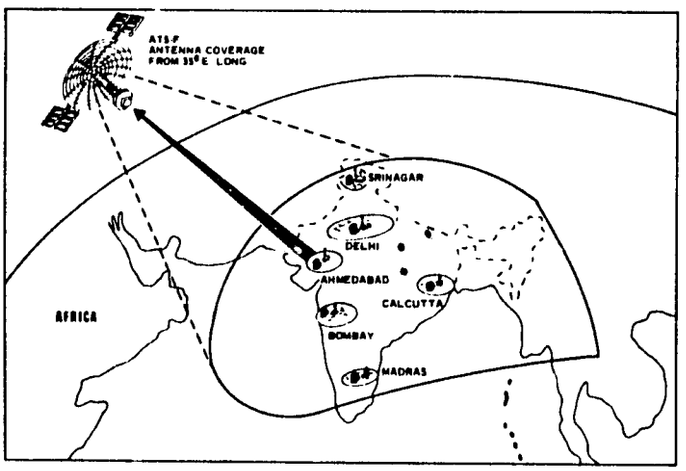
The FCC then decided to select the applicants to provide the United States with communication satellite service. The fierce rivalries between the applicants resulted in a decision in 1973 which would permit all companies to build and operate their own communication satellite system. Also, in 1973 the FCC established a new rule which permits full use of the 2.50-2.69 GHz bandwidth for educational television broadcasting to community receivers; however, 35 MHz on either end of the band is to be shared with fixed satellite service.[120]

Several domestic satellite corporations have been established in the United States, and they plan to orbit satellites by 1974 or 1975. For example, Western Union has contracted, at slightly under $21 million,[121] with Hughes Aircraft Company for the design and manufacture of three satellites. Permits have been approved for the building of seven earth terminals to be located in New York, Los Angeles, Chicago, Dallas, Atlanta, Portland, and Honolulu.[122] The first satellite is scheduled for launch in the fall of 1974.[123]

THE INDIA EXPERIMENT*

As is shown in Figure 20, after the experiments in the United States, the satellite is to be moved to a position over East Africa and made available for

Figure 20
Satellite Location for Indian Experiment



Adapted from: Leonard Jaffe and Donald Silverman, "Satellites for Television Distribution," NASA, unpublished paper. Presented June 3, 1971, Genoa, Italy.

*This section, an article by the author, appeared in *Educational Technology* (c) Vol. 12, No. 6, June, 1972, pp. 14-17, and is entitled "The Joint United States-India Educational Broadcast Satellite Experiment."

*The information in this section is primarily based upon 1971 and 1972 documentation. For more current information contact Director, India ATS-F Satellite Instructional Experiment, Ahmedabad, India.

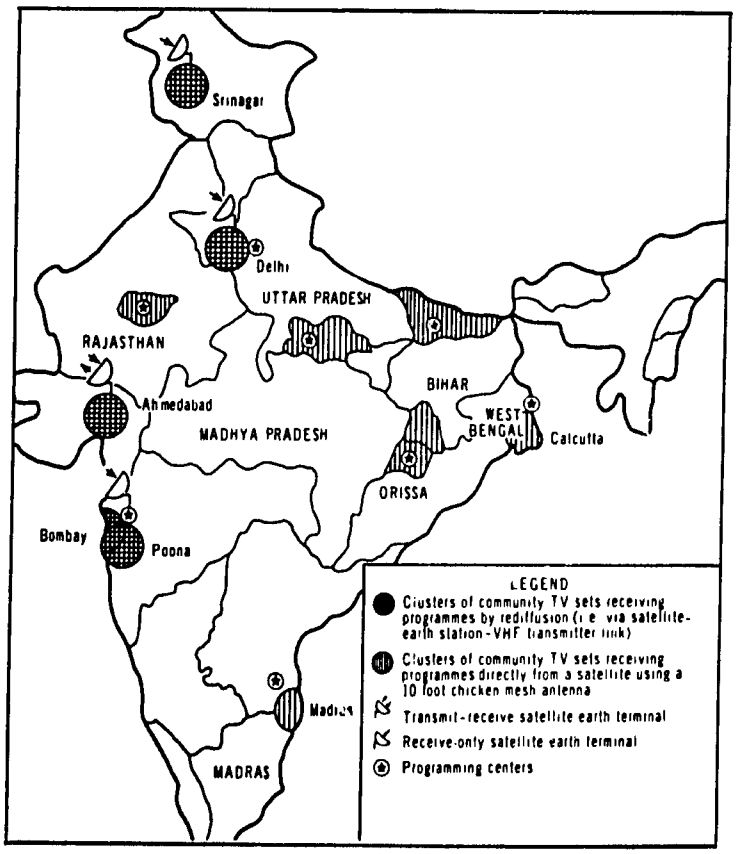
approximately one year for the Indian experiment. The Indian portion[124] of the experiment has three primary instructional objectives:

1. to contribute to family planning objectives;
2. to improve agricultural practices; and
3. to contribute to national integration.

The experiment is to start in mid-1975, and is to involve the broadcasting of instructional television programs to an estimated 4,000-5,000 Indian villages. The languages to be used in this experiment are Hindi, Kashmiri, Bengali, Oriya, Marathi, Gujarati, Tamil, and English.[125] About 2,200 villages are to receive programs from the satellite through a community receiver. The receiver will use a 10-foot, inexpensive mesh antenna with a front-end converter to change the signal from UHF to VHF and from FM to AM.[126] The remaining villages are to be provided programs received by earth stations and redistributed to community centers via conventional VHF transmitters.[127]

The community receivers are to be located in twelve clusters of about 400 villages each.[128] These clusters are to be selected to obtain the widest possible range of meaningful experience from the experiment. To gain experience in different cultural and linguistic settings, the clusters are to be spread over different parts of the country. Shown in Figure 21 is the current plan for community reception, which is to be spread to seven clusters throughout the states of Uttar Pradesh, Bihar, Madhya Pradesh, Orissa, Rahasthan, West Bengal, and Madras;

Figure 21
Experimental Sites



Adapted from: "Satellite Instructional Television Experiment, SITE," Agenda Item No. 20, Ahmedabad, (July 4, 1971).

the sets in the rebroadcast areas are to be located in five clusters in villages around Ahmedabad, Bombay, Poona, Delhi, and Srinagar, since the terrestrial TV transmitters are to be located in these cities.[129]

It is interesting to note that all clusters are to be within a radius of approximately 50 miles. While the cluster radius was planned to aid in facilitating maintenance of the sets when required, its major reason is directly related to the Indian Government's decision to continue the broadcast service after the experiment, via a small, inexpensive terrestrial distribution system until its domestic satellite is ready.[130] If a domestic satellite is not forthcoming in 1976 or 1977, the service will be maintained.

