EDUCATIONAL OPPORTUNITIES WITH COMMUNICATIONS AND BROADCAST SATELLITES AND WIRED BROADBAND COMMUNICATION NETWORKS

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CHAPTER 1

THE U.S. EDUCATIONAL SYSTEM, TECHNOLOGY, AND TELECOMMUNICATIONS

The education industry is among the largest in the American economy. A recent article on the magnitude of the American educational establishment indicates that in the United States in the 1970-71 academic year, there were more than 62 million students, teachers or administrators in the U.S. educational enterprise. In the last ten years, student enrollments in all categories increased by 13 million to a level of 59 million students.[1] During the same period, while enrollments were increasing by 29 percent, the costs of education have risen by 60 percent to 70 billion dollars and one million new teachers have increased the teacher population by 51 percent to over three million. The primary approach for coping with increasing enrollments to date have been the multiplication of the number of conventional classrooms and teachers to the point where the growth in the educational expenditure has far exceeded the growth in Gross National Product (GNP). In 1949, the United States, at all levels, spent about 9 billion dollars for all of education. This represented 3.5 percent of GNP. In 1961,

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[1]"The Magnitude of the American Educational Establishment: 1960-70," Saturday Review, November 19, 1970, p. 67.

educational expenditures accounted for some 5.6 percent of the national GNP and have currently grown to some 8 percent.[2]

There are indications that education may be nearing saturation in its relative share of the national economy. Current attempts to increase taxes for education have been meeting stiff opposition throughout the country. This is particularly evident in public elementary and secondary education, whose major source of revenue for operating expenses has traditionally come from local property taxes and where a "tax-payer's revolt" has forced educational planners and administrators to study ways and means of making the system more efficient or productive to maintain the quality of education or to provide a diminished service. Here one can not fail to take notice of the fact that education is the most labor intensive of all major U.S. economic sectors, with over 74 percent of current outlays in elementary and secondary segment going to the salaries for the instructors and administrators. Thus the productivity of the system is very heavily dependent upon the productivity of the instructors. Increasing the productivity of the teachers, increased allotments of monetary resources for more cost-effective instructional media and technology, and new instructional strategies involving optimal teacher-technology mixtures seem to be the key requirements for coping with the rising costs, enrollments and deficiencies.

A recent study has tried to relate public elementary and secondary school expenditures to income per capita and enrollments

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[2]A. T. Denzau, Public Education Finances: 1949-1985, Memorandum 71-4 (Saint Louis, Missouri: Washington University, 1971), p. 1.

and has derived the following equation:[3]

$$D_t = 0.337 \quad Y_t^{0.99845} \quad (0.7\ E_t + S_t)^{1.5533}$$

where, D_t = current expenditures (billions of 1958 dollars),

Y_t = real personal income per capita (thousands of 1958 dollars),

E_t = K-8 enrollment (millions),

S_t = 9-12 enrollment (millions).

It shows that for every 100 percent increase in the elementary and secondary school enrollments, the public school expenditures have had a tendency of increasing by 200 percent. The increase in expenditure obviously has been quite improportionate and unless new strategies for controlling costs of education are defined and adopted without sacrificing the quality of education, the whole public education sector is in grave peril. One cannot expect tax-payers to keep on paying these improportionate increases indefinitely and if the number of property-tax increases that did not get through lately is any indication of the mood of the nation, the time to act has already come.

The cost of education is only one of the areas of major dissatisfaction of the educational establishment. There are two other key issues; the style and orientation of education and the equality of educational opportunity, that in combination with the soaring costs of education have led to a situation that is being described by many as an "educational crisis" and "crisis of confidence" with increasing regularity.[4] The present dissatisfaction with the schools can be

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[3] *Ibid.*, p. 9.

[4] J. Cass, "The Crisis in Confidence--and Beyond," *Saturday Review*, September 19, 1970, pp. 61-62.

traced to the criticisms that education still acts as a sorting device, benefitting the gifted more than the slow learners, and the children of the rich more than the children of the poor; that what the schools teach most of all is the importance of schooling; that schools serve to stratify society by wealth; that schools teach people to depend upon institutions rather than themselves for their well-being; and that failure is structured into the American system of public education where losers are essential to the success of the winners.[5,6] Silberman,[7] after an extensive study financed by the Carnegie Corporation of New York, sees an enormous failure of the schools which is so pervasive that it extends into Scarsdale as well as Harlem, into Palo Alto as well as rural Mississippi; and indeed no level of education appears to be immune from its contagion. Silberman found the American schools to possess a systematic infection that is not recognized by the average citizen:

> Because adults take the schools so much for granted, they fail to appreciate what grim, joyless places most American schools are, how oppressive and petty are the rules by which they are governed, how intellectually sterile and esthetically barren the atmosphere, what an appalling lack of civility obtains on the part of teachers and principals, what contempt they unconsciously display for children as children.[8]

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[5]Barry D. Anderson and Edward Greenberg, "A Search for Educational Production Functions: The Problems and Possibilities" (unpublished research paper, Center for Development Technology, Washington University, 1971), pp. 16-20.

[6]P. Schrag, "End of the Impossible Dream," Saturday Review, September 19, 1970, pp. 68-70.

[7]Charles E. Silberman, Crisis in the Classroom--The Making of American Education (New York: Random House, 1970).

[8]Ibid., p. 10.

Moreover, he concluded that the schools of this nation continue to deny, in the most systematic fashion, equality of educational opportunity for substantial number of youngsters. Both expenditures and educational outcomes are distributed disproportionately in favor of the rich, white, and suburban child.[9]

The inequalities in the U.S. educational system have also been documented in the Coleman report,[10] which was prepared in response to the Civil Rights Act of 1964. Comparative data from a very large sample of schools and students suggested that the differences among American public schools in class size, buildings, equipment, teacher skills, library services, and other inputs that can be easily changed by spending more or less money seemed to have less effect on the success in schools than social class, as indicated by family income. As Howe,[11] former U.S. Commissioner of Education, puts it, the Coleman Report conclusions were disturbing to American educators who had long assumed that the way to get most out of education was to put more into it.

In a nutshell, education is being asked to equalize opportunity, update itself, become more responsive to the individual learner and the real world, and control costs at the same time. In addition, there is also a rising demand for education, training, and retraining that

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[9] Ibid., p. 62.

[10] J. S. Coleman, et. al., Equality of Educational Opportunity, Report prepared for the U.S. Office of Education, Washington, D. C., 1966 (Washington, D. C.: Office of Education, 1966).

[11] Harold Howe II, "Anatomy of A Revolution," Saturday Review, November 20, 1971, pp. 84-88.

cannot be accommodated within the formal system. According to the Perkins report,[12] there are 30 million Americans who have no more than a grammar school education and 50 million over the age of 25 who do not have a high school diploma. There are ten million unemployed and many million more who are underemployed. These millions of citizens have available to them only the bits and pieces of a non-formal education system. The opportunity and the demand for a more flexible educational system--complete with instructional training, examinations, and appropriate certification or degrees--are rapidly coming into focus. Knowledge has been growing so fast that yesterday's solution to a problem may not be valid today. In modern times we cannot expect the education given once during youth will be sufficient for the next thirty to forty years, which is the active service period of a man. It seems that the time has come where technology is to become education's saviour. The Commission on Instructional Technology[13] has clearly expressed its well founded conviction that technology can make education more productive, individual, and powerful, making learning more immediate, give instruction a more scientific base, and make access to education more equal. The Commission has concluded that the nation should increase its investment in instructional technology, thereby upgrading the quality of education, and, ultimately, the quality of individual's lives and of society generally.

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[12]J. A. Perkins, et. al., Instructional Broadcasting: A Design For Future, Report to the Corporation for Public Broadcasting, Washington, D. C., 1971 (Washington, D. C.: Corporation for Public Broadcasting, 1971), p. 3.

[13]S. G. Tickton, ed., To Improve Learning--An Evaluation of Instructional Technology (New York: R. R. Bowker Company, 1970).

Before proceeding further, it would be beneficial to clarify what one means by the phrase "instructional technology". Often it is used to denote media born out of the communications revolution that can be used for instructional purposes alongside the teacher, textbook, and blackboard. A less familiar but more accurate definition of instructional technology goes beyond any particular medium or device. "It is a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication, and employing a combination of human and nonhuman resources to bring about more effective instruction."[14] One should take note that neither definition equates instructional technology with "machines"--an easy mistake to make. By either definition, instructional technology includes a wide array of instruments, devices, techniques, and messages, each with its particular problems and potentials.

In this study, as its title suggests, we are only concerned with the exploration of the two major options for the transmission of "information" related to the instruction. We will be dealing with the two options for transmission system segments of all telecommunication media. Figure 1, taken from a report authored by Bretz,[15] shows

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[14] Ibid., p. 21.

[15] Rudy Bretz, Communication Media: Properties and Uses, A Report by The Rand Corporation, Santa Monica, California, September, 1969 (Santa Monica, California: The Rand Corporation, 1969), p. 13.

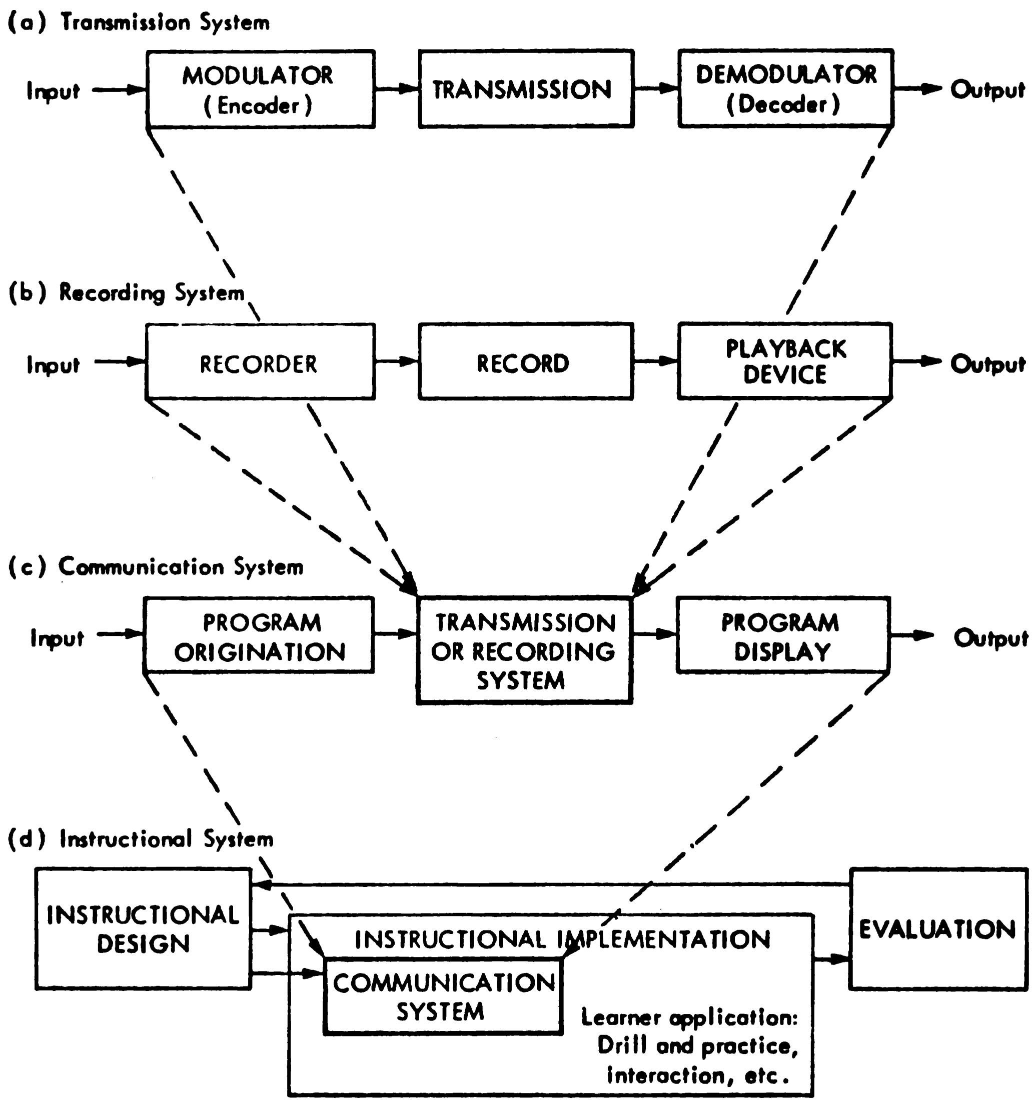

FIGURE 1

Systems within Systems of Communication Technology the relationship among transmission, communication and instructional systems.[16]

As suggested by the title itself, this study is devoted to the examination of policy questions inherent in the complete realization of the educational opportunities offered by fixed- and broadcast satellites and wired broadband communication networks (BCN) through their particular configurations, possible reduction in the communication costs, and, in the case of BCNs, an abundance of information carrying capacity due to the non-radiating nature of the system. It is assumed that economic, social, and political pressures would bring about increased utilization of telecommunication media in education and there would be an increasing need for long distance, area coverage, and local distribution capabilities offered by the satellites and BCNs. Competitive alternatives offered by recording-media and localized

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[16]Communication media can be identified by the fact that they are capable of communicating messages that are complete within themselves and do not require face-to-face verbal narration at the point of reception; and that they are capable of reproducing a program either by simultaneous reproducibility (point-to-point, or point-to-many-point) or sequential reproducibility (recording or recording and printing). Communication media can be distinguished from each other if they utilize different or additional ways of representing information and if they are based on devices (hardware) that are of a different kind. Thus, in a typical instructional system, not all the instructional devices fall in the communications medium category; some are merely teaching aids. Also, it is plausible to have a multi-media situation (for details, see Chapters III and IV of Bretz [1969]). Not all communication media use telecommunications or "electronic transmission of information". Several communication media are based on a recording medium such as the CBS Electronic Video Recorder (EVR). However, many telecommunication media have recording-media counterparts, which could be used to record messages as they arrive via telecommunication media, or to record messages in advance for later transmission via these media. It is only in telecommunication media that message production or the reproduction source is at some distance from the receiver and electronic transfer of information over a "communication" channel (wire, waveguide, or radio-waves) is involved.

systems have been noted with the underlying assumption that telecommunication media would still be needed in various situations where local control of the information transmitted or received is not a critical requirement, where an instantaneous transmission of information is desired, where a point-to-multipoint dissemination is needed, and where possible cost reductions due to the economies of scale and specialization are important. Discussions on comparative advantages and disadvantages of centralized and localized communication media are beyond the scope of this thesis. However, interested readers are referred to reports by Singh and Morgan,[17,18] DuMolin,[19] and Ohlman.[20]

While exploring the educational communication opportunities offered by satellites and BCNs or cable television systems, a broad view has been taken. Services have been extended to include not only radio and television broadcasting and distribution of television and radio signals for rebroadcasting but also facsimile and data transmission, information retrieval systems, and provision of remote computer services for instruction and instructional administration. Such an approach, though somewhat different than those often encountered in

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[17]Jai P. Singh and Robert P. Morgan, Computer-Based Instruction: A Background Paper on Its Status, Cost/Effectiveness and Telecommunications Requirements, Memorandum 71-1 (Saint Louis, Missouri: Washington University, 1971).

[18]Jai P. Singh and Robert P. Morgan, Educational Computer Utilization and Computer Communications, Memorandum 71-7 (Saint Louis, Missouri: Washington University, 1971).

[19]James R. DuMolin and Robert P. Morgan, An Instructional Satellite System for the United States: Preliminary Considerations, Memorandum 71-2 (Saint Louis, Missouri: Washington University, 1971).

[20]Herbert Ohlman, "Communication Media and Educational Technology: An Overview and Assessment with Reference to Communication Satellites" (unpublished M.S. dissertation, Washington University, 1971).

usual radio and television oriented approaches, is entirely consistent with the National Association of Educational Broadcasters Board Committee on Long Range Planning recommendations.[21] Today, there is a great deal of emphasis on individualization of instruction, interactive learning, and flexible-format access, sometimes to the point of on-demand access. These new pressures have caused several new transformations in the conventional passive media of television and radio. A number of demand-access audio systems have been implemented in the various parts of U.S.; Bell-Canada is experimenting with Information Retrieval Television (IRTV)[22] and MITRE Corporation has already demonstrated the feasibility of a time-shared, interactive, computer-controlled, information television (TICCIT).[23] Development of these new systems have also much to do with the development of wired broadband communication systems, popularly known as cable TV systems, because it is they which have opened up the avenues for any large scale implementation of the individualized media.

Earlier it was said that while exploring the opportunities offered by satellites and BCNs it would be assumed that future years would see increased and extensive use of technology in instruction, both in and out of the school house. At this point it would be

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[21]NAEB Board Committee on Long Range Planning, "Report of the NAEB Board Committee on Long Range Planning," Educational Broadcasting Review, IV (February, 1970), 23-29.

[22]C. A. Billows, "Information Retrieval by Television," Electronics and Communication, December, 1968, 35-37.

[23]J. Volks, The Reston, Virginia, Test of the MITRE Corporation's Interactive Television System, Report MTP-352 (McLean, Virginia: The MITRE Corporation, 1971).

desirable to make it clear that such an extensive utilization will not automatically come about itself. Realization of extensive technology utilization for instruction would require extensive institutional and curriculum engineering. So far the impact of technology has been small compared with the magnitude of the educational system in the United States as a whole. Its introduction into the U.S. schools has been uncoordinated, ineffective, and piecemeal. As Schramm states:

> Rather than filling a functional role in a comprehensive approach to the design of instruction, most (instructional technology) innovators have chosen or been forced to confine themselves to their own special medium or technique. Rather than moving into the center of the planning process in education, most technologically oriented educators are on its periphery.[24]

To become more effective, instructional technology must be established on an integrated, total-system basis, with broad support from teachers, administrators, and the public, as well as long-term commitment from school boards. Today, the future of instructional technology does not lie so much in the development of hardware as in the organizational and curricular innovations and re-education of teachers and educators in the value of technology as an aid to instruction. Teachers have to be taught to look at technology as a resource for developing new alternatives and individualizing instruction, rather than as a dangerous, mechanistic intruder threatening their jobs. Also, institutional reforms are necessary for the realization of the full potentials of certain technologies or instructional systems. For example, the flexibilities and speed inherent in Computer-Assisted-Instruction (CAI) systems become

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[24]Tickton, To Improve Learning, p. 23.

meaningless if it is to be implemented within a rigid lock-step educational environment.

Planning for the technology utilization involves design of least-cost instructional strategy involving a proper mix of teachers, communication media and teaching aids. It becomes a straightforward economic problem of allocating limited resources in an optimal way. Requirements are properly defined in terms of the end product and the least-cost alternative or strategy is selected from the several available alternatives. This kind of analysis requires information concerning cost and effectiveness of the various combinations of media, aids, and teacher-time for achieving certain learning goals in specific subject areas at certain educational levels. This kind of information is simply not available today. For example, as far as TV is concerned we know that it performs as well as face-to-face instruction but we do not know how the achievement varies when it is used in conjunction with other inputs. There is a need for a series of studies where a variety of instruction inputs are used towards achieving certain pre-specified instructional objectives and where relative trade-offs between various media, aids and teacher-time are obtained.

With certain generalization and oversimplifications, if we assume that T and M represent the teacher and media inputs to the educational system whose output can be defined as $Y = f(T,M)$, with the current experimental information we find that in most cases $Y(=f(T,M)) \leq f(T) + f(M)$ because in most situations media inputs have been used rather unimaginatively. There is no reason why, with a properly conceived strategy involving diverse instructional inputs and limited teacher-time substitution by media in subject areas where media instruction is more cost-effective than teacher-instruction, one cannot achieve a situation where $f(T,M) > f(T) + f(M)$. It seems that educational planners have realized this gap, and certain forthcoming educational telecommunications and technology experiments would attempt to take a first cut at it. The United States Office of Education has also realized the need for a comprehensive and coherent approach to educational planning and one should look forward to new initiatives and directions in this area through the newly established National Center for the Improvement of Educational Systems (NCIES) and National Center for Educational Technology (NCET).[25]

When one is planning a communication system, be it commercial or educational, one of the first things one wants to know is the kinds of information the proposed system would be required to carry, the performance requirements, volume of the information that is to be transferred, and the points that are to be interconnected. Some of these things would not be known until the communication media and

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[25]This new thrust is clearly evident in a document (Plan For A Satellite-Related Educational Systems Experiment) circulated by the Office of Telecommunications Policy of the U.S. Department of Health, Education, and Welfare in October 1971. In addition to raising the question of the cost-effectiveness of alternative combinations of media and teaching aids, it also raises the questions related to technology utilization -- how it could be made an integral and essential part of a learning system, what kinds of informing and training of people are necessary to get them to modify their behavior and adopt roles as needed to operationalize a defined instructional system, and what changes in the structure and function of responsible institutions are necessary and how these can be accomplished. Communication with responsible people in the policy making divisions of the Office of Education suggests that the next few years will see some 200-500 experiments dealing with educational renewal and exploring various strategies for increased technology utilization.

and other educational input tradeoffs are known and understood and one has also discovered the acceptable balance between the localized flexibility and the economies of scale obtainable from certain centralization of the delivery system that would be acceptable to the users, teachers, and school administrators. It is in this respect that one hopes that the steps would be taken to answer questions related to the place of technology in the least-cost operation of the educational enterprise and the social engineering steps required to achieve greater technology utilization. Today, it seems self-evident that various communication media and systems hold the promise for greater cost-effectiveness and thus for increasing the efficiency of the educational system. But we have yet to find out the means and ways of exploiting the hidden potentials of these media and technology oriented instructional systems within the framework of the educational establishment.

CHAPTER 2

OPPORTUNITIES WITH FIXED AND BROADCAST SATELLITES

Introduction

In this chapter, we will briefly examine the opportunities offered by the technology and the options open to educational interests for their realization. The opportunities discussed in the following section extend far beyond the much talked about program distribution for Public Broadcasting Service and National Public Radio on a national as well as sub-national scale; they cover broadcasting to remote areas and for thinly spread ethnic as well as professional groups, delivery of computer assisted instruction to remote and small schools, delivery of a great variety and volume of instructional TV programming to school CCTV, CATV and ITFS headends, and delivery of raw computing power for instructional as well as administrative uses. The discussion on system alternatives comprises the educational possibilities of the future domestic satellite systems as well as the synthesis of a dedicated educational satellite system for serving a large number of small earth-stations with high-power satellites. It also describes the thinking to date starting from the famous Ford Foundation Broadcaster's Non-Profit Satellite Proposal in 1966, and the educational satellite communication experiments that will be conducted through experimental high-power transponders onboard NASA's

Advanced Technology Satellites (ATS) -F and -G and joint United States-Canada Communications Technology Satellite (CTS).

The communication satellite family may be defined as including three basic types:

(1) Point-to-point relay satellites

(2) Distribution satellites, and

(3) Broadcasting satellites.

Relay satellites serve to provide communication between one point on the earth and another, for example, for relaying telephone and telegraph messages. This type of service is normally provided by International Telecommunications Satellite Consortium (INTELSAT) for international traffic. Distribution satellites, as they relate to sound broadcasting and television, distribute program material from one point origin to conventional terrestrial broadcasting stations, which transmit it to the end user. It corresponds closely to network operation. The distribution function may either be combined with a relay function, or be provided by a separate satellite system. The broadcasting satellite transmits signals for direct reception by the general public. The 1971 World Administrative Radio Conference (WARC) has defined only two types of communication satellite services: (1) Fixed-Satellite Service, and (2) Broadcasting-Satellite Service. Fixed-Satellite Service (FSS) is defined as a space service for point-to-point communication between fixed earth stations via active/passive satellites. By the virtue of the altitude of the satellite, this service is also capable of distributing program material over a wide area for rebroadcast purposes. Broadcasting-Satellite Service (BSS) is defined as a space service in which signals transmitted or retransmitted by satellites are intended for direct reception by the general public either individually or through a community installation. Community systems use moderately sized, medium power satellites to distribute a few television and/or radio channels to many augmented receivers which are either viewed directly by groups of people or connected to a local redistribution system. ETV/ITV systems, CATV systems, and CCTV installations are primary applications. The difference between the program distribution services through FSS and BSS is that FSS generally uses low-power satellites and rather large, sophisticated earth terminals to meet the highest signal quality recommended by the International Radio Consultative Committee (CCIR), whereas program distribution involved in a community type BSS uses relatively high-power satellites and low-priced earth stations. In a community type BSS service, performance requirements for TV or radio signal distribution may be relaxed below CCIR recommendations.