Directories are being prepared for each cluster village, containing complete statistical data on each village and its residents.[131] Research teams are to visit villages to obtain firsthand information on actual conditions; they will include, in addition to local leaders and social scientists, technical personnel who are to decide on the suitability of the location for installation of inexpensive mesh antennas, television sets, and so forth.[132] Additionally, a support team or maintenance group is to be organized for each village.

Program Planning

In the process of planning programs, the Indians found it necessary to study programming mixes, which was complicated by the large number of languages in the country. Of course, the fact that four audio channels can be broadcast simultaneously via the ATS-F has helped to solve part of the problem. However, it will be necessary to allocate times for different types of programs. These details are being worked out by a Program Coordination Committee, which has representatives from the Ministry of Information and Broadcasting, All-India Radio, Indian Space Research Organization (ISRO), and users such as the Ministries of Education, Health, Family Planning, and Agriculture.[133]

Software Development[134]

In order to gain insights into the ways in which television can be used as a direct instrument for promoting developmental tasks set by the Indian government, a number of software pilot studies have been undertaken.[135] The Krishi Darshan program was organized in 1967 by the Indian Space Research Organization in collaboration with All-India Radio, India Agricultural Research Institute, and the Delhi administration.[136] Community television receiving sets were placed in 80 villages in the general vicinity of Delhi, and half-hour, rural-oriented programs are being broadcast three times a week; to date, experience indicates that it may be possible to make relevant changes in the development of isolated communities.[137] These programs have been on the air for more than four years, and have provided valuable experience in the design of rural broadcasts, interdisciplinary interaction, and problems relating to media management, utilization, research, and feedback.

To determine how to make a developmental message interesting and entertaining to the people of India, in 1970 a pilot project called AVEC (Audio-Visual Educational Communication) was begun.[138] Its primary objective is to conduct broad research in the audiovisual field in order to develop suitable prototypes for instructional purposes.[139] The work has been undertaken by an interdisciplinary team composed of India's most talented artists, writers, scholars, dramatists and sociologists and has proved to be quite successful.[140]

Since the experiment is to involve broadcasting for about four hours every day, a total programming time of approximately 1,460 hours has been made available by NASA.[141] Realizing the importance of having a large proportion of the programs ready for use before the start of the experiment, the Indians hope to have about 1,000 hours of programs thoroughly pretested and finalized before the experiment's inception.[142] In order to have personnel ready for the production of these programs, a number of steps have been taken, including establishing a TV training institute at Poona and a training institute for TV teachers at Delhi, both with aid from the United Nations Development Program (UNDP).[143]

Evaluation

The evaluation of the experiment is to be based on predetermined, measurable objectives, and it will be conducted in a systematic manner, on a pretest/post-test basis.[144] Exact criteria for the evaluation have not been completely determined; however, the experimental design is to permit the measurement of the influence of various environmental parameters on the effectiveness of the program. The overall experiment is to be constantly reviewed as it progresses. It is anticipated that immediate feedback on the experiment will be made available through:[145] social service organizations operating in the cluster areas; pretesting, which will be carried out in the eight program-generating centers spread throughout India; and tapecasting rough programs before final transmission. Long-term evaluation is to be accomplished by a consortium of Indian social scientists.

Experiment Costs

No current cost figures are available for the experiment, but the original hardware costs shown in Table 10 were estimated at approximately seven million

Table 10
Estimated Hardware Costs of SITE

Item	Costs In U.S. Millions
One Earth Station (Transmit and Receive capability)	1.50
Three Earth Stations (Receive-only capability)	0.30
Three VHF Transmitting Stations	3.00
3,300 (3,000 + 10 per cent as standbys) conventional TV receivers ($240 each)	0.792
2,200 (2,000 + 10 per cent as standbys) TV receivers for direct reception ($345 each)	0.764
30 Jeeps for receiver maintenance	0.080
Five receiver maintenance centers	
a) Land	0.040
b) Buildings	0.133
c) Test equipment	0.133
Total	6.742

SOURCE: B. S. Rao, *et al.*, "Satellite Television: A System Proposed for India," United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Thematic Session 1, Report No. A/Conf. 34/I.1, (June 24, 1969), p. 13.

U.S. dollars.[146] The estimates were provided to the United Nations by the Indian Government on June 24, 1968.[147] Therefore, there is some doubt that the figures are representative of actual costs; since revisions have been made in the original plan, the costs of materials have increased, and the information originally available for calculating the costs was limited. In addition, to produce a realistic picture of costs, software costs must be represented to include such things as the money that UNDP, the International Telecommunication Union (ITU), and others have spent and will spend, and the total costs of program design, development, testing, and presentation. Just what it will cost to train the necessary people, develop programs, and so forth, has not yet been detailed.

The India Domestic Satellite System

The Indian government has already made plans to follow up SITE with a domestic satellite system.[148] If SITE is successful the national system will include a hybrid television system for both modes of community reception used in the experiment. Consequently, the last eight years of work have been leading to a system now known as the Indian National Satellite for Television and Telecommunications (INSAT).