Direct broadcast systems intended for individual reception use large, high-power satellites to broadcast limited numbers of TV channels directly to augmented home receivers. Direct broadcast to unaugmented home receivers is no longer feasible as 1971 WARC regulations do not allow use of conventional Amplitude Modulation - Vestigial Sideband (AM-VSB) transmission from space in the 620-790 MHz frequency band. WARC regulations specifically prescribe use of Frequency Modulation (FM) for space broadcasting in this band.[1] Such a restriction requires addition of a sub-system to convert FM modulation to AM-VSB if

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[1]Jai P. Singh, Operating Frequencies for Educational Satellite Services, Memorandum 71-10 (Saint Louis, Missouri: Washington University, 1971).

if conventional home receivers are to be used. For transmissions in other space broadcasting frequency bands (2.5 GHz, 12 GHz, etc.), augmentation is required even with AM-VSB transmission because ordinary home receivers are not designed to receive transmissions in these frequency bands.[2]

The beginning of the communications satellites is traced to the successful launching of the Store and Forward Repeater (SCORE) satellite by the Signal Corps on December 18, 1958. SCORE was a low-altitude satellite with a delayed repeater without any power-generation facility onboard. Since this event, which took place almost thirteen years ago, communication satellite technology has travelled a long way and has acquired a high degree of sophistication through a series of steps from SCORE, Courier IB, Echo I and II, to Telestar I and II and relay satellites and thereon to Syncom-II, Early Bird, Intelsat II, III and IV.[3] Communications satellites prior to Syncom used controlled orbits of low to medium altitude and had antennae of negligible gain. Such satellites could be used only while mutually visible by two full-tracking earth stations. The successful launch of Syncom-II in July 1963 ushered in an era of uninterrupted

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[2]Direct broadcasting to unaugmented receivers was intentionally avoided because many nations feared exploitation of these services by developed nations (specifically U.S.A. and U.S.S.R.) for propaganda purposes. Even if Amplitude Modulation - Vestigial Sideband transmissions were allowed in 620-790 MHz frequency band making possible direct broadcasting to standard home receivers, in all likelihood U.S.A. would hever have used it domestically because these frequencies are being used rather extensively for terrestrial communications (including UHF-TV).

[3]J. R. Pierce, The Beginnings of Satellite Communication (San Francisco: San Francisco Press, 1968).

communications through stationary satellites and less complex non-tracking earth stations. Early Bird or Intelsat-I, launched in April 1965, was the first commercial communications satellite in the geo-stationary orbit linking Europe and America, and was patterned after Syncom. Since the launching of Intelsat-I, INTELSAT consortium has launched some 10 operational satellites in three different series (Intelsat-II, -III, and -IV), but the only significant changes have come about in the communications capacity of the satellites belonging to the various series. Intelsat-II had a 240 voice circuit capacity, Intelsat-III 1,200 circuits or 4 TV channels, and Intelsat-IV is capable of accommodating 3,000 circuits with transponders in the earth mode and 9000 circuits with transponders in spot beam coverage mode, or 12 TV channels.[4] There has not been much increase in power radiated over an unit bandwidth. Communications satellites for defense have advanced from the 100-pound Initial Defense Communication Satellite (IDCS) to 500-, 1000-, and 1500-pound spacecraft (United Kingdom Skynet-I, U.S. Defense Phase II, and Tactical Communications Satellite Program, respectively). However, all of these satellite programs continue to use low-powered transmitters--under 10 watt of output except for the 20 watt transponder onboard TACSAT. As Feldman states:

> . . .this work with low-power satellites will not gain them (satellites) an ascendant role in the "communications revolution". To play a leading role, communications satellites must either provide significantly new services or drastically reduce the cost of existing ones.[5]

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[4]Communications Satellite Corporation. Pocket Guide to the Global Satellite System (Washington: Communications Satellite Corporation, 1970).

[5]Nathaniel E. Feldman and Charles M. Kelly, "The Communication Satellite--A Perspective for the 1970's," Astronautics and Aeronautics, September, 1971, 25.

Intercontinental TV service provided by Intelsat, even through low-power satellites and complex earth-stations, is a new service, but the duplication of a similar system for domestic communications is bound to inhibit its extensive exploitation. The cost of communication has a direct bearing over the new opportunities and services, and duplication of an Intelsat type system with few isolated earth stations is certainly not going to reduce the communication cost significantly below what Intelsat charges ($3,000 per hour for TV relay). One should also realize that in an Intelsat type system, some 85 percent of this cost is directly attributable to complex earth stations located in isolated areas[6] and the terrestrial microwave/cable facilities connecting earth station with the TV operating center.[7] However, high-power satellites, whether they be fixed- or broadcast type, operating in frequency bands that allow colocation of low-cost earth stations in the close proximity of the redistributing/originating centers and user clusters open up the avenues for significant cost reductions as well as introduction of many new services that can not be implemented with a low-power satellite operating in standard 4 and 6 GHz frequency bands.

Satellite-Based Educational Communication Services

A great deal has been written on satellite applications for education. However, most of it pertains to the distribution of public

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[6]Intelsat satellites use 4 and 6 GHz frequency bands that are shared with terrestrial common carrier facilities on a coequal basis. Due to concentration of 4 and 6 GHz common carrier facilities in most urban areas, it becomes necessary to site the satellite earth station in isolated areas far away from the areas of common carrier concentration to avoid undue interference to and from terrestrial common carriers.

[7]Feldman and Kelly, Communication Satellite, p. 28.

television and radio network signal to affiliate stations, CATV headends and community installations in remote areas that lack either broadcast stations or CATV facilities. Anyone who has followed the literature in this area would readily concur with the statement that most authors have somehow treated TV and radio program distribution and broadcasting as the sole possibilities for satellite-based educational telecommunications. The absence of any discussion on the delivery of educational interactive communication media by satellites is astonishing and even more so when there seems to be increasing emphasis on the individualization of learning and learner-system interaction. What must be realized is that a satellite system is nothing but a delivery system with certain unique characteristics and could be made a part of any instructional system employing any combination of media as long as the information flow does not exceed the communication capacity of the satellite channel. Satellite channels could be used to distribute TV programs, carry voice or data. Their use will be primarily dictated in the situations where they seem to offer a distinct edge over competitive transmission alternatives in terms of cost or provide new services that are not possible without it.

The high cost of present long-distance communications have resulted in their scant use in U.S. schools and colleges. Very few institutions use such services--and then only in limited experimental operations. A Stanford Research Institute study has projected only a small decrease in the communication costs for the 1970's. This

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[8]H. M. Zeidler, et. al., Patterns of Technology in Data Processing and Data Communications, Report 7379B-4 (Menlo Park, California: Stanford Research Institute, 1969).

combined with the fact that cost of a telephone line has been very much constant over the last decade are quite surprising when one considers the advances in terrestrial microwave, coaxial line, millimeters waveguides, and satellite communication that have taken place. The fact is that such long-haul systems have indeed dropped the long-haul portion of the telephone circuit cost and further reductions are expected. But the problem is the local telephone plant that has become increasingly labor intensive and the cost increases therin have offset the reductions in the long-haul portion to the point where it accounts for over 80 percent of the cost of long-distance connections. In certain applications, those relating to data transmission, it is the nature of the existing telecommunications plant that impedes its increased utilization. Because of the economic factors, the Bell plant has been built so that each improvement, in general, has been compatible with the existing facilities. The basic nature of the network has remained suited for analog communication, particularly voice, and discriminates against digital transmission such as those encountered in remote computer time-sharing, inter-computer communication, etc. A detailed discussion on the inadequacies of the existing telecommunications plant for data transmission are beyond the scope of this thesis and interested readers are referred to the SRI study on the matter.[8,9] In a nutshell, there is a lot to be gained by developing a service that bypasses the local

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[9]Donald A. Dunn, Policy Issues Presented by the Interdependence of Computer and Communications Services, Report 7379B-1 (Menlo Park, California: Stanford Research Institute, 1969).

telephone plant facilities and provides direct interconnection between the user and the resource center, among resource centers, and between program origination centers and redistribution facilities.

It has been suggested that satellites may have an important role in:[10]

(1) Interconnecting educational institutions, particularly those related to higher education, among themselves and with certain service and resource centers, for sharing of instructional, research and administrative resources; for providing institutions poor in certain resources with access to services which otherwise might not be available.

(2) Interconnecting remote and isolated institutions with certain service and resource centers to provide students and teachers therein equitable access to services such as computing, computer-managed/based instruction (CAI/CMI), etc. that are currently more readily available to their counterparts in urban and suburban areas, and to provide in-service teacher development programs; and

(3) Delivery of both public as well as instructional television and radio programs to cable and ITFS headends and broadcast stations for either real-time or delayed redistribution for in-school as well as in-home utilization.

Table 1 shows the possible roles for communications satellites in the delivery of certain media and services such as ITV, CAI,

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[10]Robert P. Morgan and Jai P. Singh, Progress Report--Program on Application of Communications Satellites to Educational Development (Saint Louis, Missouri: Washington University, 1971), pp. 43-52.

TABLE 1

Primary Roles for Satellites Towards the Delivery of Certain Educational Communications Media and Services

SERVICE	PRIMARY ROLES FOR SATELLITES
Instructional Television	Direct delivery to schools and learning centers, to broadcast stations, ITFS and cable headends for further redistribution.
Computer-Assisted Instruction	Delivery of CAI to small, remote institutions, particularly those 50-70 miles or more away from a major metropolitan area.
<u>Computing Resources</u>	
Multi-Access Interactive Computing	Delivery of interactive computing to remote institutions for the purposes of problem solving and implementation of regional EIS.
Remote Batch Processing	Delivery of raw computing power to small, remote institutions for instructional computing and administrative data processing.
Computer Interconnection	Interconnection of the computer facilities of institutions of higher education and regional computer networks for resource sharing.
<u>Information Resource Sharing</u>	
Interlibrary Communication	Interconnection of major libraries for bibliographic search and interlibrary loans, etc.
Automated Remote Information Retrieval	Interconnection of institutional and/or CATV headends with major information storage centers.
Teleconferencing	Interconnection of educational institutions for information exchange without physical movement of the participants and for gaining access to specialists.

computing resources, and information resource sharing. These roles have been defined by taking into account the present and near-term state-of-the-art of satellite technology and other competing alternatives and are based on detailed studies by Jamison et. al.[11] and Singh and Morgan.[12,13,14] Table 1 defines the role of satellites in the delivery of certain specific services for in-school utilization; it excludes the whole question of in-home utilization or utilization in learning centers that bypass the conventional certification system. If the current level of American interest in the Open University of England is any indication of the future along with the fact that a similar program (not supported by broadcasting) has been initiated in New York through Ford Foundation support,[15] communication satellites jointly with CATV systems may become the delivery mechanism for such instruction.

The networking needs for Public Broadcasting Service (PBS) and the National Public Radio (NPR) have been defined by the Corporation for Public Broadcasting in its filing with the Federal Communications Commission (FCC) in the matter of establishment of domestic

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[11]Dean Jamison, John Ball, and James Potter, "Communication Economics of Interactive Instruction for Rural Areas: Satellite versus Commercial Telephone Systems" (unpublished report, Graduate School of Business, Stanford University, 1971).

[12]Morgan and Singh, Application of Communications Satellites, p. 43.

[13]Singh and Morgan, Computer-Based Instruction, pp. 20-30.

[14]Singh and Morgan, Computer Utilization and Communications, pp. 66-79.

[15]External Degree Program, Newsletter, Syracuse University Research Corporation, I (September, 1971), p. 1.

communication satellite facilities (Docket 16495).[16] However, one must remember that both PBS and NPR are relatively new national constructs and the expectations for future are not in terms of firm requirements but in future possibilities. Tables 2 and 3 present the current and near-term expected satellite networking requirements for NPR and PBS on the basis of the CPB filing[17] and a General Electric study[18] for PBS. Unlike commercial broadcasting network practices, there is a great deal of emphasis on multiple point origination, sub-national program distribution provisions or regional split, and channels for program assembly from distant affiliates. Both PBS and NPR have agreed upon a common list of 28 origination points. PBS networking requirements are also different from those of commercial TV networks in that they specify stereo audio and a dual grade of service--a very high performance link for program distribution to broadcast stations and an adequate but slightly lower performance link for school roof-top and CATV installations. NPR requirements or expectations differ from those of their commercial counterparts in the respect that NPR is trying to build a high-fidelity stereo network--something that does not exist today primarily because of the cost and inadequacy of the AT&T plant. Currently radio as well as TV networking is limited to rather

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[16]Federal Communications Commission, Docket 16495, "Comments of the Corporation for Public Broadcasting and the Public Broadcasting Service," Docket 16495, May 12, 1971.

[17]Ibid.

[18]J. H. Dysinger, et. al., An Investigation of Network Television Distribution Systems, Report to the Public Broadcasting Service, Washington, D. C., February, 1971 (Washington, D. C.: Public Broadcasting Service, 1971).

TABLE 2

Public Radio Service Interconnection Requirements

SOURCES	DESTINATIONS
NATIONAL PUBLIC RADIO (NPR)	92 MAJOR EDUCATIONAL RADIO STATIONS
NATIONAL EDUCATIONAL RADIO NETWORK (NERN)	CATV HEADENDS
REGIONAL RADIO NETWORKS (CURRENTLY UNDER DEVELOPMENT)	COMMUNITY AND SCHOOL RECEIVERS, LOW POWER REBROADCAST TRANSMITTERS THROUGH DIRECT SATELLITE DISTRIBUTION/BROADCASTING IN REMOTE AREAS OF ALASKA, MOUNTAIN STATES AND APPALACHIA WHICH DO NOT HAVE ACCESS TO ANY ER SERVICE.

SYSTEM REQUIREMENTS

(A) PROGRAM DISTRIBUTION

- 50 STATE COVERAGE
- NATIONAL AND SUB-NATIONAL PROGRAM DISTRIBUTION PROVISION
- PROVISION FOR MULTIPLE POINT ORIGINATIONS
- DELAYED PROGRAMMING FOR MOUNTAIN AND PACIFIC TIME-ZONES
- PROVISION OF A 3.5 kHz ORDER WIRE WITH EACH OF THE TWO "CHANNELS" CONSISTING OF TWO 15-kHz AUDIO CHANNELS FOR STEREOPHONIC SOUND
- PROVISION FOR PART-TIME USE OF ADDITIONAL CHANNELS FOR REGIONAL SPLIT, PROGRAM ASSEMBLY AND SPECIAL EVENT COVERAGE
- SPACE LINK WITH A SIGNAL TO NOISE RATIO OF 50 dB

(B) DIRECT DISTRIBUTION TO COMMUNITY INSTALLATIONS

- SUB-NATIONAL COVERAGE -- ALASKA, ROCKY MOUNTAINS AND APPALACHIA
- SEPARATE CHANNEL FOR EACH AREA
- PROVISION FOR REGIONAL AS WELL AS NATIONAL MULTI-POINT PROGRAM ORIGINATIONS
- A CHANNEL-WIDTH OF 15 kHz
- SPACE LINK WITH A SIGNAL TO NOISE RATIO OF 43 dB

TABLE 3

Public Television Service Interconnection Requirements

SOURCES	DESTINATIONS
PUBLIC BROADCASTING SERVICE (PBS) EASTERN EDUCATIONAL TELEVISION NETWORK (EETN) CENTRAL EDUCATIONAL NETWORK (CEN)	207 PTV/ITV STATIONS FOR REDIFFUSION VIA 109 FEED POINTS; ADDITIONAL 98 TO BE FED THROUGH STATE NETWORKS.
SOUTHERN EDUCATIONAL COMMUNICATIONS ASSOCIATION (SECA)	CABLE TELEVISION (CATV) HEADENDS.
MIDWESTERN EDUCATIONAL TELEVISION (MET) ROCKY MOUNTAIN PUBLIC BROADCASTING NETWORK (RMPBN) WESTERN EDUCATIONAL NETWORK (WEN) NATIONAL EDUCATIONAL TELEVISION (NET) CHILDRENS TELEVISION WORKSHOP (CTW)	COMMUNITY AND SCHOOL RECEIVERS THROUGH DIRECT DISTRIBUTION BROADCASTING FROM SATELLITE(S) IN REMOTE AREAS OF ALASKA, MOUNTAIN STATES AND APPALACHIA WHICH DO NOT HAVE ACCESS TO ANY ETV SERVICE.

SYSTEM REQUIREMENTS

(A) PROGRAM DISTRIBUTION

- 50 STATE COVERAGE
- NATIONAL AND SUB-NATIONAL DISTRIBUTION PROVISIONS
- DELAYED PROGRAMMING FOR PACIFIC AND MOUNTAIN TIME-ZONES
- PROVISION FOR MULTIPLE POINT ORIGINATIONS
- PROVISION OF AN ORDER WIRE FOR EACH CHANNEL
- PROVISION OF PART-TIME USE OF ADDITIONAL CHANNELS FOR SPECIAL EVENT COVERAGE, SPECIAL TIME-ZONE DELAYS, PROGRAM ASSEMBLY, REGIONAL SPLITS ETC. IN ADDITION TO TWO SATELLITE CHANNELS DURING 0600-2400 HOURS EVERY DAY
- TWO 15-kHz SOUND CHANNELS FOR STEREOPHONIC SOUND
- SPACE LINK CONFORMING TO CCIR RECOMMENDATIONS, i.e. A SNR OF 55 dB

(B) DIRECT DISTRIBUTION TO COMMUNITY INSTALLATIONS

- SUB-NATIONAL COVERAGE -- ALASKA, ROCKY MOUNTAINS AND APPALACHIA
- SEPARATE CHANNEL FOR EACH AREA
- PROVISION FOR NATIONAL AS WELL AS REGIONAL PROGRAM ORIGINATION
- PROVISION FOR PART-TIME USE OF ADDITIONAL CHANNELS FOR EVENINGS AND WEEKENDS
- ONE 15-kHz SOUND CHANNEL FOR MONOPHONIC SOUND
- SPACE LINK WITH A SNR OF 43.5 dB TO PROVIDE TASO GRADE 2 SIGNAL

low quality audio based on either 3.5 or 5 kHz wide channels. Most high-fidelity and stereo programs are prerecorded and trucked.

Options for Educational Satellite Systems

Possible communications satellite systems for education are depicted in Figure 2, as are the important components that go into their making--type of satellite and service, uplink and downlink (earth-to-space and space-to-earth) transmission frequencies, modulation, reception by users and the mode of education. In this section, the implications of the various alternatives for satellite, service, and frequency of operation would be discussed in detail from the technoeconomic and policy viewpoints. However, the frequencies would be the first subject because they affect the discussions on satellites as well as satellite services.

Operational Frequencies for Satellite Services

The process of selecting operational frequencies for fixed- as well as broadcasting-satellites involves many considerations--international radio regulations, natural environment, man-made noise, hardware considerations, and interconnection and spectrum space considerations--and in its turn the operational frequency has great implications over the system economics. A detailed and up-to-date discussion on the choice of operating frequencies for educational satellite services could be found elsewhere.[19] Here it would suffice to say that frequency allocations were effected internationally by the

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[19]Singh, Operating Frequencies, pp. 50-51.

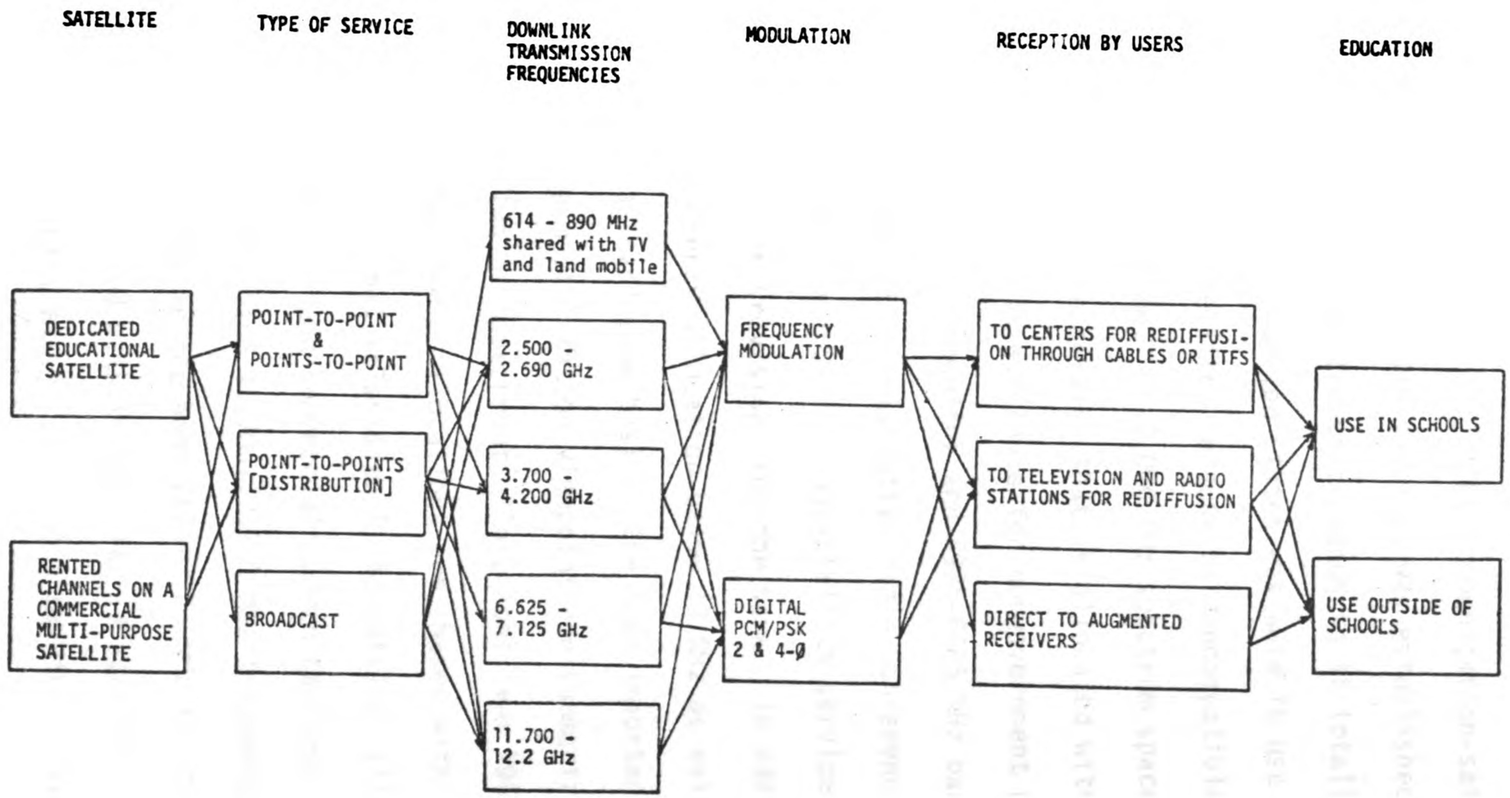

FIGURE 2

Possible Communications Satellite Systems for Education

1963 Extraordinary Administrative Radio Conference (EARC) and 1971 World Administrative Radio Conference (WARC) of the International Telecommunications Union (ITU). The communication-satellite service (now known as fixed-satellite service) was established by the 1963 EARC which allocated five frequency bands to it totalling 2,600 MHz of spectrum space. The United States was able to use only 2,000 MHz for communications satellites because of noncompatible use of 600 MHz for terrestrial purposes. Of 2,000 MHz spectrum space for communication-satellite service that is allocated within the U.S., only 50 percent of it is available for nongovernment purposes (3700-4200 MHz band for downlink and 5925-6425 MHz band for uplink).