The present plan is to install one television set in each of India's 550,000 villages over the next five to ten years. The satellite will be multi-purpose, i.e., for all telecommunications, and thus will be used for television as well as telephone, facsimile, and so forth.[149] Television capabilities would include three video channels, each accompanied simultaneously by 14 audio channels. The estimated hardware costs for the INSAT system are shown in Table 11. The national system

Table 11
Cost Estimate for the INSAT System
With 5 Rebroadcast Stations
(All figures in millions)

Description	U.S. $	
	Initial Cost	Annual Maintenance
1. Earth Stations (2) (Transmit & receive capability)		
(a) Land (50 acres @Rs. 60,000 each)	0.40	..
(b) Buildings @Rs. 500,000 each	0.13	0.01
(c) Equipment @Rs. 5.7 M each	1.52	0.15
2. Satellite in orbit (Hughes Estimate)	10.30	...
3. VHF Transmitters (5)		
(a) Land @Rs. 600,000 per station	0.40	...
(b) Building @Rs. 800,000 per station	0.53	0.01
(c) Equipment including air conditioning	4.06	0.45
4. *Earth Stations Receive capability (3) @Rs. 750,000 each	0.30	0.01
5. TV receivers (616,000) @Rs. 1,800 each	148.00	7.40
6. †Receiver front-ends @Rs. 787.50 each 559,625 (508,750 + 10%)	58.40	1.75
	224.34	9.78

*Two more receive stations would be located along with the two transmit stations. As the receive-only stations would be located at the rebroadcast stations, no separate amount is shown for land and building for these.

†When the cost of a receive-only and rebroadcast station is $1.1 million and the cost of a front-end is $105, the cross-over point works out to 10,450 receivers per service area. The five rebroadcast stations would cover 57,475 conventional receivers and the remaining 508,750 villages would have direct receivers.

SOURCE: B. S. Rao, *et al.*, *Satellite Television: A System Proposal for India.* United Nations Conference, United Nations Document No. A/CONF. 34/I.1, (June 24, 1968).

is to be developed in two phases. Phase I, from 1969 to 1976, is the preparation phase, in which the foundation for implementing the program is developed.[150] In this phase, Indians will learn the appropriate skills for design, development, and fabrication of equipment; how to develop software; how to establish management systems; and so forth. The practical experience is to be gained through the DAE-NASA ITV experiment.

Using the skills and expertise developed in Phase I, Phase II (1976-1986) would see the launching of INSAT and a gradual coverage of an additional 100,000 to 150,000 new community reception centers each year until all of India's communities have been provided with satellite signal receivers.[151]

THE PROPOSED BRAZILIAN EXPERIMENT*

Interest in a Brazilian educational satellite began with a 1966 Stanford University study[152] which explored the possible value of satellite technology to developing countries. The potential described in the Stanford report prompted the Brazilian National Commission for Space Activities (CNAE),[153] now the Institute of Space Research (INPE), to conduct its own satellite feasibility study[154] during 1967-68, resulting in the conclusion that a satellite information distribution system would make a major contribution to national development. As a result, INPE developed a major program now in progress entitled "Satellite Avancado de Comunicacoes Interdisciplinares," better known as "Project SACI." SACI has three general phases:**

Phase I involves the reception of selected voice, slow scan, and teledocumentation[155] broadcasts from Stanford University, and the transmission of Brazilian cultural programs to Stanford via the ATS-3. As mentioned above, this experimentation began in January, 1972, and all Brazilian transmissions and receptions are confined to the Institute of Space Research at Sao Jose dos Campos in the State of Sao Paulo.

Phase 2 includes the use of terrestrial and celestial information distribution systems to demonstrate the use of new technologies in ways directly benefiting the people of Brazil. Furthermore, Phase 2 is also viewed as providing the opportunity for developing on a small scale the equipment, personnel, organizations, and programming that might lead to a technically and economically feasible satellite information distribution system to support a nationwide educational system.

To execute the satellite portion of Phase 2, INPE submitted a proposal to NASA for use of an Applications Technology Satellite which discussed satellite time allocations and the use of frequencies in the range of 2.5 to 2.69 GHz.[156] In the summer of 1973, NASA and INPE established an agreement for use of approximately 50 hours of ATS-F time on a time-available basis, since most of the educational experiment time has been allocated to the U.S. experiments.

Phase 3 would see Brazil with its own satellite to provide educational opportunities as well as other communication services for the entire nation.[157] The emphasis herein is on Phase 2.

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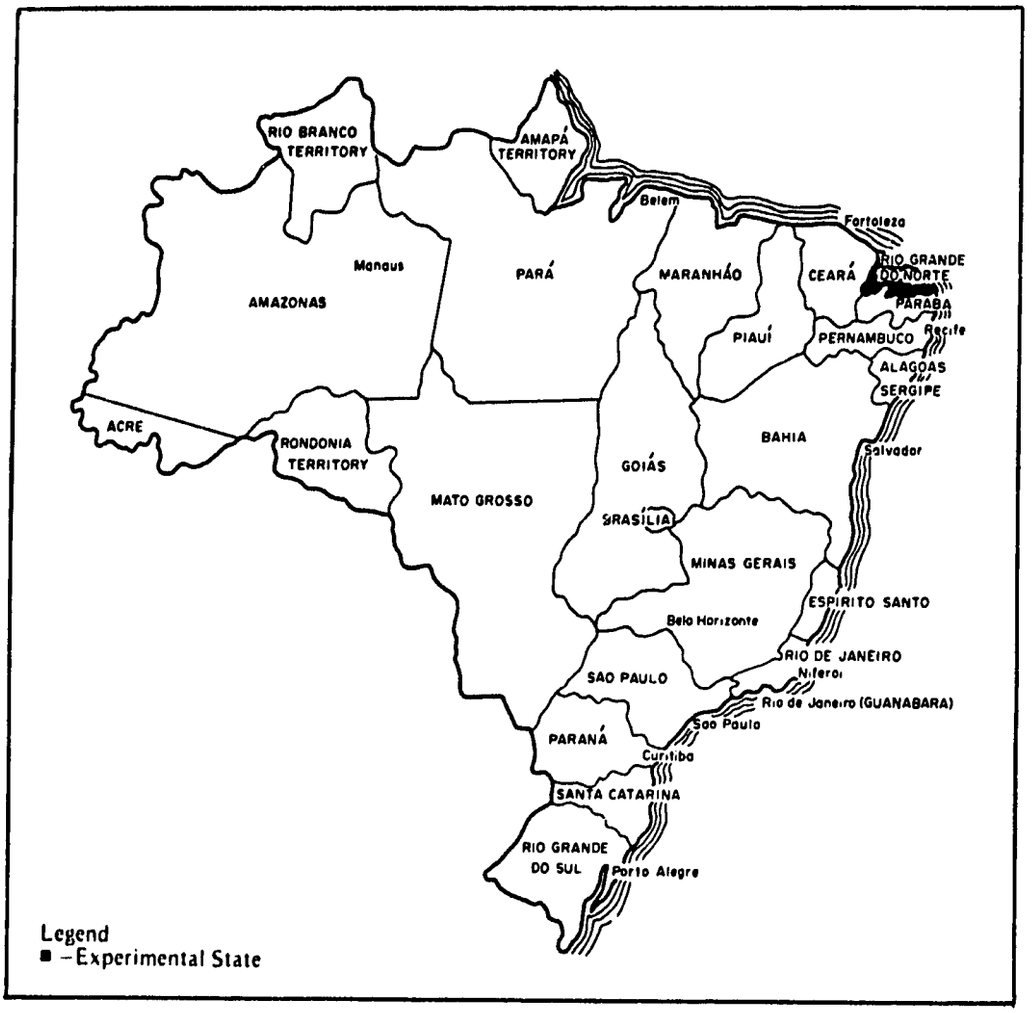
**The information in this section is primarily based upon 1971 and 1972 documentation. For more current information contact: Director, Brazil ATS-F Experiment, Nacional Instituto de Perquisas Espaciais, Sao Jose dos Campos, S.P. Brazil.