The 1971 World Administrative Radio Conference established a new space service--the broadcasting-satellite service--and effected frequency allocation provisions for the same. In addition, WARC also effected new frequency allocation below 10 GHz as well as above it on shared as well as exclusive basis. The most important allocations from the near-term utilization viewpoint are summarized in Table 4 along with the two nongovernment allocations from 1963 EARC. It should be recognized that these allocations are shared with terrestrial services--Instructional Television Fixed Service (ITFS) in the case of 2500-2690 MHz band and commercial common carriers in the case of 3700-4200, 5925-6425, and 11,700-12,200 MHz frequency bands. Downlink frequency allocation in the band 6625-7125 MHz for television program distribution is shared with terrestrial TV auxiliary broadcast (studio-to-transmitter links, etc.). Table 5 shows the current terrestrial utilization of these frequency bands. The greater is the terrestrial utilization, the more difficult is the use of frequency bands for

TABLE 4

Fixed- and Broadcasting-Satellite Frequency Bands of Near-Term Importance

Frequency Band	Service	Flux-Density Limitation	Shared Terrestrial Services
2500-2535 MHz	Fixed-Satellite Downlink	-154 dBW/m^2/4 kHz	Instructional Television Fixed Service (ITFS)
2500-2690 MHz	Broadcasting Satellite Downlink	-152 dBW/m^2/4 kHz	ITFS
2655-2690 MHz	Fixed-Satellite Uplink	. . . .	ITFS
3700-4200 MHz	Fixed-Satellite Downlink	-152 dBW/m^2/4 kHz at 5° escalating to -142 dBW/m^2/4 kHz at 25°	Common Carrier
5925-6425 MHz	Fixed-Satellite Uplink	. . . .	Common Carrier
6625-7125 MHz	Fixed-Satellite Downlink	-152 dBW/m^2/4 kHz at 5° escalating to -142 dBW/m^2/4 kHz at 25°	Operational Fixed (6575-6878 MHz) TV auxiliary broadcast (6875-7125 MHz)
10,950-11,200 MHz	Fixed Satellite Downlink	-152 dBW/m^2/4 kHz at 5° escalating to -142 dBW/m^2/4 kHz at 25°	Common Carrier - F
11,450-11,700 MHz	Fixed Satellite Downlink	-152 dBW/m^2/4 kHz at 5° escalating to -142 dBW/m^2/4 kHz at 25°	Common Carrier - F
11,700-12,200 MHz	Fixed Satellite Downlink Broadcasting Satellite Downlink	. . . .	Common Carrier - M

TABLE 5

Comparison of Microwave Channel Utilization by Terrestrial Facilities

Frequency Band (MHz)	Service	Allowable Channel Bandwidth (MHz)	Number of Channels Derived[a]	Number of Authorizations[b]	Authorizations Per Channel
2,500- 2,690	Instructional Television Fixed Service	6	31	155	...
3,700- 4,200	Common Carrier	30	17	16,620	978
5,925- 6,425	Common Carrier	30	17	11,820	695
6,575- 6,875	Operational Fixed (Public Safety and Industrial)	10	30	7,310	244
6,875- 7,125	TV Auxiliary Broadcast[c]	25	10	2,050	205
12,700-13,250	TV Auxiliary Broadcast[c]	17	7	310	14
12,200-12,700	Operational Fixed	20	25	490	196

[a]Maximum bandwidth, nonoverlapping.

[b]Estimated from FCC frequency list dated August 7, 1970.

[c]Includes TV pick-up, TV STL, TV intercity relay, and TV translator relay.

satellite communications from the viewpoint of earth-station locations and interference avoidance. As is evident from Table 5, 3700-4200 and 5925-6425 MHz bands are the most heavily used of all the allocations. This necessitates use of highly directive antennae for the earth-station and, in most cases, siting the earth-station away from the urban areas saturated with common carrier microwave links operating in 4 and 6 GHz frequency bands. Earth-station siting is not that difficult and expensive in the 2.5 GHz and 12 GHz frequency bands which are relatively little used.

From the viewpoint of educational applications, 2.5 GHz frequency band[20] offers most economical operation--manageable antenna size, relatively tested hardware and low hardware cost, low rain attenuation, etc. However, this band is only 190 MHz wide and it has been speculated that all 190 MHz bandwidth may never be used in the Northern America due to certain astronomical instruments that operate above 2670 MHz. In addition, 35 MHz-wide chunks of this band, on both ends, are also allocated to the fixed-satellite service for small earth-terminal communications. In these situations, the educators would be able to exploit only 120-155 MHz spectrum space in this band,

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[20] 2500-2690 MHz frequency band was pushed by the United States in the WARC for educational applications. Though the WARC recommendations mark this entire band (except the two 35-MHz wide pieces on the two extremes of it) for broadcasting-satellite downlink, it is speculated that the forthcoming domestic rule-making in the matter of the national table of frequency allocations would eliminate this restriction and allow the use of this band within the United States for all sorts of educational telecommunications. If this restriction is not removed, it would not be possible to use this band for interactive communications except for the two 35-MHz pieces.

i.e., distribution of some 4-6 TV channels or equivalent in a particular geographic area. It is very conceivable that the demands for educational communications might exceed the capacity of this band. In this case, it has been suggested[21] that educators should look to the 11,700-12,200 MHz frequency band for accommodating additional services. It is also recommended that interactive communication services be given preference over TV and radio program distribution in the 2500 MHz band and that program distributing services or broadcasting to community installations be accommodated in the 11,700-12,200 MHz band. Use of any other frequency band below 12,200 MHz with 2,500 MHz band would only further complicate the colocation problem.

From a system economics viewpoint, under ideal conditions, lower frequency bands hold most promise. For area coverage satellite relays to small terminals where the available downlink power is the most limiting constraint on system performance, it has been shown that system capacity performance degrades rapidly with increasing frequency, e.g., 10 dB between 1 and 12 GHz, as determined by the potential satellite relay downlink capacity.[22] Higher frequencies suffer from increased atmospheric attenuation, particularly during rainfall periods, and electronic equipment operating at higher frequencies cost more as well as have comparatively poorer raw electrical power to radio frequency power conversion efficiencies. However, it should be

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[21]Singh, Operating Frequencies, pp. 50-51.

[22]John L. Hult, Spectrum for Area Coverage From Satellite Relays to Small Terminals, Paper P-4301 (Santa Monica, California: The Rand Corporation, 1970).

realized that satellite systems seldom operate under ideal conditions. As discussed earlier, satellite services share frequencies of near-term interest with terrestrial facilities. Since terrestrial systems have been in existence long before the inception of space services and lower frequency bands (1-10 GHz) are attractive for their purposes too, lower frequency bands were extensively exploited by the terrestrial systems. Interference protection considerations inherent in the frequency sharing framework limit the maximum power that satellites could radiate and dictate--a certain minimum separation between the stations of the two systems using same frequency bands. Figure 3 illustrates the performance of the various downlink bands listed in Table 4 for a high quality TV relay link (52 dB Signal-to-Noise Ratio) with 99.95 percent reliability.[23] It shows the possible tradeoffs between the satellite power and ground station complexity and hence cost; it also shows the limit to which these tradeoffs could be carrier out--limits imposed by power flux density restrictions listed in Table 4. Satellite Effective Radiated Power (ERP) is directly related with the satellite cost whereas Earth Station Figure of Merit is a measure of the earth station sensitivity. The larger is the figure of merit, the greater is the sensitivity and the cost. It is clear from the tradeoffs shown in Figure 3 that 2.5 GHz and 12 GHz downlink have the potential of delivering high quality TV signal to very small terminals (costing few hundred of dollars). However, it should also be noted that operation with small terminals requires rather high-power transmissions from

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[23]Link reliability represents the availability of certain signal strength for certain percent of the times.

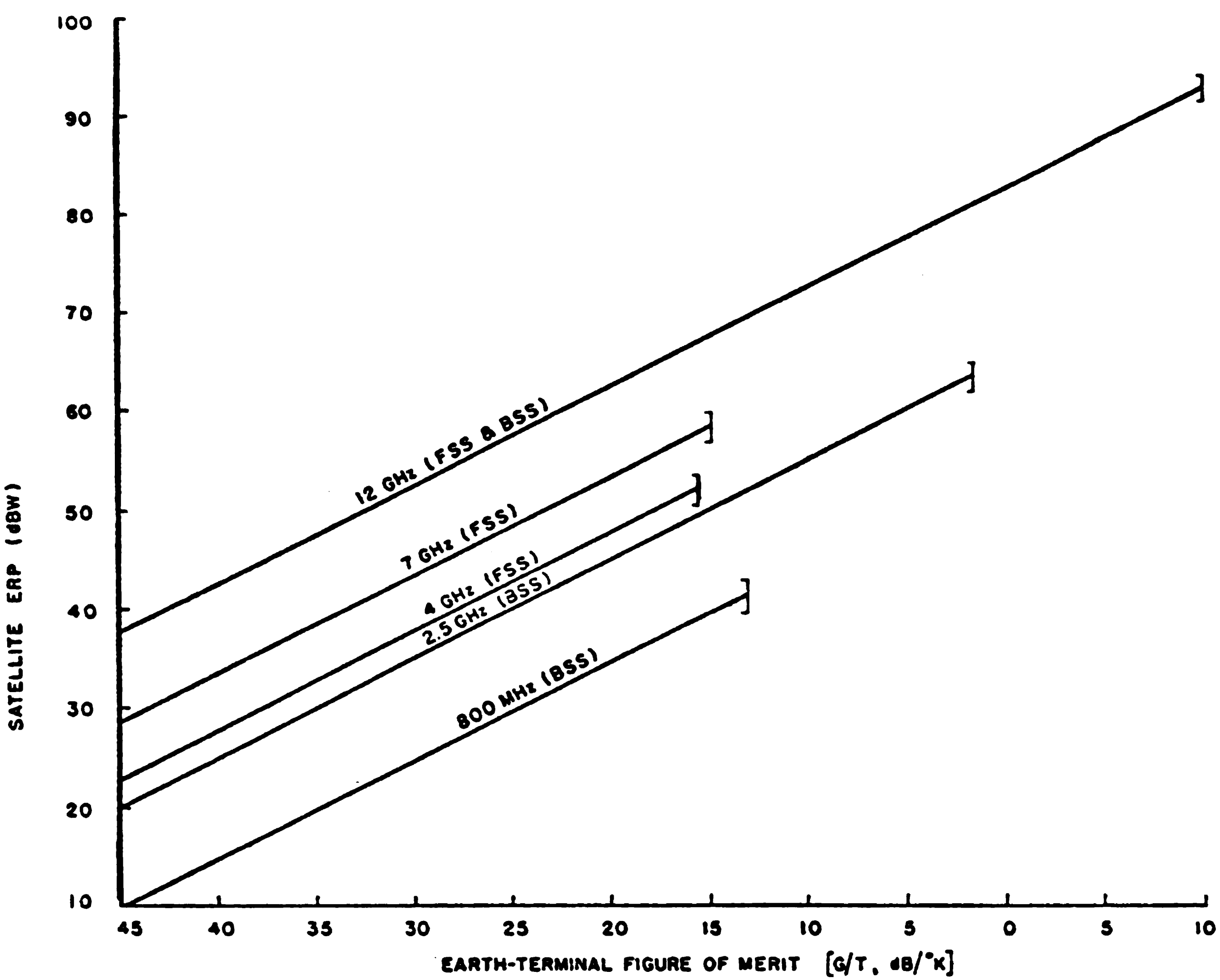

FIGURE 3

Earth-Terminal Figure of Merit [G/T, dB/°K] Performances Calculated for a 99.95 Percent Link Reliability, 52 dB SNR Performance, 20 MHz RF Bandwidth and $B_{RF}/B_V = 4.77$

the satellite, and it presents the least-cost design only when the system is going to employ a large number of earth stations.

Figure 4 shows the tradeoffs involved in synthesizing the least-cost system. As the space segment cost decreases, implying less flux density on ground or smaller power output from the satellite, the ground terminal (segment) cost must increase to provide a specified level of performance. The total system cost is the sum of space and ground segment costs and a minimum cost synthesis leads towards a more expensive satellite and a less expensive ground terminal as the number of ground terminals or stations increases. Figure 4 shows two tradeoffs--one with 10,000 ground terminals and the other with 1 million, and as shown the least-cost solution for 1 million direct delivery points would involve a satellite with higher radiated power and lower-cost earth terminal units than those for the system involving only 10,000 direct delivery points.

Domestic Satellite Proceedings and Educational Communications

On January 23, 1970, Peter Flanigan, Assistant to President Nixon, wrote a memorandum to Dean Burch, Chairman of the Federal Communications Commission recommending a competitive, unregulated approach for the establishment of domestic communication satellite facilities.[24] This memorandum constituted a clear and much needed Presidential-level direction for policy, the absence of which had been the real stumbling block in the domestic satellite proceedings to that date. Communication

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[24]United States, The White House, Press Release, Memorandum to Honourable Dean Burch from Peter Flanigan (Washington, D. C.: The White House Press Office, January 23, 1970).

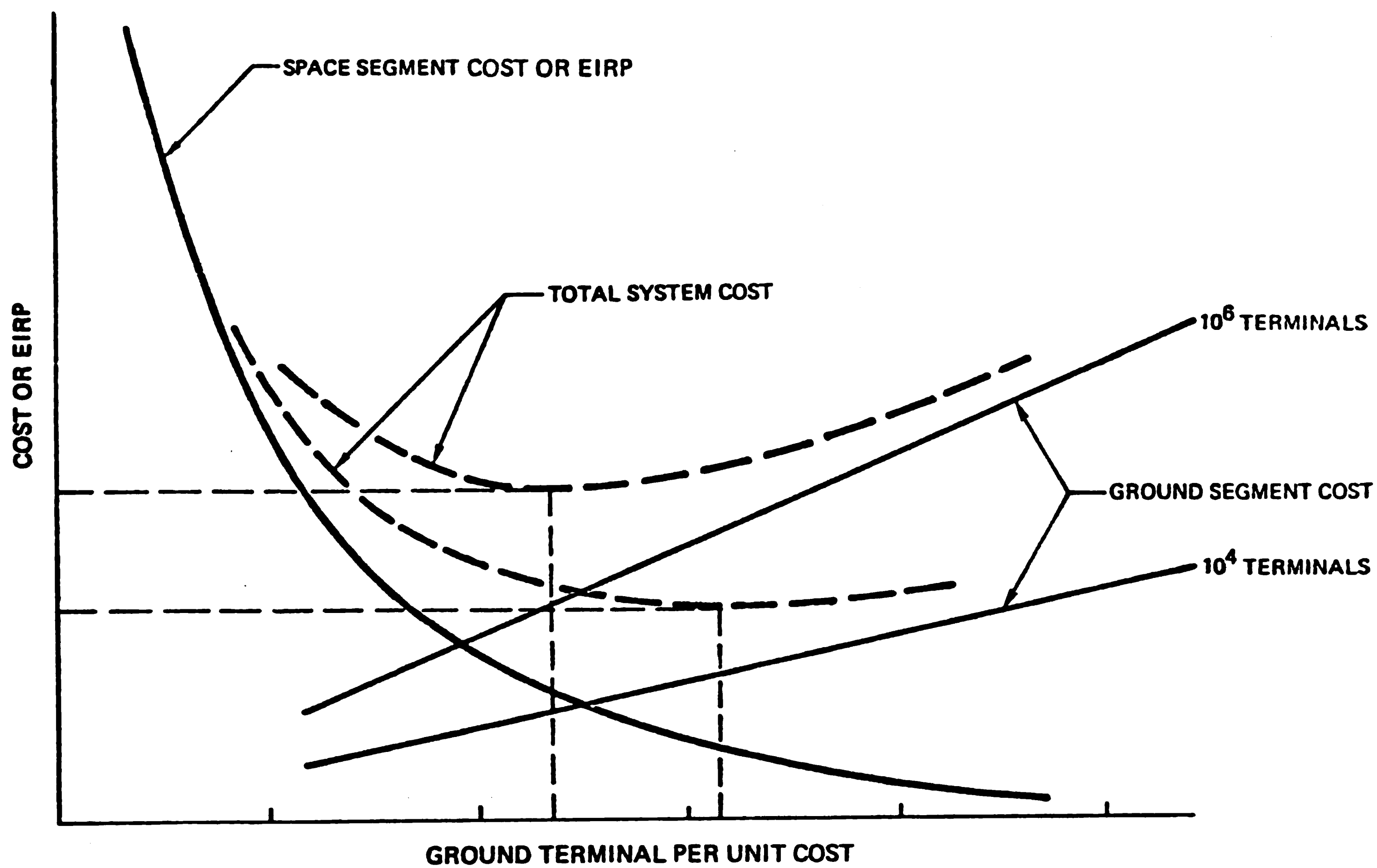

FIGURE 4

Graphical Representation of Performance/Cost Trade-Offs

Satellite Corporation (COMSAT) held the view that it had a Congressional mandate through the 1962 Communications Satellite Act that established it as a "carrier's carrier" and that it was COMSAT's responsibility to maintain and own earth stations used with its satellites. There were others who did not agree with COMSAT's interpretation of the 1962 Act. The Presidential directive, based on an extensive study headed by Clay T. Whitehead, now Head of the Office of Telecommunications Policy, also represented a clear reversal from the actions recommended by the telecommunications task force established by President Johnson under the leadership of Eugene V. Rostov. The Rostov Task Force had recommended a demonstration pilot domestic satellite program using the most advanced technology available and having COMSAT as the trustee-owner of the space segment and manager of the program. Free satellite channels were to be provided for non-commercial and instructional television programming.[25]

Some two months after receiving the Presidential recommendations, the Federal Communications Commission issued a new report and order on March 20, 1970, inviting applications for the establishment of domestic communication satellite facilities. However, the FCC refrained from making any policy decisions regarding the number of systems it would permit in view of the limited spectrum and orbit resources as well as the whole question of a monopolistic control over the system versus an unregulated, competitive approach. These were left for decision after all the applications were received and

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[25]Eugene V. Rostov, Final Report of the President's Task Force On Communications Policy, 1967 (Washington, D. C.: Government Printing Office, 1969), Chapter Five.

studied. The above-mentioned Report and Order (Docket 16495, March 20, 1970) also declared that applicants proposing multipurpose domestic communications satellite systems should discuss the terms and conditions under which satellite services will be made available for data and computer usage in meeting the instructional, educational, and administrative requirements of educational institutions. The FCC further stated that applicants seeking authorization for domestic communications satellite system should define the terms and conditions under which satellite channels will be made available for non-commercial broadcast networks, if the applicant's proposed service includes commercial television or radio program distribution.

At the March 15, 1971 deadline for submissions to the FCC for domestic satellite proposals, eight common carriers and aerospace companies had submitted proposals: (1) COMSAT; (2) COMSAT-AT&T; (3) Fairchild Hiller; (4) MCI-Lockheed; (5) Western Telecommunications; (6) RCA Global Communications; (7) Hughes-GT&E; and (3) Western Union. Some significant technical characteristics and public service offerings of these eight proposals are summarized in Table 6. Figure 5 shows the operating channel capacity of the eight proposals whereas Figure 6 provides a graphical representation of the total system cost presented to the FCC by each applicant.

The Corporation for Public Broadcasting also submitted its comments in response to the FCC Report and Order reminding the FCC of CPB and PBS's strong interest in the domestic satellite proceedings because the Commission's decisions were likely to have a strong impact

TABLE 6

Summary of Domestic Satellite Filings

	AT&T/COMSAT	COMSAT	MCI-LOCKHEED	FAIRCHILD-HILLER
SYSTEM				
Number of Satellites	3 in Orbit 1 ground spare	3 in Orbit 1 ground spare	2 in Orbit 1 ground spare	2 in Orbit 1 ground spare
Orbit Locations [Longitudes]	94°, 104°, 119°W.	99°, 114°, 124°W.	114°, 119°W	104°, 115°W.
SATELLITE				
Weight at Sync. Orbit	1600 pounds	1600 pounds	3900 pounds	2905 pounds
Spacecraft Size	110 inches in diameter 230 inches in height	110 inches in diameter 230 inches in height	8' x 5' x 6' [Stowed] x106' [unfurled]	9' in diameter (Stowed) 25.3' in length
Stabilization	Spin	Spin	3-Axis [Momentum-wheels]	3-Axis [Momentum-wheels]
Station Keeping	Hydrazine Thrusters	Hydrazine Thrusters	Ion Propulsion Thrusters and Hydrazine Engines	Hydrazine Thrusters
Primary Power	~740 watts [solar cells on drum]	~740 watts [solar cells on drum]	4.4 kW [Solar Cell Array]	750 watts (solar cell cylinder)
Life Time	7 years	7 years	10 years	7 years
Launch Vehicle	Atlas Centaur	Atlas Centaur	Titan III D/Agena	Titan III C
COMMUNICATION SUB-SYSTEM				
Frequency Bands [Receive/Transmit]	5.925-6.425/3.7-4.2 GHz	5.925-6.425/3.7-4.2 GHz	5.925-6.425/3.7-4.2 GHz 12.7-13.25/11.7-12.2GHz	5.925-6.425/3.7-4.2 GHz 12.75-13.25/6.625-7.125 GHz 2.5-2.69 Trans. Optional
Polarization	Linear	Linear	Linear	Linear
Number of Transponders	24	24	48 [24 for 6/4GHz operation; 24 for 12 GHz operation]	120 [96 0.1w for narrow-beam point-to-point service; 24 for wide-area TV distr.]
Usable Bandwidth per Transponder	34 MHz	34 MHz	36 MHz	34 MHz
Transponder Output Device	TWT	TWT	TWT	TWTs for wide-area service; Solid State devices for narrow-beam point-to-point
E.I.R.P. per Transponder	33 dbW [beam-edge]	33 dbW [beam-edge]	34.5 at 4 GHz [beam-edge] 46 dbW at 12 GHz	36 dbW for narrow-beams 35.2 dbW for wide-area coverage at beam-center
EARTH STATIONS				
95-105' cooled T/R[G/T= 41.2 db/°K] 4/6GHz	5	2	--	6
42' cooled R/O[G/T= 35 db/°K] 4/6GHz	--	3	--	--
32' cooled T/R[G/T= 33 db/°K] 4/6GHz & 12 GHz	--	--	20	--
32' cooled T/R[G/T= 31.5 db/°K] 4/6GHz	--	3	--	--
32' uncooled T/R[G/T= 29.0 db/°K] 4/6 GHz	--	25	--	--
32' uncooled R/O[G/T= 29.0 db/°K] 4/6 GHz	--	99	--	--
25' uncooled R/O	--	--	--	Over 100
PUBLIC SERVICE OFFERINGS	Willing to discuss with CPB the terms and conditions. Nothing specific.	Willing to work out some sort of preferential service public broadcasting to meet the genuine requirements of the Corporation for Public Broadcasting [CPB].	Proposes to make available for experimentation in educational service, the equivalent of five TV channels without charge for a period of five years. Also plans to offer equal transmission capacity for the remaining satellite life at a fraction of regularly established rates.	[1] Two fully non-interruptable satellite transponder channels, at no cost, to the Public Broadcasting Service; shared use of narrow-beam channels for "off-shore" locations of Alaska, Hawaii, Puerto Rico and Panama Canal Zone; [2] Part-time, free use, of two satellite transponder channels for health-care delivery throughout U.S.; [3] Free service of one or two instructional television channels from the satellite directly to a low-cost terminal for school or community use on 2.550-2.690 GHz band; [4] Free use of the spacecraft segment for a communication system for Alaska.

TABLE 6--Continued

	HUGHES AIRCRAFT COMPANY	RCA GLOBAL COMMUNICATIONS/ RCA ALASKA COMMUNICATIONS	WESTERN UNION TELEGRAPH COMPANY	WESTERN TELECOMMUNICATIONS
SYSTEM				
Number of Satellites	2 in Orbit 1 ground spare	2 in Orbit + 1 at a later date 1 ground spare	3 in Orbit 1 ground spare	2 in Orbit + 1 at a later date 1 ground spare
Orbit Locations [Longitudes]	100°, 103°W.	[114°], 121°, 125°W.	95°, 102°, 116°W.	113°, 116°, [119°]W.
SATELLITE				
Weight at Sync. Orbit	452.5 pounds	638 pounds	452.5 pounds	727 pounds.
Spacecraft Size	73 inches in diameter . . . . . in length	. . . .	73 inches in diameter . . . . . in length	72 inches in diameter . . . .
Stabilization	Spin	Spin/3-Axis [not decided]	Spin	Spin
Station Keeping	Hydrazine Thrusters	Hydrazine Thrusters	Hydrazine Thrusters	Hydrazine Thrusters
Primary Power	220 watts [Solar cell on the spinning drum]	Approx. 305 watts [Solar cells]	220 watts [Solar Cells on the spinning drum]	270 watts [Solar Cells on the spinning drum]
Life Time	7 years	7 years	7 years	7 years
Launch Vehicle	Thor-Delta M-6T	Thor-Delta 904/ Atlas/TE-364-4	Thor-Delta M-6T	Delta 2914
COMMUNICATION SUB-SYSTEM				
Frequency Bands [Receive/Transmit]	5.925-6.425/3.7-4.2 GHz	5.925-6.425/3.7-4.2 GHz 12/13 GHz Experiment	5.925-6.425/3.7-4.2 GHz	5.925-6.425/3.7-4.2 GHz 12.75-13.25/11.7-12.2 GHz
Polarization	Linear	Linear	Linear	Linear
Number of Transponders	12	12 for 4/6 GHz operation 12 for 12/13 GHz operation	12	6 for 4/6 GHz operation 6 for 12/13 GHz operation
Type of Transponder	Linear, Frequency Translation	Linear, Frequency Translation	Linear, Frequency Translation	Linear, Frequency Translation
Usable Bandwidth per Transponder	36 MHz	36-37 MHz	36 MHz	36 MHz
E.I.R.P. per Transponder	33.1 dbW for Cont. U.S. 26 dbW for Alaska & Hawaii	35 dbW for Cont. U.S. 26 dbW for Hawaii & Puerto Rico	33.1 dbW for Cont. U.S. 24 dbW for Alaska & Hawaii	32 dbW for Cont. U.S. [for 4 GHz operation] 38 dbW for Cont. U.S. [for 12 GHz operation] 26 dbW [4GHz] for Alaska & Hawaii
EARTH STATIONS				
93' cooled T/R [G/T= 36.7 db] 4/6GHz	2	1	--	--
60' cooled T/R [G/T= 36.2 db] 4/6GHz	--	--	--	3
45' uncooled T/R [G/T= 37.5 db] 12/13GHz	--	--	--	1
45' cooled T/R [G/T= 32.3 db] 4/6GHz	--	--	7	--
35'/32' cooled T/R [G/T=31.5 db] 4/6GHz	--	13	--	--
35' uncooled R/O [G/T=27.8 db] 4/6GHz	Over 100	--	--	--
20' uncooled R/O [G/T=25 db] 4 GHz	--	Exact Number not known	--	Exact Number not known
18' uncooled R/O [G/T=27.1 db] 12GHz	--	--	--	Exact Number not known
15' uncooled R/O [G/T=23 db] 4GHz	--	--	--	--
PUBLIC SERVICE OFFERINGS	Two channels on first satellite with complete backup and no preemption. Pre-emptive rights on two channels on spare satellite. Free access to channels from any authorized ground station.	Two TV channels at reduced rates for ETV distribution. Public Radio program distribution on "piggy back" basis on the channels assigned for ETV. Promotional rates for experimental ITV services via standby satellite. Two TV channels for Alaska on regular rate basis.	Willing to offer one or more channels for ETV distribution if the FCC decides that it is in public interest that non-commercial ETV networks should be provided satellite channels without charge.	No cost or reduced cost channels for PTV networking.

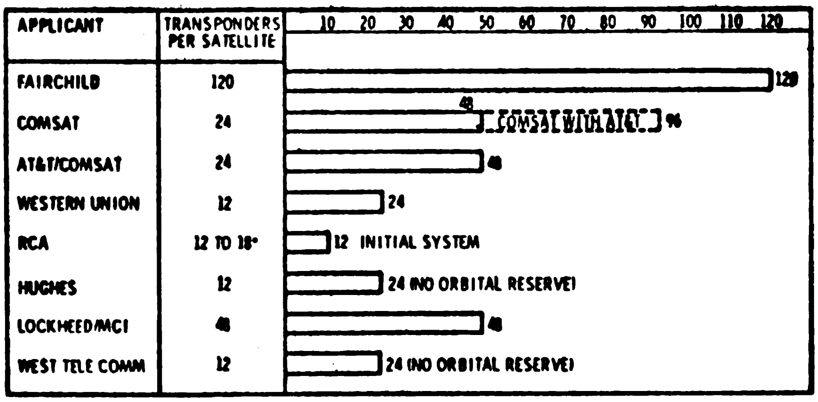

FIGURE 5

Comparison of Operating Channel Capacities
(TV Channels) of Domestic Satellite Proposals

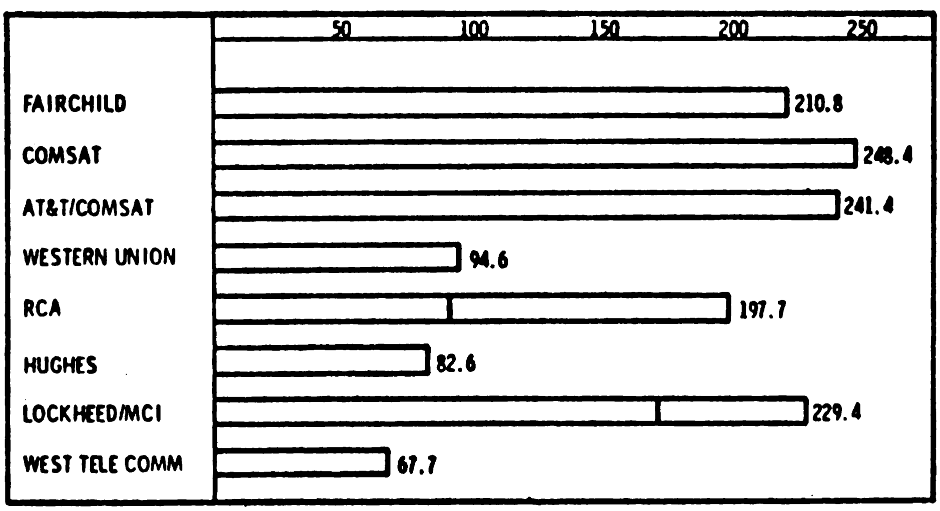

FIGURE 6

Total System Investment (in million dollars) on the growth and vitality of public broadcasting.[26] CPB and PBS asked the Commission to ensure that public broadcasting receives satellite service without charge for a limited and carefully defined network as a dividend to the public for their investment in the space program--an investment that exceeds $20 billion. However, a number of interested parties stressed an equally valid point that there is no such thing as free service; if one user does not pay for the service, payments must be obtained from other users or from the system operator's stockholders. In reply, CPB resorted to the arguments of Dirlam and Kahn[27] which present a very spirited justification of free services for educational broadcasters. It pointed out that if the FCC decides not to provide free services for non-commercial broadcasting and goes for spreading the benefits of space technology over all users of the future commercial systems, it will not be the common public that will benefit most from it. The bulk of these savings will accrue to private industry. It also pointed out the fact that commercial networks had long ago accepted the thesis underlying free interconnection for public broadcasting when they first approved the Ford Foundation proposal for Broadcaster's Non-Profit Satellite Corporation (BNSC) that had also contemplated financial support from commercial networks for public broadcasting in addition to free interconnection facilities for the public broadcasting network.[28]

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[26]FCC, Docket 16495, CPB and PBS Comments, pp. 14-22.

[27]Joel B. Dirlam and Alfred E. Kahn, "The Merits of Reserving the Cost Savings from Domestic Communications Satellites for Support of Educational Television," Yale Law Journal, Vol. 77 (1968), pp. 494-519.

Of eight applicants for authorization to establish domestic communication satellite facilities, four held the view that though they would not commit themselves at this time, they would be willing to provide one or more channels for PTV distribution and network service if the Federal Communications Council decides that it is in the public interest that non-commercial TV and radio networks be provided satellite channels without cost (see Table 6). Three applicants (MCI-Lockheed, Fairchild-Hiller, and Hughes Aircraft Company) made very generous offers for free interconnection channels and to some extent free use of earth-stations. RCA Global Communications expressed its willingness to provide satellite channels at reduced cost as far as the interconnection for PTV and PR was concerned. It also offered promotional rates for experimental ITV services via standby satellites including two TV channels for Alaska on full-rate basis. One of the applicants, MCI-Lockheed Satellite Corporation, showed considerable interest in educational applications beyond PTV and PR networking. It retained Stanford Research Institute to explore the developing public interest in satellite telecommunications to serve United States schools and offered free use of five satellite transponders for a period of five years for all kinds of educational telecommunications.[29] MCI-Lockheed decided to employ an approach

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[28]Federal Communications Commission, Docket 16495, "Comments of the Ford Foundation in Response to the Commission's Notice of Inquiry of March 2, 1966," Docket 16495, August 1, 1966.

[29]Lloyd I. Krause, Satellite Communications for U.S. Schools--A Proposed Public Service Offering by Private Business, A report prepared for the MCI-Lockheed Satellite Corporation, Washington, D. C., March, 1971 (Washington, D. C.: MCI-Lockheed Satellite Corporation, 1971), pp. 15-16.

similar to that employed at Dartmouth College during the 1960's to stimulate the development of computer time-sharing by making available free computer time and access or at negligible costs, to a variety of new users.[30]

Although the Federal Communications Commission is yet to take an action on the domestic satellites and decide regarding the best approach for providing people dividends for their investment in space research and development, the Office of Telecommunications Policy of the Executive Office of President Nixon has completed its study and forwarded its recommendations to the FCC.[31] In addition to prodding the FCC for a quick decision on the matter and recommending entry of all financially and technically competent applicants, the OTP recommendations have made the whole question of public dividend through free satellite channels for public broadcasting very controversial. The following paragraph is taken from the summary of the OTP recommendations that were sent to FCC Chairman Dean Burch by Clay T. Whitehead on October 28, 1971:

> . . .The American people should and can receive a dividend from U.S. investments in space technology through domestic satellite services. However, a discriminatory tax on this mode of communication for any purpose, including support of public television, is an inefficient, inequitable, and largely counterproductive approach to the realization of that objective. By raising the cost and thus deterring the commercial use of

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[30]During the 1960's, International Business Machines (IBM) tried this approach very successfully and stimulated the use of computers on college campuses.

[31]United States, Executive Office of the President, Office of Telecommunications Policy, Letter from Clay T. Whitehead to Honorable Dean Burch, October 28, 1971 (Washington, D. C.: Office of Telecommunications Policy, 1971).

> satellite services, this tax would simply encourage less cost-effective technologies and stifle innovation in satellite technology. If a subsidy for worthwhile public service is required, it should be granted by the Congress and supported by a tax that does not burden a particular mode of communications.[32]

A careful examination of the OTP policy document brings out some of the questionable premises behind some of the conclusions contained in it. One must realize that no other communication technology has seen greater United States investment (tax-payer's money) than satellite technology--it has come to reality through NASA's and military's interest in it and in the process its research and development has been funded to date exclusively through government funds under various projects. Even the Intelsat satellites could be, and quite justifiably, branded as derivates of Syncom and TACSAT satellites. Another premise that not having a tax would encourage development of more cost-effective technologies does not tally very well with the past experiences. Most of the applicants do not offer any significantly new services (other than wide-area TV program distribution) and if AT&T's cost history is any guideline for point-to-point communication applications as well as users, cost reductions from improved long-haul facilities have seldom been reflected in reduced charges. In addition to the question of public dividend, there are few problems with the unregulated, competitive approach suggested in the OTP guidelines.[33] In a purely competitive situation, chances of "cream-skimming" are great and very much alive. Certain services which could be important

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[32] Ibid., p. 3.

[33] Ibid.

to all people but less economically attractive in certain areas, or, services which may be socially desirable but not very profitable might never come into being. It is difficult to imagine that rural electrification and provision of telephone services in remote rural areas would have been possible without certain regulatory framework and government initiative.[34]

Another approach to this whole question of the provision of high-risk but socially desirable satellite-based telecommunications services lies in a federally funded program that makes available to the prospective government and educational user groups and agencies new opportunities that might not come about themselves. One must recognize the fact that public education in America enjoys a local control and there is a great deal of apprehension about any federal initiatives other than string-free funding. By avoiding federal control of programming and the information that will be piped through the system, one could get around this problem. Some think that the future years hold greater promises for new federal initiatives in the area of education in view of the recent Supreme Court decisions in California and Texas that have ruled traditional funding of education through local property taxes as unconstitutional.

A study of the eight applications for authorization to establish domestic communication satellite facilities reveals that, as far

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[34]The orbit and spectrum considerations also prohibit a completely unregulated and competitive approach. Spectrum and orbit are scarce but non-depleting resources and certain coordination is needed to ensure non-interference among the various systems as well as an efficient exploitation of these resources.

as the operational frequency is concerned, all the proposals are confined to uplinks of 5.925-6.425 GHz and 12.75-13.25 GHz, and downlinks of 2.550-2.690 GHz, 3.7-4.2 GHz, 6.625-7.125 GHz, and 11.7-12.2 GHz. All proposals contemplate using conventional 4/6 GHz operation. Fairchild-Hiller proposal is the only one which has proposed to take advantage of the 2.5 GHz downlink--the frequency most suited for educational satellite-applications. Western Telecommunications and MCI-Lockheed were the only two applicants that proposed exploitation of 11.7-12.2 GHz downlink band on an operational basis. The satellite effective radiated powers per transponder are rather small and range between 32-36 dBW for 4 GHz downlinks for the 48 states and 46 dBW for 12 GHz downlinks.

All the proposed systems are capable of satisfying the peak video signal to rms video noise objective of 55 but with earth stations of varying sensitivities. The figures of merit or G/T (antenna gain to system temperature ratios) have a range 41.2 to 25 dB/°K for 4/6, 7/13 and 12/13 GHz operation. Fairchild-Hiller's 2.5 GHz small earth-terminal coverage is designed around 49.8 dB Signal to Noise Ratio (SNR) (7 feet diameter antenna), whereas MCI-Lockheed's 12 GHz service is designed to provide 54 dB SNR with an earth station with G/T = 33 dB/°K. The costs of the earth-stations proposed by various applicants seeking authorization vary tremendously--$6.4 million for each of the five earth stations in the Comsat/AT&T proposals to $2,000 for 7 feet terminals for Fairchild-Hiller's 2.5 GHz service.

As far as the PBS requirement of multiple point originations is concerned, that is, the requirements that result in transmit/receive type earth stations at multiple locations, all proposals are far from satisfactory. The MCI-Lockheed proposal is the closest, in that it provides some 12 of the 28 locations. Next are RCA and Western Telecommunications that satisfy seven and four locations respectively. The remaining five proposals provide for only two locations. Thus a major modification in the location of the sites for transmit/receive stations would be needed if they were to satisfy the public broadcasting requirements outlined in an earlier section.

Another thing that has to be kept in mind is that none of the proposals contemplate providing an orderwire and stereophonic high fidelity (2-15 kHz) channels accompanying the video signal. These would have to be accommodated by multiplexing them with the visual carrier and reducing the visual carrier's deviation. This may result in slightly higher G/T requirements at ground for a given 34- or 36-MHz satellite transponder, transponder power output, and certain performance criteria.

The major problem related to all these proposals is that none, with the sole exception of Fairchild Hiller's 2.5 GHz transponder offer, allow use of low-cost, small earth-terminals and particularly receive/transmit terminals needed for multi-access or intercomputer communication. The reasons that these proposals contemplate using larger earth-terminals are: (1) relatively low effective radiated power (33-35.5 dBW over 34-36 MHz RF channel); (2) use of conventional 4 and 6 GHz operation where the power flux density reaching earth is limited by an International Radio Consultative Committee (CCIR) recommendation to prevent interference to terrestrial common carriers sharing the same band; and (3) the proposed rulemaking that limits the size of the ground transmitting antenna for a 6 GHz earth-to-satellite link to 25-30 foot diameter to increase orbital-spectrum communication efficiency (defined by number of channels/degree of the geostationary arc/MHz). One must not forget the fact that 4 and 6 GHz frequencies are shared with terrestrial microwave facilities and certain coordination procedures are required in earth-terminal siting if interference to and from terrestrial microwave repeaters operating on the same frequencies is to be avoided. This leads to difficulties in colocating the earth-terminal with the ground distribution headend or the interactive terminal cluster as the case may be. Colocation becomes particularly difficult, often impossible, in urban areas and requires substantial investment in microwave links connecting the far-away earth-terminal with the redistribution facility/terminal cluster.

Table 7 illustrates the cost involved in using conventional 4/6 GHz operation due to complex earth stations and the terrestrial interconnecting links that are required to connect them with the operating centers. The information is extracted from the Fairchild Hiller filing.[35]

From information provided in Table 7, we see that the average cost of providing terrestrial interconnection is about $3 million per earth-station. The cost shown in Table 7 is for receive/transmit (R/T) type earth-stations. Earth-stations capable of receiving only

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[35]Federal Communications Commission, Docket 16495, "Fairchild Industries Proposal for a Domestic Satellite Facility," Docket 16495, March 1971 (Washington, D. C.: Federal Communications Commission, 1971).

TABLE 7

Earth Segment Cost for 4/6 GHz Operation for the Proposed Fairchild-Hiller System

(in millions of dollars)

Item	Earth Station Location					
	Atlanta	Los Angeles	Seattle	New York	Dallas	Chicago
Earth Station	6.09	8.84	6.19	8.27	8.95	8.16
Connecting Links	1.75	5.83	2.47	0.72	6.40	1.1

Source: Fairchild Hiller Corporation, Application for a Domestic Communication Satellite System, March, 1971 (Germantown, Maryland: Fairchild Hiller Corporation, 1971).

television relays cost in the neighborhood of 60,000-100,000 dollars but still involve considerable cost in terrestrial interconnections. It is for this reason caution is required in evaluating the free offerings made by the domestic satellite system applicants. For example, today MCI-Lockheed Satellite Corporation plans to provide free use of five transponders for five years for educational applications. But, the educational community would have to procure their own earth-stations to make use of this offer--receive-only earth-stations that are expected to cost in the neighborhood of $60,000. Even if the space segment cost is zero, the large earth station cost only allows use of the MCI-Lockheed offer in the situation where only a few delivery or interconnection points are involved. For a system involving a large number of delivery points (from few hundred to couple of thousand), the earth segment cost dominates the total system cost and MCI-Lockheed offer does not lead to the most economic solution any more.

A Dedicated Educational Satellite System

In the previous section it was noted that the current domestic satellite proposals do not include any provision for satellite-broadcasting services except for a sole transponder operating in the 2.5 GHz band on the Fairchild Hiller satellite and are built around relatively low-power satellites precluding the many new service and cost reduction opportunities inherent in low-cost small earth-terminal operation. It is not that the technology is not available. What is lacking is a public and potential user awareness of the technology potential, public support for a meaningful exploitation of the available technology, appropriate government regulations and initiatives, and special interests. In this section an attempt would be made to show what new communications technology can offer if exploited to its fullest extent and the limitations inherent in it.

The key to new services or significant cost reductions lies in the use of low-cost receivers, high efficiency and high-power transmitters onboard satellites, narrow- and shaped-beam high-gain satellite-borne antennae, and increased satellite life-time and reduced placement cost per unit weight. Though the implications of these new developments have been examined in great detail elsewhere,[36-38] it would not be inappropriate to examine them again briefly. As opposed to the receive-only earth-stations costing in the neighborhood of $60,000-100,000 that are contemplated for use in the domestic satellite filings for TV program distribution, NASA has supported the development of single TV-channel receivers capable of providing high-quality TV signal on ground in conjunction with high-power satellites (50-57 dBW ERP for 800 MHz and 2.5 GHz bands; 65-68 dBW ERP for 12 GHz band) that are expected to cost in the neighborhood of $500-2000 per unit complete with a small antenna (5-7 feet diameter) and installation. Table 8 presents manufacturing costs of the various receivers when manufactured in the quantitites of 1000 and 1 million. These costs are based on 1971 manufacturing costs. These costs show marked decrease as the time progresses, and by 1975, the receiver costs for a production volume of 1 million are expected to be one-half to three-fourths of the costs quoted in Table 8. Some of these terminals, those operating in 800 MHz and 2.5 GHz frequency bands, are expected to go into use in 1974-75 when NASA's Advanced Technology Satellite-F (ATS-F) would be used in India and the Rocky Mountains for educational broadcasting from

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[36]John L. Hult, Satellites and Future Communications Including Broadcast, Paper P-3477 (Santa Monica, California: The Rand Corporation, 1967).

[37]Perry W. Kuhns, Directions and Implications of Communication Technology, Technical Memorandum NASA TM X-52911 (Cleveland, Ohio: Lewis Research Center, 1970).

[38]A. M. Greg Andrus, "Television Broadcasting Satellite Possibilities," Proceedings of Mexico International Conference on Systems, Networks, and Computers (Oaxtepec, Mexico, 1971), pp. 119-124.

TABLE 8

Receiver Cost Based On Model Beginning Production Year, 1971

Frequency	Special Features[a]	Quantity 10^3	Quantity 10^6
620-790 MHz	No Preamplifier	$ 76.00	$41.00
	With Transistor Preamplifier	$ 82.00	$44.00
	With Tunnel Diode Preamplifier	$ 85.00	$46.00
	With Parametric Amplifier	$ 94.00	$51.00
2.50-2.69 GHz	No Preamplifier	$ 89.00	$44.00
	With Transistor Preamplifier	$106.00	$52.00
	With Tunnel Diode Preamplifier	$106.00	$52.00
	With Parametric Amplifier	$121.00	$60.00
11.8-12.2 GHz	No Preamplifier	$119.00	$46.00
	With Tunnel Diode Preamplifier	$141.00	$54.00
	With Parametric Amplifier	$168.00	$65.00

[a] In each frequency band, special feature entries denote receivers with increased sensitivies as one goes progressively through the various kinds of preamplifiers that are listed. This provides a tradeoff with the satellite power because receivers with higher sensitivities need lesser amounts of satellite radiated signal power to produce a given quality picture.

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space.[39,40] Canadian Technology Satellite (CTS), a satellite that is scheduled for launch in 1974 and is designed with a moderate power output of 200 watts in the 12 GHz band, is expected to use $15,000 earth stations for CATV headend interconnection and provision of general communication service and television programming to "bush" areas in the northern parts.

The ever increasing demands for more satellite communications channels will place an unbearable burden upon the solar power requirements onboard the satellites and the limited spectrum and orbit resources unless more directive antennae are used to beam the radio frequency power to areas of interest. The same is true of higher power satellites used for broadcasting where in certain situations one could implement a 50-70 percent saving in the solar power requirement by using directive and shaped beams that avoid rf power spillovers in the areas where coverage is not desired. In addition to the possible power saving, directive and shaped beams allow greater reuse of the available frequency spectrum. NASA's ATS-F and -G satellites will experiment with directive antennae in the immediate future. In the domestic satellite filings, Fairchild Hiller Corporation was the only one that proposed use of such antennae.[41] For educational applications,

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[39] J. P. Corrigan, "The Next Steps in Satellite Communications," Astronautics and Aeronautics, September, 1971, pp. 36-41.

[40] Corporation for Public Broadcasting and Department of Health, Education, and Welfare, Proposal for Educational Experiments at 2500 MHz on ATS-F, June 1971 (Washington, D. C.: Corporation for Public Broadcasting, 1971).

[41] It is interesting to note that Fairchild Hiller also happens to be the prime contractor for NASA's ATS-F and -G satellites. The satellites envisioned in Fairchild's domestic filing are based on ATS-F and -G main-frame, including 30 feet diameter antennae.

applications that include delivery of programming as well as two-way communications, use of directive and shaped-beam antennae will not only provide a great deal of flexibility in communications but also increased channel handling capacity for the 2.5 GHz frequency band--a frequency band that decidedly is the most attractive from the viewpoint of system economics.