Phase 2 — The Rio Grande do Norte Educational Experiment

The State of Rio Grande do Norte, shown in Figure 22, was selected as the experimental site because its varied environment, diverse native groups, and

Figure 22
Brazilian States and Territories – Experimental Site



omnibus problems are representative of almost all regions of Brazil.[158] Consequently, INPE felt that if the educational problems could be overcome here, they could be overcome anywhere in Brazil. So objectives were set for upgrading teachers and improving curricula.

The Brazilian experimental objectives differ from those of India. India is primarily concentrating on the use of satellites to reach an adult audience in remote areas to promote national integration, provide instruction in agriculture, and contribute to family planning. The Brazilian experiment emphasizes the use of satellites for the central development and broadcasting of educational TV and radio programs, upgrading classroom instruction through the improvement of teachers' subject-matter knowledge, teaching methods and use of technology.[159]

In addition, the Brazilians will attempt to determine pupil retention as a function of different media, i.e., teacher, radio, TV and combinations thereof.

The experiment began in the fall of 1972 and is to last for approximately four years.[160] The first year or so is to be dedicated to work with a terrestrial information distribution system, with emphasis on a celestial system throughout most of 1974-75. Initially, the transmissions are being made to schools via VHF and medium-wave methods using three radio stations located in Natal, Mossoro, and Caico, and two TV stations,[161] one located in Natal and the other at Santana do Matos. When properly equipped, some of the experimental schools are scheduled to receive programs relayed by a satellite.[162] However, prior to the use of the satellite, its use will be simulated through a terrestrial transmission of its signal.[163] The actual satellite experiment will use a community reception system.

Six hundred schools have been selected to participate in the experiment, and an attempt will be made to improve the first four years of education through in-service education and student programs.[164] The experiment has been divided into missions according to years with specific emphasis on the types of individuals to which the program content will be geared and the media and distribution mode to be used.

As depicted in Table 12, the major thrusts of the first year are training supervisors, the upgrading of teachers, and showing both how to work with media

Table 12
SACI Experiment Profile

Mission	SACI Experiment Courses and Training	Distribution Modes
1972	1. Supervisor and Teacher Training 2. Course for Preparation of Primary Level Lay Teachers, 1st Stage—Elementary Level	1. Operational Demonstration 2. TV and Radio via Surface
1973	1. Supervisor and Teacher Training 2. Course for Preparation of Primary Level Lay Teachers, 2nd Stage—Secondary Level 3. 1st Grade Teaching (for Students)—1st and 2nd Years	1. Operational Demonstration 2. TV and Radio via Surface 3. TV and Radio via Surface
1974	1. Supervisor and Teacher Training 2. Course for Preparation of Primary Level Lay Teachers, 3rd Stage—Third Level 3. 1st Grade Teaching (for Students)—1st, 2nd, 3rd and 4th Years	1. Operational Demonstration 2. TV and Radio via Surface 3. TV and Radio via Surface and Satellite
1975	1. Supervisor and Teacher Training 2. Course to Bring Elementary Teachers Up to Date 3. 1st Grade Teaching (for Students)—1st, 2nd, 3rd and 4th Years	1. Operational Demonstration 2. TV and Radio via Surface 3. TV, Radio, Slow Scan and Facimile via Satellite

SOURCE: Instituto de Pesquisas Espaciais (INPE) *LAFE-174, SACI Project Review meeting for Progress Examination*, Sao Jose dos Campos, S.P. Brazil, November 25-26, 1971.

to improve learning. Up to two hours of television and one or more hours of radio programs are provided per day, providing in-service education in the Portuguese language, social studies, health and natural sciences, mathematics, civics and moral education, and pedagogic and didactic notions. While in-service education continues, in the remaining three years a shift to student learning will occur.

Additionally, all radio and TV programs have programmed instruction booklets at the schools to complement them. While the basic subjects will remain the same thoughout the experiment, the content will be expanded from year to year to match the audience of the experiment.

Project Operational Structure

One factor was apparent from the beginning of the SACI Project and that was the importance of national, state, and local involvement in the experiment; consequently, every effort was made to convince the respective groups that their support was needed and to spell out specific functions they should perform and roles they should play.

The federal, state, and municipal entities are observing and monitoring the experiment and supplying material and technical assistance, with INPE being in charge of coordinating the experiment. The local working unit is responsible for preparing supervisors and teachers, transmitting radio and TV programs, and taking care of transportation, communication, and maintenance; regional supervisors have been appointed by the Secretary of Education and Culture of the State of Rio Grande do Norte, with responsibility for training and coordinating the activities of the municipal supervisors and acting as an interface between INPE and the municipal supervisors. The municipal supervisors worked closely with the teachers during the 1972 mission preparing them to use in-service training programs and to understand and use multimedia learning approaches with students; they are to expand their activities to include students during the last three years of the experiment, providing feedback on successes and failures to their superiors.[165] To date, little is known about the success of the scheme.