One of the things that should be noted is that the costs described in Table 8 are for the receive chains only and are valid for earth stations designed for reception of satellite transmitted high-power TV signals. Some of the new services that are being explored by the Department of Health, Education, and Welfare in cooperation with NASA include two-way communication with the help of small terminals for interactive instruction and tele-diagnosis services in the isolated areas. Establishment of two-way communication service requires the addition of a transmitter chain in the earth stations. It has been found that in a situation involving a large number of small earth stations, it is not realistic to talk about a video return link from every earth station. There is not enough frequency spectrum available to sustain this kind of application. Moreover, provision of a return video-link costs too much--earth station unit price jumps up all the way to $20,000-100,000 range. However, provision of narrow-band links that contain few voice channels, low and medium speed computer interconnection channels, and even slow-scan television transmission could be made for an additional cost of $2,000 to $10,000 depending upon the bandwidth of the return-link. Narrow-band return links are sufficient for most of the interactive applications discussed earlier in this chapter. Experiments have already been conducted or are being conducted to establish the feasibility and cost-effectiveness of such interactive communications via satellites and low-cost earth stations. Using NASA's ATS-1 satellite, in May 1971, Stanford University demonstrated the feasibility of delivering computer-assisted instruction to isolated schools. ATS-1 and -3 are currently being used in Alaska for providing people living in remote villages and population clusters access to hospital facilities in Anchorage and Fairbanks for tele-diagnosis, consultations, and for requesting emergency help. Forthcoming educational experiments involving ATS-F and -G satellites are expected to demonstrate the cost-effectiveness of providing CAI alongside ITV as well as talk-back TV directly from a high-power satellite to scattered population in the remote areas of Alaska, Rocky Mountains, and Appalachia.

There is at present no high-powered satellite system in operation and consequently no experience exists on practical problems involved in system utilization and in manufacturing and commissioning of equipment (satellite and earth station) particularly for a small, earth station environment. However, due to the work that has gone into the preparation for the forthcoming ATS-F and -G high-powered broadcasting experiments, it is possible to estimate the cost of small-terminal satellite TV relay systems within reasonable limits. Unfortunately, in absence of any substantial work in the area, the same cannot be said with respect to the low-cost small earth-terminal systems involving narrow-band return links. In the recent past, the Public Broadcasting Service (PBS) commissioned a study to investigate new concepts for network television distribution systems for interconnecting standard broadcast stations as well as instructional centers. The report of the study,[42] conducted by the Space Systems Organization of the General Electric Company, is now available and presents some interesting insights into the economics of a dedicated satellite system that capitalizes on both the utilization of newly developed technologies and designs that are keyed specifically to the service needs (rather than constraining the needs to previous transmission practices and out-dated equipment).

To begin with, after an extensive systems analysis, the General Electric study,[43] concentrated on direct distribution of programming from one or more points of origin to terrestrial broadcasting stations and other distribution facilities such as CATV installations, school CCTV facilities, etc. The whole concept of indirect distribution of programs to terrestrial redistribution facilities was omitted because direct distribution systems presented the lowest cost type in the region of interest to educational television. Indirect distribution satellite systems have the major disadvantage of requiring supplementary ground microwave links or "tails" for complete distribution and would require much more costly terminals at the school sites.[44] Figure 7 shows the relative costs of satellite and terrestrial distribution systems and it is obvious from it that as the area covered

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[42]Dysinger, Network Television Distribution.

[43]Ibid.

[44]Proposals for multi-purpose satellite facilities (Table 6) mostly provide for indirect distribution.

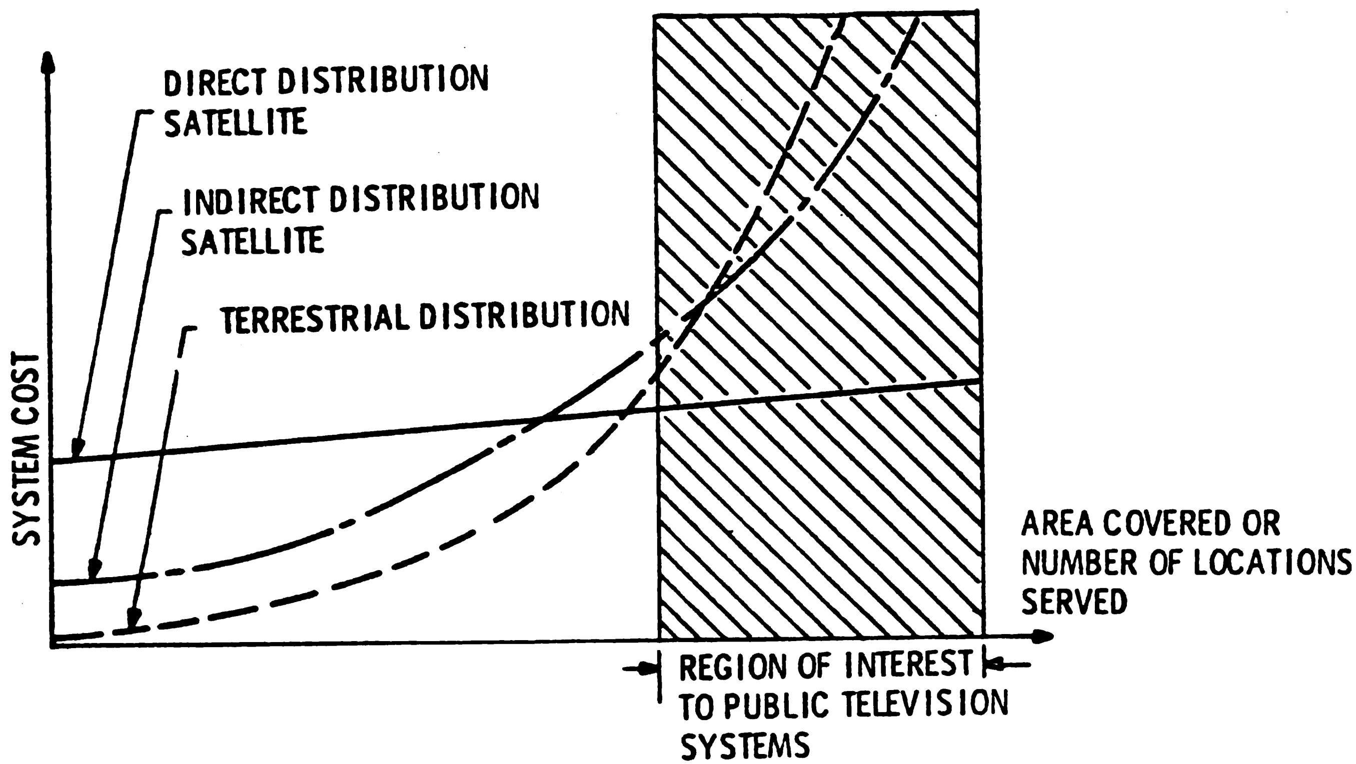

FIGURE 7

Cost Advantage of Direct Distribution Satellite or the number of locations served increases ($\geq$100,000) direct distribution satellite systems provide as least-cost alternative for networking.

The General Electric study[45] proposed a two-service concept using a common satellite(s). It proposed a high-grade signal quality for networking of broadcast station--55 dB Signal-to-Noise Ratio (SNR), and a slightly lower-quality signal comparable to TASO Grade 1 for program delivery to instructional centers (45 dB SNR). This was achieved by using a more sensitive earth station for broadcast stations than those used at school sites (higher G/T for networking terminals and low G/T for school terminals). It analyzed systems capable of providing 4 to 12 national TV channels, up to 96 regional (time-zone) channels, and combinations of these. For the systems close to the cost-performance optimum, the exchange was found to range between six to eight regional channels per national channel. The top curve of Figure 8 shows the total system cost as a function of the downlink frequency and the number of TV channels available from the multichannel satellite system. The bottom curve normalizes this cost per channel. Between the curves, the multi-satellite systems are identified for the points connected by solid lines.

Figure 8 shows several trends. First, that satellites using a larger number of channels per beam but a national distribution pattern (some 12° beamwidth) are much higher in annual cost because of the wasted power spillover to areas without ground terminals. Of the six satellite systems shown in the figure, one beam per satellite

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[45]Dysinger, Network Television Distribution, pp. 2-5.

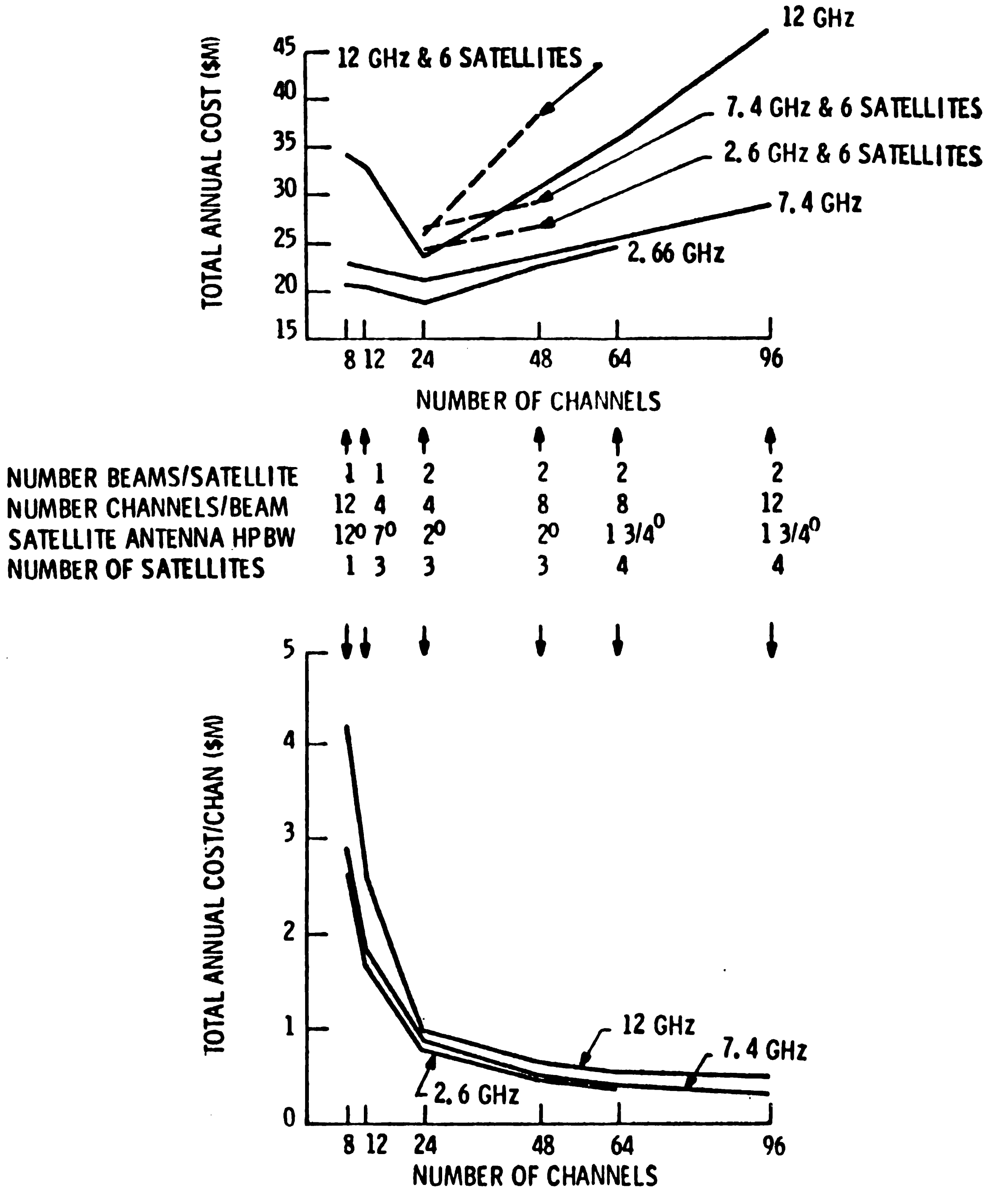

FIGURE 8

Total System Costs as a Function of
Operating Frequencies and Number of Channels

system is more expensive than satellites employing two beams. Another interesting point that came out of the study is that all the systems seem to have a rather high fixed-cost component indicating that the total annual cost per channel will decrease as the number of channels increases because the fixed cost is distributed and amortized over the number of channels. It implies that the economics of these systems favor large capacity and multiple users.

Figure 9 shows the networking terminal cost as a function of the downlink frequencies and number of received channels per site whereas Figure 10 shows the system cost sensitivity to school or instructional center earth-station antenna size and the downlink frequency. From Figures 8-10, one should not have any difficulty in deducing that the cost of networking service is the least at frequency of 2.5 GHz, and increases as frequency is increased for the range studied (2.5-12 GHz). Table 9 presents a summary of the representative cost results of the investigation of the range of channel capacities and frequency bands of interest. Operator annual costs are defined to include the space segment costs (satellites, satellite development, launch vehicles, and satellite operating costs), and the uplink transmit terminals. Receiving costs include all the school and networking terminals. Total system cost is the sum of operator and receiving costs. Thus, one finds that operation of a dedicated system to provide multi-channel program distribution and TV broadcast station networking (100,000 school sites and 800 broadcast stations in total) at 2.5 GHz is expected to cost in the neighborhood of 22 million

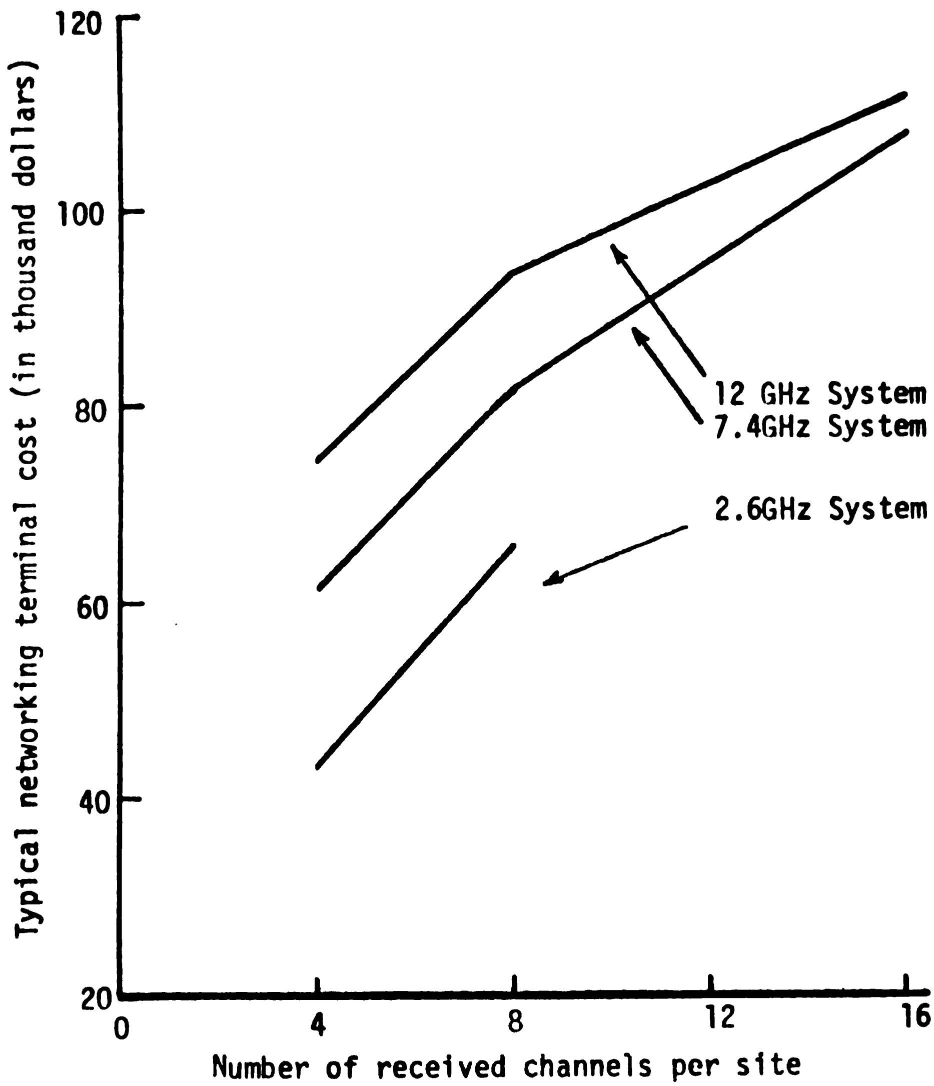

FIGURE 9

Networking Terminal Costs as a Function of Operating Frequency and Number of Received Channels

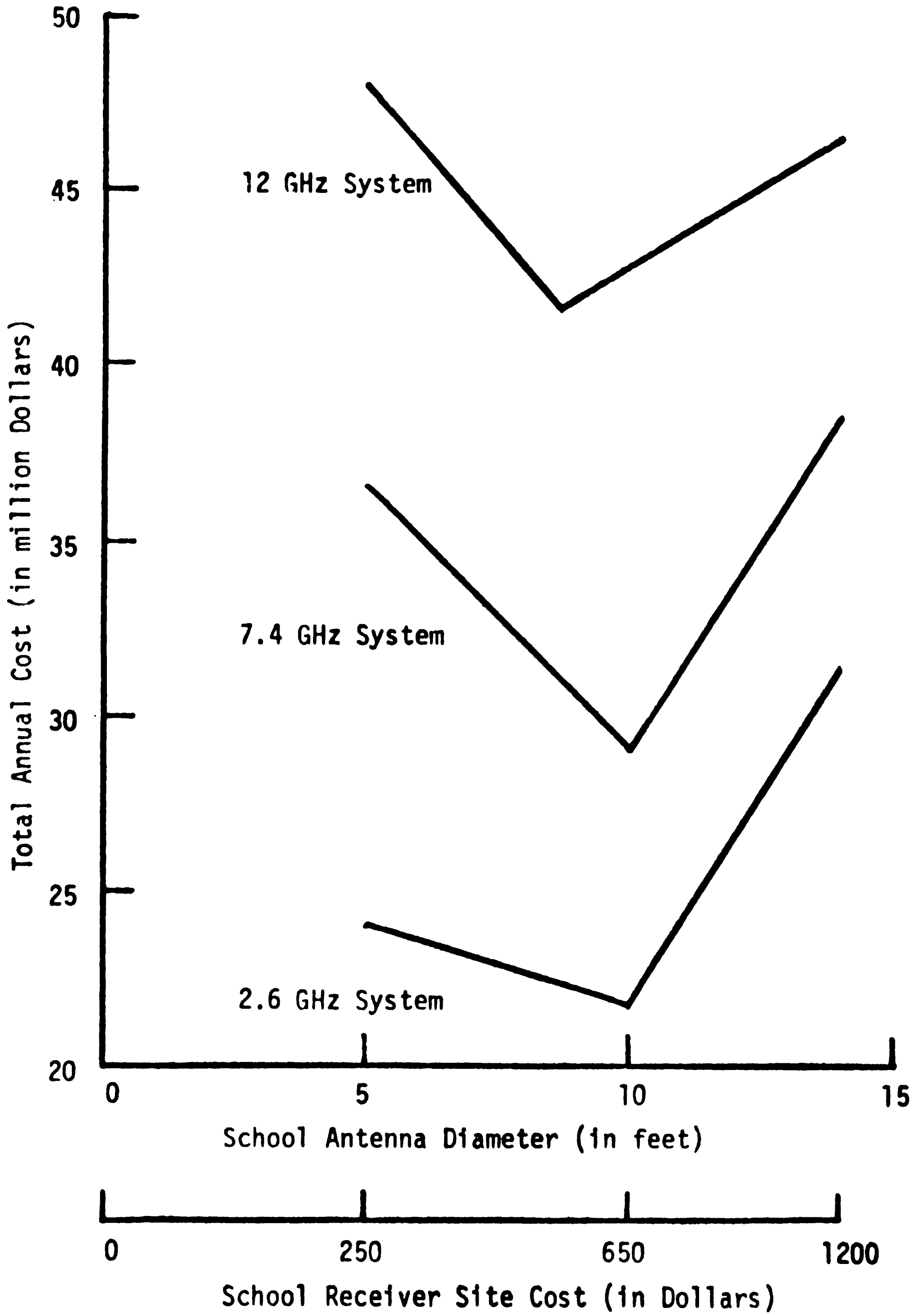

FIGURE 10

Total Annual Costs for School Terminals
as a Function of Operating Frequencies and Antenna Size

TABLE 9

Summary of Representative Costs Results of General Electric Investigation

	8 Channels[b] (1 Satellite)	48 Channels[b] (3 Satellites)	96 Channels[b] (4 Satellites)
2.5 GHz SYSTEMS			
Operator Annual Cost Per Channel	$ 1 M	$ 0.2 M	. . . .
Operator Annual Cost	$ 9 M	$10 M	. . . .
Receiving Cost Total (Annual)	$12 M	$12 M	. . . .
Satellite Power	6.8 KW	700 W	. . . .
7.4 GHz SYSTEMS			
Operator Annual Cost Per Channel	$ 1 M	$ 0.2 M	$60 K
Operator Annual Cost	$ 9 M	$ 9 M	$13 M
Receiving Cost Total (Annual)	$14 M	$14 M	$16 M
Satellite Power	6.4 KW	500 W	570 W
12 GHz SYSTEMS			
Operator Annual Cost Per Channel	$ 2 M	$ 0.4 M	$ 0.4 M
Operator Annual Cost	$17 M	$21 M	$35 M
Receiving Cost Total (Annual)	$17 M	$11 M	$12 M
Satellite Power	30.6 KW	4.5 KW	5.5 KW

[a]Source: J. H. Dysinger, et. al., An Investigation of Network Television Distribution Systems, Report to the Public Broadcasting Service, Washington, D. C., February, 1971 (Washington, D. C.: Public Broadcasting Service, 1971).

[b]M = million; K = thousand; KW = kilowatts; and W = watts.

dollars a year--at least an order of magnitude less than the comparable cost for a similar service from the American Telephone and Telegraph Company (AT&T).

CHAPTER 3

WIRED BROADBAND COMMUNICATIONS NETWORKS AND EDUCATIONAL TELECOMMUNICATIONS IN URBAN AREAS

Introduction

Cable television, often called Community Antenna Television (CATV), began as a minor adjunct to the present system of over-the-air broadcasting in the late 1940's to bring distant TV signals to areas which did not have any coverage. Now it is on the verge of becoming a major communication medium in its own right. A system that was developed to provide TV coverage to small towns in wide and sparsely populated areas seems to have set the stage for a great "communications revolution" in major metropolitan and urban areas--a revolution that some experts call the coming of the Broadband Communication Networks or the beginning of a "wired nation".[1-3] In 1950, the number of CATV installations in the country was only five. Today, nearly 22 years after the first CATV system was born in Clatsop County in the state of Oregon, the number of CATV installations has grown to over 2500 serving more than 5 million TV households out of a total of nearly

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[1]Harold J. Barnett and Edward Greenberg, A Proposal for Wired City Television, Paper P-3668 (Santa Monica, California: The Rand Corporation, 1967).

[2]Electronic Industries Association. The Future of Broadband Communications (Washington, D. C.: Electronic Industries Association, 1969).

[3]R. L. Smith, "The Wired Nation," Nation, May 18, 1970, pp. 583-606.

62 million. The number of homes having CATV available is expected to increase from under 9 million in early 1970 to almost 50 million by the end of 1980. During the same period, the number of CATV subscribers is expected to increase from 5 million to over 26 million.[4] Thus by the end of 1980, two out of every three households will have CATV available and the saturation with CATV systems is expected to be in the neighborhood of 40 to 45 percent.[5] The prediction of an ultimate penetration of 40 to 45 percent is based on the logistic growth curve and a measure of "attractiveness" defined in terms of missing network signals; it does not include additional increase in consumer demand resulting from extensive two-way services discussed later in this chapter.

Wired communication systems have developed on different lines in the United States from those in the United Kingdom and elsewhere. In North America, cable systems have developed as a means whereby programs not clearly receivable from the air could be brought within economical reach of local subscribers, or as an alternative to local programming. Only since the middle 1960's CATV has been recognized as a means of overcoming limitations of the present TV broadcast frequency allocations for bringing a television of abundance to overcome common-denominator programming that had become the basic method of allocating broadcast time and content in the absence of other

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[4] R. W. Peters, et. al., Business Opportunities in Cable Television (Menlo Park, California: Stanford Research Institute, 1970), pp. A3-4.

[5] Roland E. Park, Potential Impact of Cable Growth on Television Broadcasting, Report R-587-FF (Santa Monica, California: The Rand Corporation, 1970).

workable methods short of dictatorship. With a common-denominator approach, as one often finds on the networks, content tends to be superficial and entertainment with mass appeal a major ingredient.[6] However, with a non-radiating system with a large channel capacity (theoretically speaking 50-100 TV channels on a single coaxial cable), one could afford the luxury of speciality-oriented programming to serve a variety of interests in depth and escape the common-denominator prison.

In the United Kingdom, where there were and still are generally speaking only two programs (BBC and ITV) and in every part of the country these signals are easily available from air, the early impetus for the development of wired systems came from the cheaper and better reception promised by the baseband transmission of TV signal and use of non-standard and cheaper receivers that do not have any VHF/UHF signal processing circuits.[7] However, today the impetus for the development of wired systems within the United States is provided by not only better reception and the diversity in programming that would be possible but also from the realization of the wired network as a minimum 300-megahertz (MHz) bandwidth "pipe" to provide many

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[6]The television broadcast structure of today stems almost entirely from certain basic policy determinations made twenty years ago (Federal Communications Commission, Sixth Report and Order [17 Fed. Reg. 3905-1952]). Some seventeen percent of the American population has access to ten or more TV channels, nine percent to nine channels, eleven percent to eight channels, twenty percent to seven channels, nine percent to six channels, thirteen percent to five channels, eleven percent to four channels, seven percent to one to three channels, and three percent to none.

[7]R. P. Gabriel, "Wired Television Systems: Their Economics and Details of Systems for Pay TV and Audience Measurement," International Broadcast Engineer, October, 1966, pp. 413-420.

information services for home, business and government. Since the cable or wired systems would reach schools as well as homes and provide large channel capacity for standard TV programming as well as promise for many new telecommunications services, they provide an unparalleled opportunity to the educational interests for creating new learning situations that bypass the conventional schools with walls as well as for increased technology utilization within schools through resource sharing among the schools interconnected by the wired network. Whereas communications satellites have great promise for introducing new long-distance telecommunications services as well as wide-area coverage, the cable systems offer significant new opportunities for local interconnection and delivery.

In October 1969, the Electronic Industries Association submitted a document[8] to the Federal Communications Commission. This well-conceived report took the stand that the services to be provided by broadband communications networks (BCN) in the late 1970's and early 1980's were of "landmark importance", of "national resource dimensions", and that development of these resources should be a national goal. It said that broadband communication is the tool not only to provide a means for new styles in human settlements, but also to rebuild, in a sociological sense, the crowded inner core of major cities.

> Broadband communication systems using cable can be structured to promote small, self-determining communities within the massive megalopolis. Through these, city dwellers can find order, identificable territory, community pride, and opportunity to

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[8]Electronic Industries Association, Broadband Communications.

> participate and vote on matters that can be of local option--education, cultural pursuits, recreational interests, etc. Such wide-band systems in the 1980's appear to IED/EIA to be of absolute necessity if the nation is going to find solutions to national pollution, urban traffic, and inner-city transportation problems.[9]

In June of 1971, Electronic Industries Association suggestions received an endorsement from the Committee on Telecommunications of the National Academy of Engineering. In a report submitted to the U.S. Department of Housing and Urban Development, the Committee on Telecommunications said that it believes that modern communications technology, thoughtfully applied, can help in relieving many problems besetting the cities and can upgrade the level of city life by providing channels for citizen-government interaction, educational telecommunications, pollution control, health-care delivery, traffic control, and crime prevention and emergency services.[10] With regard to education, it commented,

> The goals of any program for improved urban education should include increasing the attractiveness, relevance, and availability of service to the educationally deprived, and making education more available to all people. Vast opportunities for communications technology lie with the computer, two-way cable television, and, perhaps more importantly, the willingness and capacity of teachers to make them work.[11]

With this kind of a scenario, in this chapter, we will examine the implications of present and probable CATV/broadband communications

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[9]*Ibid.*, p. 4.

[10]United States, National Academy of Engineering, Committee on Telecommunications, *Communications Technology for Urban Improvement*, Report to the Department of Housing and Urban Development under Contract No. H-1221, June, 1971 (Springfield, Virginia: National Technical Information Center, 1971).

[11]*Ibid.*, p. 8.

technology for educational telecommunications, CATV regulation as it relates to educational utilization of the system, the present status of educational utilization and the prospects for tomorrow.

Cable Communication Systems--
Their Economics and Future Developments

An inspection of the nature of human communication shows that in any communication situation there is a single originator of the message (defined by a particular set of space and time) but the recipient may be an individual, a small chosen group, or a large inchoate audience. Hence, any distinction among the various services rests in the differences in the nature of the signal (aural, visual, data; speed; etc.) and differences in the recipients or "addressees". Based on the differences in the "addressees" only, the services may be categorized as: (1) Discrete-address point-to-point service such as a phone service; (2) Multiple-address point-to-points service such as a professor addressing only his distant class or a particular set of distantly located classes; and (3) Broadcast service such as the President addressing the whole nation without any intent of excluding any particular set of recipients. Looking at the services from a more familiar viewpoint of "switched" versus "non-switched" services, one could see that discrete-address type services correspond to "switched" services whereas broadcast type services require un-switched transmission facilities. Multiple-address type services could be accommodated on an un-switched facility using certain privacy arrangements such as "scramblers" or could be implemented on a switched system as in the case of tele-conferencing. After an assessment of the telecommunications requirement of the various services, Electronic

Industries Association suggested to the Federal Communications Commission that it provide a regulatory environment allowing the development of two types of broadband communications networks (BCN) in the United States.[12]

(1) A video telephone service similar to the "picture-phone" system of AT&T with the ability to act as a video output terminal with limited key-board access to computers and transmission and reception of high-speed facsimile information.

(2) A broadband communications network that would be a minimum 300-MHz bandwidth "pipe" to provide many information services for home, business and government, including broadcast video, first-class mail, and educational material, with limited return bandwidth for receiving and tabulating specific requests and responses by individual users of the cables.

The first type of BCN is obviously a totally switched system whereas the second one is primarily unswitched with very limited return bandwidth for asymmetrical interaction--asymmetrical interaction in the sense that outgoing information rate from the user will be two-to-three orders of magnitude smaller than what he will be receiving from the source. It is the second BCN that in concept is compatible with what we know today as CATV and has become the objective of the future developments in the urban cable communications for providing

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[12]Electronic Industries Association, Broadband Communications, p. 2.

multiple-address, multi-channel, aural, visual, and low-speed data signals of good quality at an attractive price to the general public and special interest groups.

Evolution of tomorrow's broadband communication networks during the mid- to late-1970's would mark the third phase of CATV development in which dozens of services would be offered by means of a two-way service (Figure 11). Table 10 presents a glimpse of the wide array of potentical BCN services for households, business, schools, and government. We are currently in phase two of the CATV development that is witnessing the expansion of CATV into the larger communities and urban areas as well as a growth in the addition of automated and local live programming and greater use of underground distribution systems. Phase one of CATV development ended in the mid-1960's when CATV operators started to look beyond their then current role of providing TV service primarily to those communities that were geographically isolated from the major TV transmission sites and/or electronically blocked by the topography of the area.

In the early days of CATV, single-channel systems were not uncommon. A received television signal was piped in the coaxial cables from the remote head-end site to individual subscribers. As more channels became available to the system operator, additional channels were placed on the existing facilities (up to 20) with the addition of wideband amplifiers covering the entire 54-252 MHz band or with the use of set-top converters while using amplifiers with a smaller bandwidth (54-108 MHz), since the coaxial cable had wideband characteristics. This practice has increased the capability of CATV systems from a

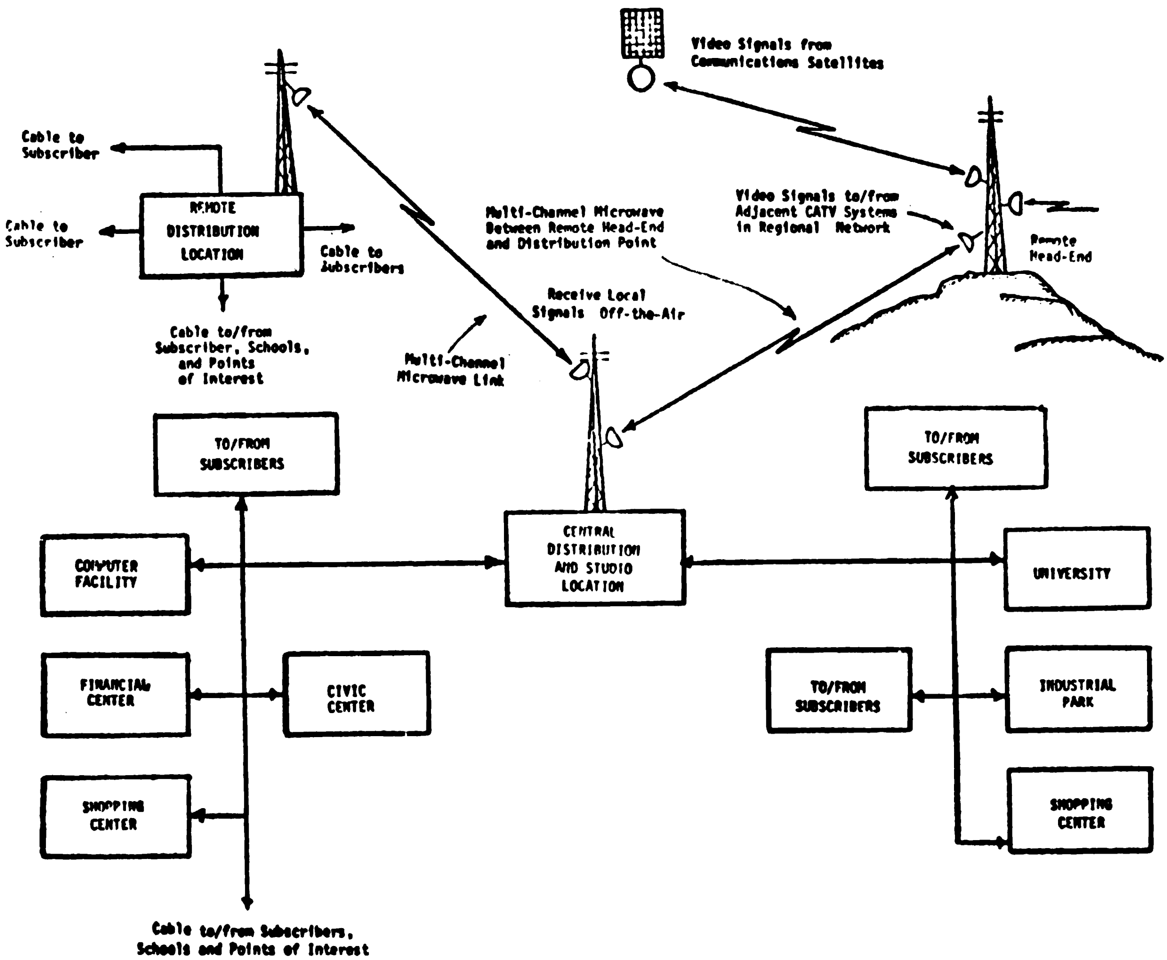

FIGURE 11

CATV Systems with Two-Way Capability

TABLE 10

Potential CATV/Wired City/Broadband Communication System Services

HOUSEHOLD	BUSINESS	SCHOOLS	GENERAL PUBLIC
Police, Fire and Medical Help Signals	CCTV	CCTV	Traffic Surveillance
Telemetering - Gas, Water and Electricity Meter	Data Retrieval	Public Radio and TV	Traffic Signal Control
Banking	Computer Time-Sharing	Computer Time-Sharing	Fire and Crime Surveillance
Electronic Mail	Facsimile Mail and News	Computer Based Instruction	Pollution Surveillance
Consumer Inquiry	Data Transmission	Data Retrieval	
Shopping	Continuous Business News - Stock Market Situation, etc.	Information Retrieval Television	
Continuous News, Weather and Business Information	Customer Sales	Implementation of an Educational Information System (EIS) for Improved Educational Management	
Facsimile Newspapers	Telemetering		
Pay Television	Police and Fire Signals		
Large Number of TV and Radio Programs			

single channel to 5, 12, 20, and as many as 40 channels. At present single-cable 12-channel systems are the most commonly used; however, many new systems have a 20-channel capability, and prospective FCC regulation could require all systems to have at least 20 channels.

As CATV moves from rural America into the major metropolitan areas of the country and as more services are offered on CATV or BCN, the prospective design concepts involved in distribution system require more careful consideration. A number of economic, technical and futuristic questions arise such as the benefits of various two-way system configurations, benefits of extended trunk runs relative to the use of microwave or lasers and the benefits of conventional Frequency Division Multiplex CATV techniques relative to multicable swithced techniques (i.e., Rediffusion Dial-a-Program and DISCADE). In the past, many CATV systems have been planned so that the distribution plant originates at a remotely located head-end site and spreads throughout the community in a branching or tree-like fashion. However, with the further development of local origination in CATV, it is likely that most operators will establish studios at a central location within the franchise area and the distribution will emanate radially from this source as well as the control hub throughout the community.

As CATV systems are installed in very large cities, more than one distribution hub is likely to be used. From a technical standpoint, there is no limitation to the number of subscribers that can be accommodated from a single head-end as long as the amplifier cascade on any one distribution line does not exceed forty-five to fifty units. However, in major metropolitan areas, it is often more desirable to use several head-ends in lieu of costly trunk runs. For instance,

the Teleprompter system in Upper Manhattan has three head-end sites. In light of these current developments, it is convenient to subdivide the description of the distribution plant into two segments: (1) Trunk facilities which includes the uninterrupted transmission of signals from a central location to multiple radially extending distribution plants; and (2) Subscriber distribution facilities connecting subscriber equipment with the local distribution "hub".

As far as the trunk facilities are concerned, the major alternatives are conventional FDM three-fourths-inch diameter coaxial cables, small gauge multi-coaxial tube feed lines involving baseband transmission of TV signals, and microwave relays operating in the Community Antenna Relay Service (CARS) band in the frequency range of 12.7 to 12.93 GHz. The relative economics of these alternatives is very much a function of the particular situations in which applications are desired. For example, a 10-mile, 12-channel, conventional coaxial cable trunk would cost about $45,000 if it were installed on existing utility poles, and about $120,000 if it were installed underground. These costs could be considerably higher in metropolitan areas. A 12-channel conventional microwave system would also cost in the vicinity of $120,000 but would be capable of transmitting signals for up to 28 miles. An Amplitude Modulated Link system delivering 20 channels would cost less than $110,000 for the first transmission link (10-14 miles) but each additional link would cost only about $7,000. The Laser-Link system, developed by Laser Link Corporation of New York, is supposed to deliver 12 channels for $50,000 but

could prove very valuable in metropolitan cities like New York where one has to get the trunk signals through tall buildings and other obstacles.

When it began to appear desirable to provide more than the standard 12 VHF channels--either for additional one-way programming or for additional non-broadcast programming plus return-signal capability--various alternative systems/techniques have been proposed for the subscriber's distribution plant. All are variations of a few basic schemes: use of UHF channels, frequency-division multiplexing (FDM) of many signals on a single cable, dual- or multiple-cables, and switched multiple-cable High-Frequency (HF) networks with or without multiplexing. The most commonly used CATV system in the United States is based on an FDM approach where a single co-axial cable carries several TV channels. Twelve-channel systems are very common as they can be easily carried in the standard VHF frequency slots. To increase the channel handling capacity, some systems employ mid-band transmission utilizing the frequency gap between VHF-TV channels six and seven (88-174 MHz) and increase their capacity by eight TV channels. However, this approach necessitates the use of a set-top converter to convert the non-standard channels to one particular standard channel. Another approach is to use carriers starting from 50 MHz and up to 350-400 MHz and use set-top converters to convert the channels at non-standard frequencies to one particular standard carrier frequency.

Dual- or multiple-cable systems allow subscribers to select channels from one of the various cables with the help of a single flip-switch. These systems may use set-top converters or may not

depending upon the need to increase the channel handling capability. Without any kind of set-top converters, dual-cable systems could provide twenty-four TV channels. With the use of set-top converters, these numbers could be increased to as many as 120-160. As of today, the set-top converter approach leaves much to be desired in terms of system performance;[13] however, there is no reason why it cannot be debugged in future years.

A different video distribution method has been used in Great Britain and Hong Kong. Rediffusion, Ltd., established a distribution complex for transmitting TV signals on individual pairs of video cable or low-attenuation telephone cable with the video frequencies modulated in the 5-10 MHz band. The original Rediffusion system carried only two or three TV channels, all of which were carried into the home via multi-pair cables. Program selection was made by operating a selector switch. Low-cost TV receivers were leased or sold as a part of the system. With increasing demands for TV channels, additional wires had to be supplied to the individual subscriber; as a result, this scheme became less attractive. The next step in this system was dial-a-program approach,[14] where an individual subscriber was supplied with only a single pair of wires connected to a switching center. By remote control, the subscriber had the option of selecting any one of the programs available at the switching center. The switching and

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[13] J. E. Ward, Present and Probable CATV/Broadband Communications Technology, A paper for the Sloan Commission on Cable Communications, September, 1971 (New York, New York: The Sloan Foundation, 1971).

[14] R. P. Gabriel, "Dial A Program--An HF Remote Selection Cable Television System," Proceedings of the IEEE, 58, No. 7 (July, 1970), pp. 1016-1023.

selection was done by a second pair of low-cost wires, which were also used to carry the audio signal. Figure 12 shows the local distribution network for Rediffusion Dial-a-Program system. Since October 1970, a small-scale field trial of the Rediffusion system has been underway at Dennis Port, Cape Cod, Massachusetts. The Dennis Port system also includes provisions for two-way communications.

The most recent development in multi-cable single-channel distribution techniques is the DISCADE system developed by Ameco, Inc., Phoenix, Arizona. The major differences between the DISCADE system and the Rediffusion is in the use of coaxial cables in place of two-wire pairs. Also, the control function is exercised directly over the co-axial cable. Thus, each subscriber has only a single, lightweight coaxial cable connected to his set. The switching centers consist of a twenty by twenty-four matrix that can handle twenty input signals and twenty-four subscribers at a time. If a conventional TV set is to be used in conjunction with the DISCADE system, a frequency converter is needed to convert the incoming TV signal from the 7-13 MHz range to a vacant VHF-TV channel.

In addition to the conventional Frequency Division Multiplex (FDM) and multicable, single-channel approaches, single-sideband FDM and digital distribution systems have been proposed.[15] These systems could become particularly attractive as twenty-four or more channels of programming become commonplace. Through the use of a single-sideband Frequency Division Multiplex (FDM) system, video channel

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[15] Peters, Business Opportunities, p. C-40.

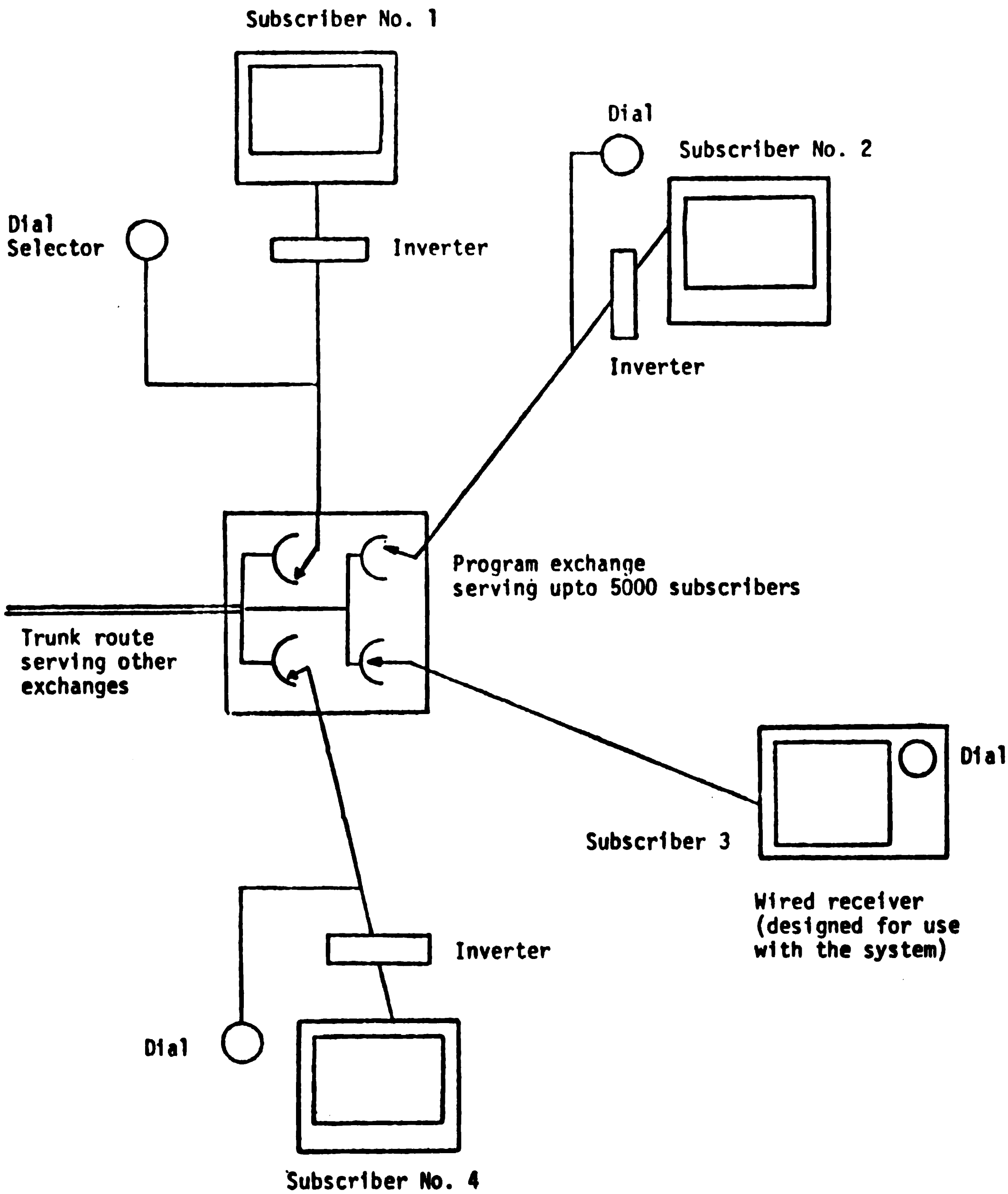

FIGURE 12

Rediffusion Dial-A-Program Local Distribution Network

bandwidths could be reduced by at least 1 MHz. In addition, if wideband amplitude modulation (AM), back-shoulder, or retrace modulation schemes were employed, another 500-kHz bandwidth reduction could be obtained. Though this scheme offers more channels for a given frequency spectrum, a major disadvantage of the single-sideband (SSB) approach is that standard TV receivers are not compatible with this type of modulation, thus expensive set-top converters would be mandatory. The digital distribution approach is perhaps more likely. The use of digital modulation for long-range transmission is feasible and most likely to be employed within a few years. The next logical step would be to carry the digital signals all the way to and from the subscriber for non-broadcast and non-TV applications.

Table 11 summarizes the per-subscriber costs of the various systems described above based upon the calculations carried out in the SRI study.[16] It should be noted that these costs include only the electronics and cable associated with the distribution of eighteen to twenty channels of video information and do not consider the impact of non-broadcast and non-TV services as well as varying subscriber densities.

Figure 13, taken from the SRI study,[17] presents the impact of subscriber density, defined as the number of subscribers per cable mile, on the cost per subscriber for the six systems discussed above. The computations included primarily distribution electronics and cable costs and excluded installation costs in homes. One finds that

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[16] Ibid., pp. C-52-57.

[17] Ibid., p. C-59.