Software Development

To provide an understanding of the environment and individuals that were to participate in the experiment and to develop educational materials and programs accordingly, INPE conducted a survey to determine the characteristics of teachers and students, and the nature of existing educational materials in the areas of experimental interest.[166]

The actual production of materials and the development of programs for the experiment have taken place at the Institute of Space Research, Sao Jose dos Campos. The Institute has a small studio, a staff of novice actors, producers, and directors, a limited number of subject-matter specialists, and a very limited budget. Nevertheless, they have been able to produce excellent situational educational radio and TV programs.[167] For example, the following approach has been used:[168]

> In creating the "Wonderful World of Mathematics," an attempt is made to eliminate the difficulty of the subject, by using everyday situational problems. A comic teacher livens up the situation, and one of the characters teaches her younger brother the things she learned by imitating her teacher.

These 15-minute TV and radio programs are combined with programmed instruction workbooks that provide a printed instructional unit for each pro-

gram.[169] Each unit has been developed for an assignment period of approximately 20 to 30 minutes, but the student progresses through the unit at his own pace.[170] Each unit is written to encourage student participation, through a series of questions that are answered from information gained partially from the TV or radio programs. Immediate feedback on student progress is provided by the student answer sheets; consequently, the instructor is able to determine the effectiveness of assignments and make or recommend adjustments in subsequent programs or in instructional units.

The software for the first year of the experiment was completed in the fall of 1972.[171] The actual TV and radio programming of the software is scheduled for two to three TV and six radio programs a day, always keeping a two-month stockpile.[172] Unfortunately, little has been accomplished in the pilot testing of these programs. However, an effort was to be initiated to validate the pretests and post-tests and to pilot test some of the programs, but its depth and scope is unknown.[173]

Evaluation

The 600 schools being used in the experiment were selected at random according to three types:[174] elementary school, elementary united, and elementary isolated. Because the main objective is to test the efficiency and effectiveness of new technologies relative to education, a comparison is to be made between schools using all of the technology, those using a portion of the technology, and those not using the technology at all. As a consequence, the schools have been divided into three groups:[175]

Experimental Group is composed of 500 schools selected at random from the 600, and all of the teachers with assigned classes in this group of schools attended the preparation course taught in 1972. Classes were conducted in the morning and afternoon through the technological system. Furthermore, the students in this group will have classes that use radio and TV as a main source of information.

Control Group I is composed of 50 schools selected at random. Teachers attended the training and the preparation course just as the members of the Experimental Group. However, the students in this group will *not* have classes that use radio and TV.

Control Group II is composed of 50 schools also selected at random; here, the teachers and students are to continue under the traditional system without the aid of the treatment offered to the Experimental Group and Control Group I.

Observation forms, pattern reports, questionnaires and objective tests are to be used to collect the data needed for evaluation. The data are scheduled to be collected as follows:[176]

At the beginning and conclusion of the experiment, questionnaires are to be used to register attitudes of authorities and leaders of communities located in the area of the experiment in order to determine the degree of receptiveness of the innovations introduced into the school system.

Questionnaires are to be used at the beginning and conclusion of each school year to register teachers' and students' attitudes in order to determine the degree of receptiveness to the educational TV and radio system.

Weekly during the first two months, biweekly in the next two months, and monthly from the fifth month on, questionnaires will be used to register teachers' opinions about programs presented. This information is to provide the production

groups with vital information on the successes and errors of the programs presented.

Daily data on student performance will be gathered using the answer sheets from the programmed instruction workbooks. Finally, at the beginning and conclusion of each school year, objective tests are to measure learning retention of teachers and students to determine software needs.

To maximize the precision in data collection and minimize their analysis time, the Mark-Sense technique is being used. The data forms are to be read by an optical scanner and recorded on magnetic tape at the Natal computer center; then the tapes are to be sent to Sao Jose dos Campos for processing and analysis.[177]

Experimental Cost

According to a 1970 Brazilian report,[178] the cost of the satellite portion of the experiment is estimated at about $7 million, approximately the same cost as the hardware for the Indian experiment. No information is available on the cost of the Indian software. Cost data are provided in Tables 13 and 14; the software portion of the Brazilian experiment will cost about $4.5 million including the programmed instruction texts, whereas hardware and engineering costs will be slightly more than $3 million. However, the cost of the four years of experimentation has been estimated to be $24 million.[179] It is next to impossible to make

Table 13
Software and Programming Cost Summary

Software and Programming Costs	U.S. Dollars
Studio including equipment (Brazilian Center for ETV Foundation at INPE)	210,900 (a)
Salaries and training of planning and integration personnel at INPE	144,000 (b)
Programming of:	
Primary Education Courses	603,000
Literacy Instruction Courses	45,000
Vocational Training Courses	45,000
Teachers Training	147,600
Administrative Instructions	45,000
Total Programming Costs	885,600 (c)
Administrative Costs	
Classroom Workbooks	75,000
Supervisory and Evaluation Personnel	114,800
	189,800 (d)
TOTAL SOFTWARE COSTS (a) + (b) + (c) + (d)	1,430,300

NOTE: An additional $3,000,000 will be spent for preparation of "programmed instruction" texts, as part of the studies in the application of new educational technologies to the Brazilian school system.

SOURCE: *Brazilian Educational Radio and TV Experiment in ATS-F*, Experimental Proposal–Submitted to NASA by INPE, (May, 1970 revision), p. 78.