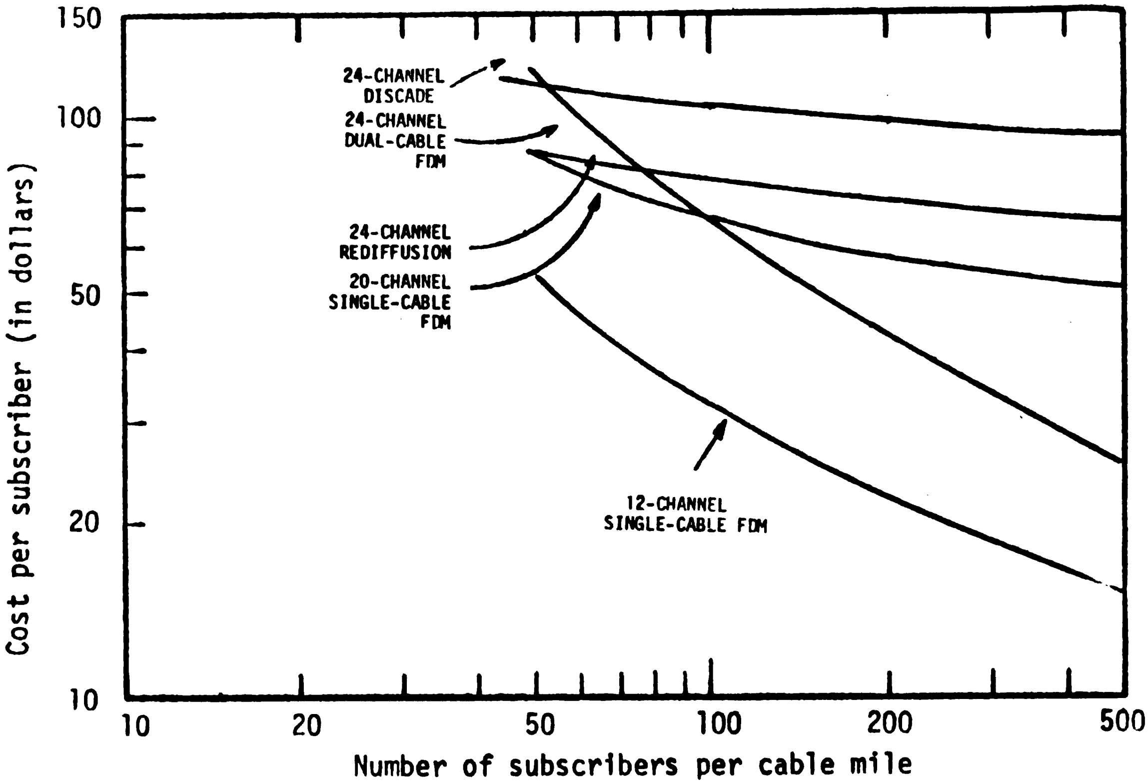

FIGURE 13

Distribution System Cost Per Subscriber--Cable and Electronics

TABLE 11

Distribution Costs per Subscriber for Selected Video Systems[a,b]

(in dollars)

System	Per Subscriber Cost
Frequency Division Multiplex (single-cable)	64.50
Rediffusion (non-switched)	66.25
Rediffusion (central switching)	80.52
Rediffusion (dispersed switching)	75.83
Ameco DISCADE I	103.83
Ameco DISCADE II	98.00

[a]Source: R. W. Peters, et. al., Business Opportunities in Cable Television (Menlo Park, California: Stanford Research Institute, 1970), pp. C-54-57.

[b]Twenty TV-channels for the FDM system and eighteen channels for the other systems.

12-channel single-cable FDM systems present the least-cost option irrespective of the subscriber density. But in the 20-24 TV-channel region, 24 channel Rediffusion and 20-channel single-cable FDM systems show distinct economic advantages over the 24-channel dual-cable FDM system for subscriber densities up to 100 per cable mile. Beyond that, 24-channel dual-cable FDM system presents the least-cost distribution system.

On a strictly technical basis, it would appear that multicable, switched systems are superior to conventional FDM systems. In a multicable switched system, the cross-modulation, harmonic distortion, off-the-air co-channel interference, and adjacent channel interference are essentially nonexistent. With a conventional FDM approach, the system must be well maintained in order to minimize these problems. The multicable systems also offer the prospect of greater immunity from interference in those areas adjacent to TV broadcast transmitters.

When making an investment today, one also has to look at tomorrow and the way the shape of the things to come might influence his investment. For one thing, it is virtually certain that tomorrow's cable communication systems would have to provide two-way communication services even though no real market exists for them today. In addition, the coming years will see imposition of certain performance standards that CATV operators would have to comply with. Thus, while making an investment today in a CATV distribution plant and selecting an appropriate system, one should also look to the future add-on costs for providing a two-way signal handling capability and meeting the performance standards. When these considerations are taken into account, the multicable single-channel distribution approach shows distinct advantages because the requisite two-way capability can be added more easily to a multi-cable switched system than to a conventional FDM system. Also, in a multicable system, actual cable use can be monitored easily, and access to specific channels can be controlled at the switching centers without the need of the additional electronics at the subscriber drop as in the case of conventional FDM systems. However, the problem with the multicable systems is that it is not possible to view two different TV programs from a single subscriber drop and though the multicable switched systems can provide better picture quality than the FDM systems, modified receivers are required to make them economically desirable relative to the FDM systems. In the unlikely event that major U.S. TV set manufacturers produce lower priced TV sets without Radio Frequency tuners and Intermediate Frequency amplifiers to interface with the multicable switched systems many consumers would be confused and will be faced with a difficult decision. Namely, should they buy a special receiver at the reduced price when there is always the possibility of changing their residence to a location that does not have either a DISCADE or Rediffusion system? This consideration is significant in that a color TV set is a major purchase for many people, and on the average, the typical U.S. family moves once every five years.

In view of these, the directions for the future will also depend upon the decisions that the FCC will take regarding noise and distortion objectives for CATV systems and toward setting the standards for a multichannel cable television receiver. However, one could always follow the approach taken in Great Britain of leasing and maintaining TV sets as part of the CATV service. This approach has merits in light of increasing TV maintenance costs, which are expected to increase almost three-fold during the 1970's. It has been reported[18] that one particular company has offered to lease and maintain a TV set and provide CATV service for a monthly charge of about $18.00.

Even though no real market now exists for two-way CATV systems, many enterprising cable system operators and equipment suppliers are

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[18] Ibid., p. C-68.

actively engaged in attempts to create the market through experimentation with two-way systems in the field and demonstration of their capabilities. Six major two-way CATV concepts have been discussed in great detail in a recently published article.[19] Of these, four are based upon the FDM transmission concept and use frequencies below 54 MHz to provide return-channels. One particular system, TICCIT, uses a standard Touch-tone phone to provide the user interaction. Of the two systems based upon the multicable switched system concept, one is a DISCADE system modified for two-way operation which has been implemented in Disney World complex in Orlando, Florida. The other multicable two-way system has been in operation for some time in Dennis Port (Cape Cod, Massachusetts) and is essentially a Rediffusion system. The attractiveness of the multicable switched concept is reflected in the fact that it is the concept underlying GTE Laboratories, Inc., proposal for a two-way cable system for St. Charles Communities, Maryland.[20]

Though the various system details differ, one could say that all the experimental systems are capable of remote program origination from any point within the system, and provide audio-video interaction (talk-back) and digital interaction along with new services such as channel and opinion polling, emergency alarms, meter reading, etc. In absence of any large scale experience with two-way systems, the

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[19] R. K. Jurgen, "Two-Way Applications for Cable Systems in the 70's," IEEE Spectrum, 8, No. 11 (November, 1971), pp. 39-54.

[20] GTE Laboratories, Proposal for An Experiment in Communications-Electronics for St. Charles Communities, Maryland, September, 1971 (Waltham, Massachusetts: GTE Laboratories, Inc., 1971).

costs to subscribers are merely guesses and extrapolations. However, it would not be wrong to say that subscribers would be able to buy two-way communication capability over their CATV systems for an investment of the order of $100-1200.

According to a Rand report[21] on two-way services on cable, addition of even a modest two-way transmission capacity will add between 15 and 30 percent to the capital cost of a single cable, one-way distribution plant. It is suggested that narrowband subscriber response services (opinion polling, alarm monitoring, etc.) and shared voice and video services (talk-back television) seem more likely candidates for home use in the next five years. The investment cost for the basic two-way equipment required would amount to roughly $150-340 per subscriber, over and above the cost for conventional one-way cable service. With this capital investment and reasonable assumptions regarding operating costs, a cable operator would need additional monthly revenues of between $4.50 and $13.00 per subscriber to break even on two-way response services. These services would require, then, at least as much additional revenue as cable operators usually receive for providing one-way television reception. If more sophisticated two-way services such as subscriber initiated "frame-stopping" are desired, the breakeven revenue requirement becomes $17 to $34--at least three times the cost of one-way cable television service today and significantly more than the average residential subscriber now pays for telephone service.

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[21]W. S. Baer, Interactive Television--Prospects for Two-Way Services on Cable, Report R-888-MF (Santa Monica, California: The Rand Corporation, 1971), p. vii.

In the coming years, the developments in cable technology and electronics would greatly influence CATV system design through the availability of reliable and cheaper wideband trunk and distribution amplifiers with improved noise and distortion performance, through the development of low-cost, low-attenuation and high performance coaxial cables, and through new and cheaper interaction mechanisms for the two-way services. Advent of high-power communications satellites is bound to stimulate interconnection of independent CATV headends for delivery of additional network services, for accessing centralized information centers, and, perhaps, for instantaneous polling of the nation on any issue as well as establishment of a national open university for continuing adult education. In brief, the effect of the new technological developments would be to encourage new services as well as significant reductions in the cost. However, as mentioned previously, it is not the technology but the regulatory framework that is likely to have the major influence over the directions for the future as well as the pace of growth. So far the regulatory policy of the Federal Communications Commission, which has forbidden cable operators in the 100 largest markets for distributing signals brought in from other cities, has been the chief barrier to cable growth in urban areas.[22] It is needless to point out that it is in the urban areas where the future potential for cable television really lies.

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[22]Leland Johnson, The Future of Cable Television: Some Problems of Federal Regulation, Report RM-6199-FF (Santa Monica, California: The Rand Corporation, 1970).

Education and Cable Communications

Education can benefit from the newly developing cable communication systems in two ways: (1) By taking advantage of the financial potentials of the cable communications as system operators or as program suppliers for the local system operator to help him meet the FCC requirement of local program origination;[23] and (2) By procuring free or reduced-cost channels from the local CATV system operator for the delivery of ITV, CAI and other educational material to homes as well as schools, for initiating greater parent involvement in the school affairs through the interactive capability offered by the system, and for creating new learning situations that bypass the conventional schools with walls for continuing education, compensatory education, and formal education for the adults.

The financial potentials of CATV is one facet to which educational interests have paid little attention so far. Educators may own and operate CATV systems, whether on a profit or non-profit basis. The FCC rules define a CATV system as a wire or cable distribution facility serving paying public subscribers, but place no specific limits upon the nature or character of the CATV operators except for prohibiting multi-media ownership in the same community. At the present time, a few CATV systems are operated on a non-profit basis by municipal and community groups, and educators. The potentials of non-profit as well as profit oriented CATV operation by educators

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[23]Federal Communications Commission, First Report and Order, Docket 18397, October 27, 1969 (Washington, D. C.: Federal Communications Commission, 1969).

have been examined in detail elsewhere.[24] Here it would suffice to say that operation of a CATV system by an educator or a group of educators on a non-profit basis affords flexibility and independence for the utilization of the excess channel capacity, upon satisfaction of the FCC's carriage and local program origination requirements and any other requirements imposed by the local franchising authorities. In the words of Schwartz and Woods:

> Self-ownership by the educator maximizes opportunities for additional local broadcast outlets, experimental educational services, specialized non-broadcast and broadband communications techniques, and offerings by other local community entities with production capabilities. It avoids the necessity, the pain, and the inconvenience of planning such telecommunications activities at the sufferance of commercial CATV operators. In the current idiom, it permits the educator to do his own thing with CATV. The general experience by educators with commercial broadcasters confirms that they cannot realistically rely upon these commercial entities to guarantee adequate spectrum space, either on a regular basis or at appropriate time intervals, to satisfy educational needs or desires; in CATV as in broadcasting, educators must be prepared to take care of their own needs in their own fashion on their own facilities.[25]

However, one must keep in mind that development of CATV systems involves considerable sums of money. According to a Rand report,[26] the cost to wire an inner urban area of 46.5 square miles to reach 130,000 comes to $6.4 million. This includes $6.15 for cable and home connections, three community origination studios at $20,000 per studio, and four major origination studios for major programs at $50,000 a

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[24]L. Schwartz and R. A. Woods, "Dollars for Education in CATV," Educational Broadcasting Review, 4, No. 3 (June, 1970), pp. 7-16.

[25]Ibid., p. 9.

[26]H. S. Dordick, et. al., Telecommunications in Urban Development, Memorandum RM-6069-RC (Santa Monica, California: The Rand Corporation, 1969), pp. 154-156.

studio. In view of this kind of a capital outlay that may be needed for a CATV system, it seems unlikely that non-profit operations of CATV distribution systems will prove to be a widespread practice. Another factor working against the non-profit operation is the proposed FCC regulation[27] that will guarantee educators a place in commercial CATV systems along with other public communication users. In addition to the FCC provisions for allocating certain channel capacity for educational and other public service applications, educators have been able to influence the local franchising agencies into getting more channels and services from the commercial CATV operators.[28] Thus, little incentive is available for developing non-profit CATV systems on the lines of non-profit, non-commercial ETV and ER broadcast stations.

CATV operation by educators on a profit-making basis is altogether a different thing and perhaps a very sensible proposition when traditional sources of support for education are drying out. The average subscriber pays the cable company $60.00 annually for services. According to an industry rule-of-thumb, operating expenses constitute approximately one-half of that figure. Depending upon amortization and depreciation policies, cable operators may expect an annual potential of $30 in pre-tax profits per subscriber. With

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[27]Federal Communications Commission, Letter from Chairman Dean Burch to the Chairman of Senate Communications Subcommittee, FCC 71-787-63303, August 5, 1971 (Washington, D. C.: Federal Communications Commission, 1971).

[28]National Education Association, Division of Educational Technology, Schools and Cable Television (Washington, D. C.: National Education Association, 1971), Appendices A-F.

a CATV system serving some 1,000-1,500 households, educators would be able to obtain yearly revenues of the order of $30,000-45,000. This way, educators would not only ensure adequate channel availability for educational and public service telecommunications but also certain yearly revenues that contribute to the educational institution or system's regular support. It may be advantageous in certain situations to join hands with others to overcome the obstacles of large capital outlay that is needed and specialized operating talents.

CATV system operation by the ETV station of the community mates the production capabilities, facilities, and talent of the ETV station or corporation to the revenue producing and signal distribution potential of the CATV operation. This seems an ideal wedding, and one that has been advocated, though perhaps not too explicitly by Bill Harley of NAEB.[29] He sees the ETV station becoming an educational telecommunications center, building on its trained personnel, its production facilities, and its sympathy and understanding for the instructional and public service needs of the schools and communities.

Another avenue for dollars for education in CATV lies in the potentials of educators as program suppliers for CATV operators. In October of 1969, the FCC directed CATV systems with 3,500 or more subscribers to operate to a significant extent as a local outlet of cablecasting by January 1, 1971,[30] and have available facilities for

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[29]National Association of Educational Broadcasters, "Public Telecommunication Centers--Wave of Future," Newsletter, May 7, 1971, pp. 1-3.

[30]Date for compliance has been suspended for the time being due to a successful court challenge in Saint Louis, Missouri.

local production and presentation of programs other than automated services.[31] In addition, the cablecaster is also to comply with the Commission's "fairness" doctrine, the political broadcast rules, and the sponsorship identification rules. Because a great many educational institutions possess closed-circuit TV facilities (a minimum of a video tape recorder and a camera), they can prove to be a marketable asset to assist in resolving the cablecaster's dilemma or in fulfilling the cablecaster's desire to provide local origination at a very small fraction of commercial TV costs. A recent Rand report[32] examines the local origination issue in detail and suggests several types of programs that could be locally originated at reasonable costs. There is no reason why local educational institutions and students cannot be involved in the production of a great many of them either as a social science or performing arts project or as an extra-curricular activity. A recent article[33] does suggest that some cable systems and educational institutions are moving in this direction.

Under the FCC rules, CATV systems are required to carry the signals of all TV stations whose signals are normally received in that particular community and, thus, the carriage of a local ETV broadcast signal, if available, is guaranteed. But education interests have become interested in procuring additional capacity for redistribution

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[31]Federal Communications Commission, First Report and Order, Docket 18397.

[32]Nathaniel E. Feldman, Cable Television: Opportunities and Problems in Local Program Origination, Report R-570-FF (Santa Monica, California: The Rand Corporation, 1970).

[33]"Advice for Non-Originators," Broadcast Management/ Engineering, November, 1970, pp. 5-14.

of ITV programs for school and in-home use, community participation, resource sharing among interconnected institutions, and adult education--high school equivalency, college-level equivalency examination, vocational training for the unemployed, and on-the-job training and retraining for industrial workers. In most states anyone wishing to operate a CATV system must approach the officials of the agency authorized to grant CATV franchise for the city, town, or village in which he wishes to operate. Some states such as Connecticut have adopted state regulation of CATV and have empowered their Public Utilities Commission to grant franchise certificates upon a finding of "public convenience and necessity". In some states, franchising is done on the local government level. However, irrespective of the franchising authority, a CATV franchise is negotiated after a public hearing on the matter has been conducted, and, in case of competing applicants, are usually granted to the applicant offering maximum benefits to the city or town in return for the franchise. Educators have started taking quite an active part in these hearings to ensure that the franchise offered to the operator defines the educational telecommunications-CATV relationship. In Long Island (New York), Suffolk County Educational Center (SCOPE), a regional educational service center has pioneered in the area of monitoring CATV developments in the areas covered by its member school districts and in writing educational provisos into CATV franchises.[34] The following

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[34]R. W. Hill, Jr., "Educational Considerations of CATV, Cablecasting and Telecommunications," Educational/Instructional Broadcasting, November, 1969, pp. 57-70.

are some of the important offerings that SCOPE members have been able to negotiate with CATV systems:

(1) CATV operator installs without charge into each school building, private or public, college and library, receiving terminal and cable connections to enable each building to receive all programs transmitted and distributed over the CATV system.

(2) Allocation of at least one video-audio channel, without charge for educational use. Channel to be used primarily for transmission of locally originated educational programming to home.

(3) CATV operator providing for school use a video tape recorder so that school authorities can provide the operator pre-recorded video tape programs for transmission, without charge, at the requested time and dates.

(4) CATV operator agrees to provide reception and distribution of one Instructional Television Fixed Service (ITFS) channel during first five years of franchise if a school district constructs an ITFS system. CATV operator has to bear the cost of down-converting the ITFS channel to VHF midband (between standard TV channels 6-7) and at school buildings again up- or down-converting them to VHF and/or UHF channels.

(5) CATV operator agrees that after first ten years of his franchise, he will provide, without charge, to each school district in its coverage area a CATV channel which will interconnect the school district media center and school media centers of each school district within the system franchise area, and the educational channel of the local CATV system and the educational channels of CATV systems in adjacent municipalities.

(6) CATV operator agrees that after he has held his franchise for ten years, he will, without charge, provide a TV studio to school districts for up to 50 percent of operating time or at least 20 hours/week (inclusive of technical operating and graphics personnel).

SCOPE has also been circulating a "model" franchise based on the above-mentioned benefits to all educators who are interested in seeing that CATV franchises specifically spell out education-CATV relationships because if not defined at the beginning, education interests would have to live at the mercy of the CATV operator for period covered by the franchise (usually 20 to 25 years). According to one source,[35] the benefits mentioned above are estimated to be worth $200,000 to $250,000 annually after the first ten years of the CATV franchise when all the benefits have matured.

At its 1970 annual meeting held in San Francisco, the 7,500-member Representative Assembly of the National Education Association, acting for 1.22 million members, passed the following resolution on CATV:

> The National Education Association believes that the use of Community Antenna Television (CATV) channels for education is essential to preserve the public interests, to afford an opportunity for educational innovation, and to encompass the learning needs of a diverse society.
>
> The Association directs its officers and staff to seek the reservation of at least 20 percent of all CATV channels for educational purposes.[36]

In furtherance to this resolution, the NEA submitted its comments to the FCC suggesting that: (1) 20 percent of any CATV system's capacity should be reserved for educational, instructional, civic and cultural applications and that this principle should apply to old as well as new CATV systems; (2) CATV systems in the top 100 markets be required to have a minimum capacity of 20 to 24 TV-channels; (3) CATV systems be required to incorporate provisions for two-way services in their design; and (4) CATV systems in top 100 markets importing any distant signals be required to pay five percent of

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[35]"The CATV-ETV Interface: Basically Smooth, But with Some Friction Spots," Broadcast Management/Engineering, November, 1970, p. 16.

[36]National Education Association, Schools and Cable Television, p. 2.

their subscription revenues quarterly in the public interest to be reinvested in public cable facilities and programming.[37]

On August 5, 1971, the Federal Communications Commission released its proposal for the near-term regulation of cable television in a letter to the Chairman of the Senate Subcommittee on Communications and the House Communications and Power Subcommittee.[38] The proposed rules would require, if adopted, that a cable system must carry educational stations within 35 miles of the cable system community and, on request, those that provide a predicted Grade B contour over the cable system's community. To make sure that cable systems' potential as a vehicle for much needed community expression is utilized, the FCC states that cable operators cannot accept the distant or overlapping signals that will be made available without also accepting the obligation to provide for substantial non-broadcast bandwidth. The FCC said that it will require cable operators in the top 100 markets to have a 20 channel capacity (actual or potential) and will adopt a rule that for each broadcast signal carried, cable systems must provide equivalent bandwidth for non-broadcast use.

With regard to public access, educational, and government channels, the FCC has decided that it will require cable operators to provide one free, dedicated, non-commercial, public access channel available at all times on a non-discriminatory basis. In addition, it will require that one channel be set aside for educational use and one channel for state and local government use on a developmental basis.

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[37]Ibid., p. 4.

[38]Federal Communications Commission, Letter by Chairman Dean Burch.

The Commission has also stated, something that education interests should note carefully, that after the five years it will determine whether to expand or curtail the free use or reservation of channels for the purposes mentioned above on the basis of the usage they receive during the first five years of the system operation.

With respect to the two-way communications, the FCC has stated[39] that it will require that there be built into cable systems the capacity for two-way communications.

A close examination of the National Education Association recommendations[40] and the proposed FCC near-term regulation[41] shows that educational interests have virtually gotten all they wanted--four out of twenty channels (twenty percent of the capacity) for educational, public access and government usage, systems in the top 100 markets to have a minimum capacity of 20 TV channels, provision of non-broadcast services and two-way communications. The only thing that educational interests wanted but that did not get through was the payment of 5 percent of the gross income from subscribers for public cable facilities and programming. Though the proposed FCC regulation of cable systems will acquire several modifications before it is adopted, the speculation is that provisions affecting educational and public access communications would be carried in their present shape.

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[39]Ibid., p. 31.

[40]National Education Association, Schools and Cable Television, pp. 1-2.

[41]Federal Communications Commission, Letter by Chairman Dean Burch, pp. 17-18, 31-32.

It is very likely that the nation would see a major "wired-city" experiment in the next couple of years. The Office of Telecommunications Policy (Executive Office of the President of the United States) has awarded a contract to Malarkey, Taylor and Associates in Washington, D. C. to list and evaluate candidate experiments, evaluate locations and methods of operation, examine various funding arrangements, and prepare implementation schedules for experiments selected for further consideration. There is a feeling among some of the administration officials that the FCC regulatory restrictions make the private entrepreneur reluctant to invest his money in the development of cable television in the major markets. Thus, a major task of the new study would be to determine whether there may not be some set of commercial services that, in the aggregate and when added to the allowable off-the-air television service, will make the coaxial cable wiring of the large cities an attractive enterprise for private investors. Experiments resulting from the study would be oriented towards developing the potentials of wired-city for urban improvement. It is very likely that in the domain of educational experiments, the recommendation of the National Academy of Engineering's Committee on Telecommunications[42] would be approved. The NAE recommendations call for experimentation with interactive instructional television, interactive community information retrieval, and computer-assisted instruction.

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[42]National Academy of Engineering, Communications Technology for Urban Improvement, pp. 36-152.

Thus we find that a new technology is knocking at the doorsteps of education to open up a wide spectrum of services and applications that will not only help to control the soaring costs of education, if used properly, but will also help make education more flexible, individualized, and, in some sense, utopian. But the real question is whether educational interests are ready to embrace these opportunities or the new technology would merely become another addition to education's arsenal of unused communications technology? The need today is not to say that a particular technology has such and such great potentials for education but to devise ways and means of achieving the potentials, to the extent possible, within the real-world framework.

CHAPTER 4

SUMMARY AND RECOMMENDATIONS

Today education is being asked to equalize opportunity, update itself, become more responsive to the individual learner and the real world, and control soaring costs at the same time. In addition, there is also a rising demand for education, training, and retraining that cannot be accommodated within the formal system of education as it exists today. It seems that the time has come when technology has to play a major role in making education more productive, individual and powerful, learning more immediate; giving instruction a more scientific base, creating new educational opportunities, and providing a more equitable access to education.

These new pressures are bound to stimulate increased emphasis on educational networking for resource sharing to reduce costs as well as to allow a wider dissemination of quality instructional information to make it more accessible and even. In addition, one may expect greater reliance on telecommunications for educational planning and data collection through a network of Educational Information Systems (EIS).

It is well known that the high cost of the present long-distance telecommunications have resulted in their scant use in United States schools and colleges. The prospect for increased utilization in the future of the existing facilities is not very bright either, as only a very small decrease in cost is expected for the 1970's. The reductions in the cost of the long-haul or "toll" segments of long-distance links brought about by the new technology have been offset by the increase in the local plant costs. Today, the local telephone plant costs amount to some eighty percent of the costs of even a long-distance connection. A great deal is to be gained by creating a facility that bypasses the local telephone plant.

In the area of local distribution of large bandwidth signals such as television, the scarcity of over-the-air spectrum has severely restricted extensive utilization of the medium and has resulted in applications that are rigid in character and narrow in scope.

According to the techno-economic analysis presented in this study, communications and broadcast satellites, and wired broadband communications networks afford unique opportunities for educational interconnection and delivery of educational material. Synchronous satellites offer attractive opportunities for providing an ideal broadcast signal to the earth's surface. A more uniform signal distribution can be provided over any reasonable desired area of coverage with less sensitivity to terrain contour than the near-horizon signals generated by earth-based broadcast stations. As a consequence, the signals should experience less fading, ghosting or multi-path degradation, and their high angle of arrival should permit better discrimination against man-made noise near the horizon. Thus, it would be possible to maintain a better quality signal over any specified broadcast area. Most importantly, wide-area coverage makes it economically feasible to satisfy the information requirements of special groups or interests which may not be significantly large within the coverage area of a ground-based broadcast station to demand any attention. An attractive feature of satellite-based networking is that, unlike terrestrial interconnection systems, it allows easy rearrangements or relocations of the network points within the region of visibility.

High-power satellites may prove extremely efficient for distributing a dozen or more TV channels to large numbers of cable-television systems or tomorrow's broadband wired communications networks using low-cost ground stations (\$10,000-\$20,000). This would not only facilitate growth of cable-television in urban areas where it is believed that from the near-term future viewpoint, the importation of distant and/or additional network signals hold the key to their growth, but would also lead to the inception of a new distribution plant that will reach subscribers without resorting to the local telephone plant. True that this plant will not be as versatile as the telephone plant, but, if designed, implemented and operated properly, it is certain to provide a number of new services that are not available today as well as a number of older services at substantially reduced costs.

Unfortunately, no one has developed a high-power satellite that would make low-cost multi-channel ground stations at cable-television headends practical. High-power direct broadcast satellites for multi-channel direct broadcasting to wide areas and locations, where cable systems and conventional over-the-air systems are not expected to gain economic viability in absence of the critical population mass and density needed, are yet to be implemented. Though NASA has been experimenting with the high-power satellite technology on a limited scale for some years now, the funding level in this direction has been so insignificant that decades may be required to achieve the technical advance needed.

In the summer of 1971, important steps towards realizing small-terminal service were taken by the World Administrative Radio Conference (WARC) and the Canadian Department of Communications. On the recommendation of the International Radio Consultative Committee (CCIR), WARC has made frequency allocations in the 12 GHz frequency band with the provision of radiating almost unlimited power over several regions of the world. This is an important development, for it is the first frequency allocation that provides power-levels at the earth's surface strong enough to allow broad-band small-terminal service. The Canadian Department of Communications, with assistance from NASA, will demonstrate small-terminal broadband communications in 1974 via a Canadian Communications Technology Satellite (CTS).

No national commitment to such an effort exists in the United States. Under Congressional direction to de-emphasize point-to-point communication satellite activity when the Communications Satellite Corporation (COMSAT) was established, NASA essentially abandoned the development of high-power satellites and then proceeded to de-emphasize all satellite communication as well. Early research and development supported by NASA and the Department of Defense (DOD) created most of the technological base for Intelsat, but with exceedingly modest further support since the early 1960's, progress in this direction has been minimal. It is important that the present administration and the Congress be persuaded to support new initiatives towards development of high-power satellites, perhaps in cooperation with other countries such as Canada, France, and India that share similar interests. Lately there has been a great deal of talk on turning the American industry and technology from defense and interplanetary space to seeking solutions for domestic problems. It has also been recognized that it may require "an unaccustomed set of incentives and support". Why not begin with communications and particularly that related to education and urban improvement--two of the most pressing needs?

The Federal Communications Commission (FCC) has eight applications before it for authorizations to establish domestic communication satellite facilities. All of the applications are centered around low-power satellites. Most importantly, most of the satellites contemplated for deployment are direct derivatives of past satellites. Hughes and Western Union filings plan the use of satellites based on the Canadian domestic satellite being built by the Hughes Aircraft and which itself is a derivative of Syncom and Intelsat-III satellites. Comsat and Comsat-AT&T filings are based on satellites very similar to Intelsat-IV developed under an international umbrella. MCI-Lockheed satellite is one of the innovative ones, but it too has a direct relationship with Lockheed's experience with Air Force satellites whereas Fairchild's satellites are based on the main-frame of NASA's forthcoming Advanced Technology Satellites-F and -G. Thus, one finds that the cost of research and development tends to inhibit any major innovations, and instead of optimizing their spacecraft capabilities with respect to the usage on the ground, applicants have taken satellites optimized for some other purpose or limited by yesterday's technology and then structured the system around it. Since the whole business is a high-risk one, the government may have to step in to stimulate new initiatives and developments through special tax write-offs for research and spending, government subsidies, loans, and guarantees.

The Federal Communications Commission had asked the prospective applicants to spell out their public service offerings for educational television and radio program distribution and instructional telecommunications. A number of applicatns have proposed generous free or reduced-cost transponder availability for public broadcasting program distribution and station interconnection. Unfortunately, none of the offerings are capable of providing the least-cost configuration for an environment consisting of 10,000 or more interconnection points. With the sole exception of the Fairchild filing that proposes a transponder operating in the 2.5 GHz frequency band with a modest power output facilitating reception by low-cost terminals ($2,000) directly in the urban areas, all proposals require rather costly earth stations ($80,000-$200,000) for multi-channel reception. In addition, most of the proposals contemplate heavy reliance on 4 GHz downlink and 6 GHz uplink transmissions that make colocation of earth stations with local rebroadcast/redistribution centers very difficult and expensive. Since these frequencies are shared with terrestrial common carriers and since they have major concentrations in metropolitan areas, it becomes necessary to locate earth-stations far away from urban areas in order to avoid undesirable interference. This necessitates use of terrestrial "tails" to interconnect satellite earth stations with urban broadcast/distribution plants and operating centers. These deficiencies in the domestic communication satellite facilities proposals currently under FCC examination strengthen the arguments for strong Congressional initiatives towards development of high-power satellite systems capable of serving low-cost broadband terminals and accommodating a limited number of narrow-band uplinks from them.

On the other hand, cable-television has evolved over the past twenty odd years as a distributor of conventional television programming. The non-radiating and broadband nature of the cable networks offer a possibility of change from television's present "economy of scarcity" to an "economy of abundance," and, being local in nature, an ability to respond to the specific information and communication needs of the community. It offers an opportunity for an abundance of channels, targeted audiences based on common interests across wide geographical areas, and, still more important, the development of television and other communications as "interactive" rather than one-way systems.

While the information on cable now flows one way, the technology to support two-way communications is here today. As a part of its rule-making proceedings, the FCC has stated its intention of requiring two-way capabilities in cable systems in the largest markets. While subscriber initiated and discrete address point-to-point services on cable network are considered far-fetched things, the consensus is that within the next five years, narrow-band subscriber response services (voice talk-back with video, opinion polling, etc.) are very likely to gain ground.

Education can benefit from the newly developing cable-communications networks in two ways: (1) By taking advantage of the financial potential of the cable networks as system operators or as program suppliers to cable operators to help them meet FCC local origination requirements; and (2) By obtaining free, reduced cost, or leased channel capacity from the commercial cable operators for the delivery of ITV, CAI, and other educational materials to classrooms as well as homes.

FCC cable rules call for provision of three TV channels free of cost on every cable system for educational, public access, and government use in addition to the carriage of the ETV broadcast station(s) within thirty-five miles of the cable system community. Noting that an average cable system is likely to have twenty to twenty-four TV channel capacity in the early days or the near-term future for which these regulations are intended, one finds that some twelve to fifteen percent of the channel capacity is to be made available free of cost for various educational and public communications.

Since cable-television franchises are negotiated on a state or town level, educational interests also have an opportunity to influence the negotiations and obtain additional concessions. In fact, the potential of this approach has already been demonstrated in several localities in New York and California where organized educators have been able to extract channel capacity and other special provisions worth $200,000-$250,000.

The regulatory policy of the Federal Communications Commission, which has to date forbidden cable operators in the 100 largest markets from distributing signals brought from other cities, has been considered the chief barrier to the cable growth in urban areas. Some have argued that cable networks could attain economic viability through non-broadcast services and operating as a common carrier service leasing channels to those who need them and are willing to pay. However, this contention has been challenged, and very rightly so, in various studies conducted by the Rand Corporation and the Sloan Commission on Cable Communication. For the near-term future, it is said, broadcast services and importation of new signals hold the key to the economic viability of cable systems in urban areas. Maybe in the late 1970's, non-broadcast services will gain enough momentum and acceptance to provide necessary revenues which they do not promise today. The same could be said for two-way services (a part of the non-broadcast segment). This is an area where a high power satellite could make a great difference by pumping a dozen or so program channels to CATV headends. In addition to commercial and entertainment programming, this could also provide a nationwide ITV program distribution facility, a second ETV network that could only be built through cable systems as there are not enough broadcast channels to allow a second ETV station in every area, and the establishment of a national university of the air on the lines of the British Open University to cater to the needs of the populace uncared for by today's educational establishment.

This study suggests that the technology that would permit low-cost educational networking and electronic distribution of educational materials is very much here. It is knocking at the school house and our doors with a great many opportunities that have the potential of revitalizing the entire educational enterprise. But as always, even with all the gaps that remain to be plugged, technology seems to be far ahead of the software: social and curriculum engineering for technology utilization, programming, and developing a total-system approach for instruction. We yet have to understand how to employ communication media, teaching aids, and the individual teacher in an integrated way to obtain maximum results. So far the impact of technology on United States education has been small compared with the magnitude of the United States educational establishment. Its introduction into U.S. schools has been uncoordinated, ineffective, and piecemeal. To become effective, instructional technology must be established on an integrated total-system basis, with broad support from all sectors of the establishment. Before one can go ahead with the planning of an educational telecommunications grid or plant, one needs to know the nature of the information that will be transmitted--its performance requirements, volume, and the "traffic pattern." In order to get this, there would have to be a good many controlled experiments with the combinations of various media under various learning situations as well as the ways in which one could introduce the desired technology.

There is yet another set of experiments connected with the question of the cost-effectiveness of the particular transmission alternatives that need to be conducted to provide comparative cost data. Though a good deal of experience is available with terrestrial communications, there is none domestically with satellite communications. There have been some experiments with NASA's Advanced Technology Satellites-I and -III but their only value is limited to obtaining some operational experience. What is needed are experiments in which the satellite-borne package is optimized or near-optimized for a certain environment and approximates the features, on a small scale, that an operational satellite is likely to have. It is expected that the forthcoming educational experiments with NASA's Advanced Technology Satellites-F and -G and the Canadian Technology Satellite will provide much of the needed information on the cost-effectiveness aspects.

In brief, the technical and economic analysis presented in the earlier chapters of this study suggests that both cable systems and communication and broadcast satellites offer new and significant opportunities for educational telecommunications and to help meet some of the most pressing needs in education and urban areas. Communication satellites will be complementary to, not competitive with, cable systems. They are likely to be the vehicle for large-scale interconnection of cable systems in the future, and also likely to be the vehicle that provides broadcast and certain narrowband, interactive communication services for schools and homes beyond the reach of either cable or terrestrial broadcast systems. The combination of the two is likely to be a very potent instrument for curing some of education's most pressing problems. With the addition of information from some of the experimental projects proposed--satellites as well as cable systems, the educational interests would be in a position to make necessary decisions to formulate a policy for their long-term participation in these technologies and systems.

BIBLIOGRAPHY

Books

Pierce, J. R. The Beginnings of Satellite Communication. San Francisco: San Francisco Press, 1968.

Silberman, Charles E. Crisis in the Classroom: The Making of the American Education. New York: Random House, 1970.

Tickton, S. G., ed. To Improve Learning--An Evaluation of Instructional Technology. New York: R. R. Bowker, 1970.

Reports

Baer, W. S. Interactive Television: Prospects for Two-Way Services on Cable. Report R-888-MF. Santa Monica, California: The Rand Corporation, 1971.

Barnett, Harold J. and Greenberg, Edward. A Proposal for Wired City Television. Paper P-3668. Santa Monica, California: The Rand Corporation, 1967.

Bretz, Rudy. Communication Media: Properties and Uses. A Report by the Rand Corporation, Santa Monica, California, September, 1969. Santa Monica, California: The Rand Corporation, 1969.

Coleman, J. S. Equality of Educational Opportunity. Report to the U.S. Office of Education, Washington, D. C., 1966. Washington, D. C.: Office of Education, 1966.

Communications Satellite Corporation. Pocket Guide to the Global Satellite System. Washington, D. C.: Communications Satellite Corporation, 1970.

Corporation for Public Broadcasting. Proposal for Educational Experiments at 2500 MHz on ATS-F, June 1971. Washington, D. C.: Corporation for Public Broadcasting, 1971.

Denzau, Arthur T. Public Education Finances: 1949-1985. Memorandum 71-4. Saint Louis, Missouri: Washington University, 1971.

Dordick, H. S. Telecommunications in Urban Development. Memorandum RM-6069-RC. Santa Monica, California: The Rand Corporation, 1969.

DuMolin, James R. and Morgan, Robert P. An Instructional Satellite System for the United States. Memorandum 71-2. Saint Louis, Missouri: Washington University, 1971.

Dunn, Donald A. Policy Issues Presented by the Interdependence of Computer and Communications Services. Report 7379B-1. Menlo Park, California: Stanford Research Institute, 1969.

Dysinger, J. H. An Investigation of Network Television Distribution Systems. Report to the Public Broadcasting Service, Washington, D. C., February, 1971. Washington, D. C.: Public Broadcasting Service, 1971.

Electronic Industries Association. The Future of Broadband Communications. Washington, D. C.: Electronic Industries Association, 1969.

Feldman, Nathaniel E. Cable Television: Opportunities and Problems in Local Program Origination. Report R-570-FF. Santa Monica, California: The Rand Corporation, 1970.

GTE Laboratories. Proposal for an Experiment in Communications-Electronics for St. Charles Communities, Maryland. Waltham, Massachusetts: GTE Laboratories, 1971.

Hult, John L. Satellites and Future Communications Including Broadcast. Paper P-3477. Santa Monica, California: The Rand Corporation, 1967.

Hult, John L. Spectrum for Area Coverage from Satellite Relays to Small Terminals. Paper P-4301. Santa Monica, California: The Rand Corporation, 1970.

Johnson, Leland. The Future of Cable Television: Some Problems of Federal Regulation. Memorandum RM-6199-FF. Santa Monica, California: The Rand Corporation, 1970.

Krause, L. I. Satellite Communications for U.S. Schools: A Proposed Public Service Offering by Private Business. A Report prepared for the MCI-Lockheed Satellite Corporation, Washington, D. C., March, 1971. Washington, D. C.: MCI-Lockheed Satellite Corporation, 1971.

Kuhns, Perry W. Directions and Implications of Communication Technology. Technical Memorandum NASA TM X-52911. Cleveland, Ohio: NASA Lewis Research Center, 1970.

Morgan, Robert P. and Singh, Jai P. Progress Report--Program On Application of Communications Satellites to Educational Development. Saint Louis, Missouri: Washington University, 1971.

National Education Association. Division of Educational Technology. Schools and Cable Television. Washington, D. C.: National Education Association, 1971.

Park, Roland E. Potential Impact of Cable Growth on Television Broadcasting. Report R-587-FF. Santa Monica, California: The Rand Corporation, 1970.

Perkins, J. A. Instructional Broadcasting: A Design for the Future. Report to the Corporation for Public Broadcasting, April, 1971. Washington, D. C.: Corporation for Public Broadcasting, 1971.

Peters, R. W. Business Opportunities in Cable Television. Menlo Park, California: Stanford Research Institute, 1970.

Singh, Jai P. and Morgan, Robert P. Computer-Based Instruction: A Background Paper on its Status, Cost-Effectiveness and Telecommunications Requirements. Memorandum 71-1. Saint Louis, Missouri: Washington University, 1971.

Singh, Jai P. and Morgan, Robert P. Educational Computer Utilization and Computer Communications. Memorandum 71-7. Saint Louis, Missouri: Washington University, 1971.

Singh, Jai P. Operating Frequencies for Educational Satellite Services. Memorandum 71-10. Saint Louis, Missouri: Washington University, 1971.

Volks, J. The Reston, Virginia, Test of the MITRE Corporation's Interactive Television System. Report MTP-352. McLean, Virginia: The MITRE Corporation, 1971.

Ward, J. E. Present and Probable CATV/Broadband Communications Technology. Report to the Sloan Commission on Cable Communications, New York, New York, September, 1971. New York, New York: The Sloan Foundation, 1971.

Zeidler, H. M. Patterns of Technology in Data Processing and Data Communications. Report 7379B-4. Menlo Park, California: Stanford Research Institute, 1969.

Periodicals

Andrus, A. M. G. "Television Broadcasting Satellite Possibilities". Proceedings of Mexico International Conference on Systems, Networks, and Computers. Oaxtepec, Mexico, 1971.

Billows, C. A. "Information Retrieval by Television". Electronics and Communication, December, 1968, pp. 35-37.

Cass, J. "The Crisis in Confidence--and Beyond". Saturday Review, September 19, 1970, pp. 61-62.

Corrigan, J. P. "The Next Steps in Satellite Communications". Astronautics and Aeronautics, September, 1971, pp. 34-41.

Dirlam, Joel B. and Kahn, Alfred E. "The Merits of Reserving the Cost-Savings from Domestic Communications Satellites for Support of Educational Television". Yale Law Journal, 77 (1968), pp. 494-519.

"External Degree Program". Newsletter, Syracuse University Research Corporation, September, 1971.

Feldman, N. E. and Kelly, C. M. "The Communication Satellite--A Perspective for the 1970's". Astronautics and Aeronautics, September, 1971, pp. 22-29.

Gabriel, R. P. "Wired Television Systems: Their Economics and Details of Systems for Pay TV and Audience Measurement". International Broadcast Engineer, October, 1966, pp. 413-420.

Gabriel, R. P. "Dial-A-Program: An HF Remote Selection Cable Television System". Proceedings of the IEEE, 58, No. 7 (July, 1970), pp. 1016-1023.

Hill, Jr., R. W. "Educational Considerations of CATV, Cablecasting and Telecommunications". Educational/Instructional Broadcasting, November, 1969, pp. 57-70.

Howe II, H. "Anatomy of a Revolution". Saturday Review, November 20, 1966, pp. 84-88.

Jurgen, R. K. "Two-Way Applications for Cable Systems in the 70's". IEEE Spectrum, 8, No. 11 (November, 1971), pp. 39-54.

National Association of Educational Broadcasters. "Public Telecommunication Centers: Wave of Future". Newsletter, May 7, 1971.

National Association of Educational Broadcasters. Board Committee on Long Range Planning. "Report of the NAEB Committee on Long Range Planning". Educational Broadcasting Review, IV (February, 1970), pp. 23-29.

Schrag, P. "End of the Impossible Dream". Saturday Review, September 19, 1970, pp. 68-72.

Schwartz, L. and Woods, R. A. "Dollars for Education in CATV". Educational Broadcasting Review, 4, No. 3 (June, 1970), pp. 7-16.

Smith, Ralph L. "The Wired Nation". Nation, May 18, 1970, pp. 583-606.

"Advice for Non-Originators". Broadcast Management/Engineering, November, 1970, pp. 5-14.

"The CATV-ETV Interface: Basically Smooth, But with Some Friction Spots". Broadcast Management/Engineering, November, 1970, pp. 16-18.

"The Magnitude of the American Educational Establishment". Saturday Review, September 19, 1970, p. 67.

Government Documents

United States. Executive Office of the President. Memorandum to Honorable Dean Burch from Peter Flanigan, January 23, 1970. Washington, D. C.: The White House Press Office, 1970.

United States. Executive Office of the President. Office of Telecommunications Policy. Letter from Clay T. Whitehead to Honorable Dean Burch, October 28, 1971. Washington, D. C.: Office of Telecommunications Policy, 1971.

United States. Federal Communications Commission. Docket 16495. Comments of the Ford Foundation in Response to the Commission's Notice of Inquiry of March 2, 1966. Washington, D. C.: Federal Communications Commission, 1966.

United States. Federal Communications Commission. Docket 16495. Fairchild Industries' Proposal for a Domestic Satellite Facility, March, 1971. Washington, D. C.: Federal Communications Commission, 1971.

United States. Federal Communications Commission. Docket 16495. Comments of the Corporation for Public Broadcasting and the Public Broadcasting Service, May 12, 1971. Washington, D. C.: Federal Communications Commission, 1971.

United States. Federal Communications Commission. Letter from Chairman Dean Burch to the Chairman of Senate Communications Subcommittee, August 5, 1971. Washington, D. C.: Federal Communications Commission, 1971.

United States. Federal Communications Commission. Docket 18397. First Report and Order, October 27, 1969. Washington, D. C.: Federal Communications Commission, 1969.

United States. National Academy of Engineering. Committee on Telecommunications. Communications Technology for Urban Improvement, June 1971. Springfield, Virginia: National Technical Information Service, 1971.

United States. President's Task Force on Communications Policy. Final Report, 1967. Washington, D. C.: Government Printing Office, 1969.

Unpublished Works

Anderson, Barry D. and Greenberg, Edward. "A Search for Educational Production Functions: The Problems and Prospects". Unpublished research paper, Center for Development Technology, Washington University, 1971.

Jamison, Dean; Ball, John; and Potter, James. "Communication Economics of Interactive Instruction for Rural Areas: Satellite Versus Commercial Telephone Lines". Unpublished report, Graduate School of Business, Stanford University, 1971.

Ohlman, Herbert. "Communication Media and Educational Technology: An Overview and Assessment with Reference to Communication Satellites". Unpublished M.S. thesis, Washington University, 1971.

United States. Department of Health, Education, and Welfare. "Plan for a Satellite-Related Educational System Experiment". Unpublished document. Office of Telecommunications Policy, Department of Health, Education, and Welfare, Washington, D. C., 1971.