Table 14
Hardware and Engineering Cost Summary

Hardware and Engineering Costs	Estimates U.S. Dollars	
	Low	High
Transmit Station		
Prime Equipment	84,500	95,050
Back-up Equipment	37,000	47,000
UHF Monitor Equipment	3,710	7,850
Test Equipment	15,000	
Transportation, insurance, etc. (to site)	22,430	26,370
Building	10,660	
Salaries	5,050	10,100
Total – Transmit Station	(178,400	212,002)
Receive Site Equipment	(742,500	2,812,500)
System Engineering, Design, Integration and Installation	300,000	500,000
HARDWARE AND ENGINEERING, TOTAL	1,220,900	3,524,502

SOURCE: *Brazilian Educational Radio and TV Experiment in ATS-F*, Experimental Proposal–Submitted to NASA by INPE, (May, 1970 revision).

a meaningful cost comparison of the Brazilian and Indian experiments due to the lack of information and their difference in magnitude. Brazil's experiment differs considerably from India's. Brazil has confined its experiment to a relatively small geographical area and has limited ground components to one ground transmission terminal and 500 small receiving terminals, whereas the Indian experiment will use one transmit-receive and three receive-only distribution earth terminals and approximately 2,200 receive-only community terminals, all of which will be devoted to four hours a day of television broadcasts. However, Brazil plans to devote a maximum of two hours a day to television broadcasting, with the remainder being used for radio broadcasts. In addition, not all of the sites will be receiving television signals; approximately 150 will be equipped for such reception.

The "tropicalized" television and radio sets to be used in the Brazilian experiment were manufactured in Brazil by Philco and ABC Radio and Television Corporations.[180] Cost figures are presented in Table 15; however, at this time no transmitter or receiver for satellite use has been developed by Brazil, and the INPE engineers estimate that they would be able to produce just thirty receivers by 1973.[181] Receivers manufactured in the U.S. by Hewlett Packard may be used. They will cost approximately $2,000 each.

Table 15
Brazilian Television and Radio Set Costs

Item	Manufacturer	Number	U.S. Dollars Cost
23" T.V. Conventional Power	ABC Brazil	76	@ 141 *per unit
12" T.V. Battery Powered	Philco Brazil	250	@ 157 per unit
Radio Battery & Conventional Power	ABC Brazil	370	@ 15 per unit
Battery 12 volt	ABC Brazil	600	@ 17 per unit

SOURCE: Shipping invoices at the Natal-INPE facility during the February-March, 1972 visit.

At this point, the cost information for both of the above experiments probably should be viewed as estimates. Some of the hardware costs are reliable, but generally it is too early in the design and production phase of the software and the hardware to know their final production or operational costs.

The Brazilian Domestic Satellite System

As was mentioned at the outset of this section, the objective of Phase III of the SACI project is a Brazilian domestic satellite system. No decision has been made, but one is expected by the spring of 1974.

CONCLUSIONS

Although the ongoing and proposed experiments may differ in objectives, magnitude, and cost, it is hoped that they will provide answers to many of the questions that communication experts, educators, engineers, and others have asked about the operational feasibility of using satellites in developed and less-developed countries. Consequently, the value of the experiment extends beyond the dollar investment or immediate results because the knowledge gained will provide guidelines for policy, design of hardware and software, and the economics of system development, implementation, and operation. Therefore, since the future of such systems depends on the outcome of these and other such studies, mistakes, shortcomings, and successes must all be recorded if results are to be truly beneficial for planning, design, development, and implementation of future systems.

Unfortunately, there is a tendency to equate the success of these experiments with the functioning of the satellite and the ground transmitters and receivers, but this is probably the least significant aspect of the experiment on which to judge its success or failure. Past satellite feats indicate that these components will function, but there is no such record to indicate that the program content will be successful.

For example, the problem facing the developing countries is not satellite technology *per se;* rather, it is the information that can be transmitted to permit development by solving basic problems. If the transmitted television programs

do not produce changes in behavior relative to population control, health and hygiene, illiteracy, or food production there is some question about whether an expensive satellite system should be used for instructional/educational purposes in the developing or developed countries.

However, at this point in time the software is not what is most important, because we do not need satellites to prove the value of TV, radio, or computer programs. What needs to be known is the types of unique services that satellite technology can offer, as well as what the technology can do that terrestrial information systems cannot within certain time and financial constraints.

These experiments are only the beginning for world educators, for whether, how, and to what extent satellites are used should largely depend upon the educational community. It must determine whether satellite technology has any educational merit, and only by monitoring closely and participating in educational broadcast satellite experimentation can the appropriate knowledge be gained. Generally speaking, this is not a role the educational community is used to playing; but it is one that should have been played more often in the past developments of technology that were used for educational purposes.

In conclusion, a note of caution may be in order for all countries since satellite experimentation is a major undertaking which poses questions about the responsibilities of the lender and recipient governments. One point is clear; the governments providing satellite technology to developing countries have a major responsibility to ensure that they have not raised expectations which cannot be fulfilled, and thereby encourage the squandering of precious natural, human, and monetary resources. Furthermore, recipient governments have both a responsibility and a commitment to their people to ensure that the resource expenditures for a given information distribution system will produce the expected national development, rather than a group of unemployed scientists, technicians, teachers, and laborers, as well as unused facilities, equipment, and industries, once the experiment has been concluded.

The offering and the acceptance of satellite, or any other technology for education, should not take place in blind haste but rather in an atmosphere of knowledge, understanding, responsibility, and commitment.

FOOTNOTES

CHAPTER II

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[50]*Ibid.*, p. 19.
[51]Coyne, *op. cit.*, p. 24.
[52]Arthur D. Little, Inc., *op. cit.*, p. 54.
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[89]*Ibid.*, pp. 41-72.
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[91]*Ibid.*, p. 40.
[92]*Ibid.*, pp. 62-67.
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[94]*Ibid.*
[95]*Ibid.*
[96]*Ibid.*
[97]Office of Telecommunications, *op. cit.*, pp. 67-90.
[98]Alaska Educational Broadcasting Commission, (December, 1972), *op. cit.*, p. 24.
[99]*Ibid.*
[100]Office of Telecommunications, *op. cit.*, p. 67.
[101]*Ibid.*
[102]*Ibid.*, pp. 46-70.
[103]Alaska Educational Broadcasting Commission, (December, 1972), *op. cit.*, pp. 63-71.
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[152]*The Advanced System for Communication and Education in National Development*, a report by the Stanford University School of Engineering, 1967, has been a major contributor to satellite applications thinking for developing and developed countries.

[153]CNAE has recently been renamed the Institute of Space Research (INPE).

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[158]"SACI Project Review Meeting for Progress Examination," LAFE-174, Sao Jose dos Campos, S. P., Brazil, Nacional Instituto de Pesquisas Espaciais, (November 25-26, 1971), p. 27.

[159]LAFE-109, *op. cit.*, p. 5.

[160]LAFE-174, *op. cit.*, p. 3.

[161]*Ibid.*, p. 18.

[162]*Ibid.*

[163]*Ibid.*

[164]*Ibid.*, p. 23.

[165]LAFE-174, *op. cit.*, pp. 25-26.

[166]"SACI Project-Report II," Comissao Nacional de Actividades Espaciais, LAFE-104, (February, 1970), p. 18.

[167]The author reviewed a number of INPE programs during a 1971-1972 trip to Brazil, along with the Brazilian production of "Sesame Street."

[168]LAFE-174, *op. cit.*, pp. 74-75.

[169]*Ibid.*, pp. 98-106.

[170]*Ibid.*

[171]This information was obtained from the INPE software production staff when the author attended the November 24-25, 1971 SACI Experiment Review Meeting at Sao Jose dos Campos, Brazil.

[172]LAFE-174, *op. cit.*, pp. 49-50.

[173]Information provided by Fernando de Mendonca, INPE Director.

[174]*Ibid.*, p. 109.

[175]*Ibid.*, p. 27.

[176]*Ibid.*, p. 115.

[177]*Ibid.*

[178]LAFE-109, *op. cit.*, pp. 66-80.

[180]This information was taken from the shipping invoices at the Natal-INPE facility during the author's 1971-1972 trip.

[181]Information provided by INPE engineers.

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GLOSSARY OF TERMS*

Aeronautical Mobile-Satellite Service — A mobile-satellite service in which mobile earth stations are located on board aircraft. Survival craft stations and emergency position indicating radio-beacon stations may also participate in this service.

Aeronautical Radionavigation-Satellite Service — A radionavigation-satellite service in which mobile earth stations are located on board aircraft.

Active Satellite — An earth satellite intended to transmit or retransmit radio-communication signals.

Amateur-Satellite Service — A radiocommunication service using space stations on earth satellites for the same purposes as those of the amateur service.

**Apogee* — The point in the orbit of a satellite that is farthest from the earth.

Broadcasting-Satellite Service — A radiocommunication service in which signals transmitted or retransmitted by space stations are intended for direct reception[1] by the general public.

**Broadcast Satellite* — A high-powered satellite which relays radio waves to a limited geographic area, requiring a small, inexpensive ($200-2,500) earth terminal or antenna attached directly to a television or radio receiver, or requiring no earth terminal or antenna at all.

Community Reception (in the broadcasting-satellite service) — The reception of emissions from a space station in the broadcasting-satellite service by receiving equipment, which in some cases may be complex and have antennas larger than those used for individual reception, and intended for use:

—by a group of the general public at one location; or

—through a distribution system covering a limited area.

Coordination Area — Area around an earth station enclosed by the coordination contour.

Coordination Contour — The line joining the points which are on all azimuths around an earth station at a distance from this station equal to the coordination distance corresponding to each azimuth.

Coordination Distance — Distance from an earth station in a given azimuth within which a terrestrial station sharing the same frequency band may cause or be subject to more than a permissible level of interference.

Deep Space — Space at distances from the earth approximately equal to, or greater than, the distance between the earth and the moon.

**Distribution Satellite* — Medium-powered satellite which relays radio waves to a limited geographic area, requiring a medium-sized and priced ($100,000-500,000) earth station.

**Domestic Satellite* — A satellite which provides communication services primarily to one nation.

Earth Exploration-Satellite Service — A radiocommunication service between earth stations and one or more space stations in which:

—information relating to the characteristics of the earth and its natural phenomena is obtained from instruments on earth satellites;

—similar information is collected from airborne or earth-based platforms;

—such information may be distributed to earth stations within the system concerned;

—platform interrogation may be included.

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*Those terms and definitions *without* asterisks are from the ITU proposed terms and definitions concerning outer space telecommunication from the Final Acts of the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971.

[1]In the broadcasting-satellite service, the term "direct reception" shall encompass both individual reception and community reception.

Earth Station — A station located either on the earth's surface or within the major portion of the earth's atmosphere for communication:

—with one or more space stations; or

—with one or more stations of the same kind by means of one or more passive satellites or other objects in space.

Equivalent Isotropically Radiated Power — The product of the power of an emission as supplied to an antenna and the antenna gain in a given direction relative to an isotropic antenna.

Equivalent Satellite Link Noise Temperature — The noise temperature at the input of the earth station receiver corresponding to the radio-frequency noise power which produces the total observed noise at the output of the satellite link excluding noise due to interference coming from satellite links using other satellites and from terrestrial systems.

Fixed-Satellite Service — A radiocommunication service:

—between earth stations at specified fixed points when one or more satellites are used; in some cases this service includes satellite to satellite links, which may also be effected in the inter-satellite service;

—for connection between one or more stations at specified fixed points and satellites used for a service other than the fixed-satellite service (for example, the mobile-satellite service, broadcasting-satellite service, etc.).

**Front End* — Antenna and associated components, excluding television or radio sets, which are used to receive and translate satellite relayed radio waves.

Geostationary Satellite — A satellite, the circular orbit of which lies in the plane of the earth's equator and which turns about the polar axis of the earth in the same direction and with the same period as those of the earth's rotation. The orbit on which a satellite should be placed to be a geostationary satellite is called the "geostationary satellite orbit."

Geosynchronous Satellite — An earth satellite whose period of revolution is equal to the period of rotation of the earth about its axis.

**Half Circuit* — A two-way communication path suitable for voice exchange between one earth station and a satellite.

Inclination of an Orbit (of an earth satellite) — The angle determined by the plane containing an orbit and the plane of the earth's equator.

Individual reception (in the broadcasting satellite service) — The reception of emissions from a space station in the broadcasting-satellite service by simple domestic installations and in particular those possessing small antennas.

Inter-Satellite Service — A radiocommunication service providing links between artificial earth satellites.

Land Mobile-Satellite Service — A mobile-satellite service in which mobile earth stations are located on land.

Maritime Mobile-Satellite Service — A mobile-satellite service in which mobile earth stations are located on board ships. Survival craft stations and emergency position indicating radio-beacon stations may also participate in this service.

Meteorological-Satellite Service — An earth exploration-satellite service for meteorological purposes.

Mobile-Satellite Service — A radiocommunication service:

—between mobile earth stations and one or more space stations; or between space stations used by this service;

—or between mobile earth stations by means of one or more space stations;

—and if the system so requires, for connection between these space stations and one or more earth stations at specified fixed points.

Multi-Satellite Link — A radio link between a transmitting earth station and a receiving earth station through two or more satellites, without any intermediate earth station.

A multi-satellite link comprises one up-path, one or more satellite-to-satellite paths and one down-path.

Orbit — 1. The path, relative to a specified frame of reference, described by the center of mass of a satellite or other object in space, subjected solely to natural forces,

mainly the force of gravity.

2. By extension, the path described by the center of mass of an object in space subjected to natural forces and occasional low-energy corrective forces exerted by a propulsive device in order to achieve and maintain a desired path.

Passive Satellite — An earth satellite intended to transmit radiocommunication signals by reflection.

**Perigee* — The point in the orbit of a satellite that is closest to the earth.

Period of a satellite — The time elapsing between two consecutive passages of a satellite or planet through a characteristic point on its orbit.

**Point-to-Point Satellite* — A relatively low-powered satellite which relays radio waves to a large geographic area requiring large expensive ($2-4 million) earth station.

**Prime Power* — Total electrical power which can be generated in a communication satellite.

Radio Frequency Power — A portion of the prime power which can be used to relay radio signals.

Satellite — A body which revolves around another body of preponderant mass and which has a motion primarily and permanently determined by the force of attraction of that other body.

Satellite Link — A radio link between a transmitting earth station and a receiving earth station through one satellite. A satellite link is comprised of one up-path and one down-path.

Satellite Network — A satellite system or a part of a satellite system, consisting of only one satellite and the cooperating earth stations.

Satellite System — A space system using one or more artificial earth satellites.

Spacecraft — A man-made vehicle which is intended to go beyond the major portion of the earth's atmosphere.

Space Operation Service — A radiocommunication service concerned exclusively with the operation of spacecraft, in particular tracking, telemetry and telecommand. These functions will normally be provided within the service in which the space station is operating.

Space Radiocommunication — Any radiocommunication involving the use of one or more space stations or the use of one or more passive satellites or other objects in space.

Space Research Service — A radiocommunication service in which spacecraft or other objects in space are used for scientific or technological research purposes.

Space System — Any group of cooperating earth and/or space stations employing space radiocommunication for specific purposes.

Standard Frequency-Satellite Service — A radiocommunication service using space stations on earth satellites for the same purposes as those of the standard frequency service.

Terrestrial Radiocommunication — Any radiocommunication other than space radiocommunication or radio astronomy.

Terrestrial Station — A station effecting terrestrial radiocommunication.

Time Signal-Satellite Service — A radiocommunication service using space stations on earth satellites for the same purposes as those of the time signal service.

GLOSSARY OF ABBREVIATIONS

AETC	— Alaskan Educational Telecommunications Consortium
AID	— Agency for International Development
AM	— Amplitude Modulation
ANIK	— Canadian Domestic Satellite
ARC	— Appalachian Regional Commission
ATS	— Application Technology Satellite
AT&T	— American Telephone and Telegraph
CAI	— Computer-Assisted Instruction
CCIR	— International Radio Consultative Committee
CNAE	— Brazilian National Commission for Space Activities (Now INPE)
COMSAT	— Communication Satellite Corporation
CPB	— United States Corporation for Public Broadcasting
CTS	— Communications Technology Satellite
DAE	— Indian Department of Atomic Energy
ELDO	— European Launch Space Vehicle
ESRO	— European Space Research Organization
FCC	— United States Federal Communications Commission
FM	— Frequency Modulation
FORMS	— Federation of Rocky Mountain States
GHz	— Gigahertz
HEW	— United States Department of Health, Education, and Welfare
INPE	— Institute of Space Research (Brazil)
INSAT	— Indian National Satellite for Television and Telecommunications
INTELSAT	— International Telecommunication Satellite Consortium
INTERSPUTNIK	— Soviet Union's International Satellite System
ITU	— International Telecommunication Union
KHz	— Kilohertz
MHz	— Megahertz
MOLNIYA	— Soviet Union's Communication Satellite
NASA	— United States National Aeronautics and Space Administration
NCET	— United States National Center for Educational Technology
NPR	— United States National Public Radio
PAM	— Pulse Amplitude Modulation
PBS	— United States Public Broadcasting System
PCM	— Pulse Code Modulation
PEACESAT	— Pan Pacific Education and Communication Experiment by Satellite
RCC	— Resource Coordination Center (Appalachian Region)
R&D	— Research and Development
RESA	— Regional Education Service Agencies (Appalachian Region)
SACI	— Advanced Satellite for Interdisciplinary Communications (Brazil)
SITE	— Satellite Instructional Television Experiment (India)
UHF	— Ultra High Frequency
UNDP	— United Nations Development Program
UNESCO	— United Nations Educational, Scientific and Cultural Organization
VHF	— Very High Frequency
WARC	— World Administrative Radio Conference

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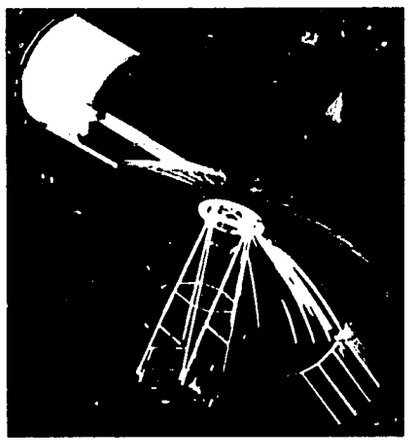

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