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ABSTRACT

Two recent developments in communications satellite technology may speed the coming of cable TV (CATV) networks. First, increases in satellite power are reducing the cost of ground stations. Second, a connection between one ground station, the satellite, and any other ground station is no longer necessarily fixed. Now one station can communicate with another, and then have the circuit switched or reconnected to some other station. Lower-cost ground stations could make possible a multi-channel network of broadcast receiving stations. Circuit switching could make possible a switched two-way communication network that would allow a group of CATV systems to interconnect for special interest programs at any time. A proposal to start building such a system has been made by Hughes Aircraft. It calls for two 12-channel satellites, a number of receive-only earth stations, and two two-way stations to transmit to any of the others. Two steps may be taken to improve program quality and reduce centralized program control: 1) require the operator to donate some capacity to a free national instructional TV network; 2) authorization for operation should require experimentation and be for a limited time only. (MG)

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THE IMPACT OF SATELLITES ON CABLE COMMUNICATIONS

by

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THE IMPACT OF SATELLITES ON CABLE COMMUNICATIONS

Cables and satellites have been two of the most dynamic elements in a decade of breath-taking communications expansion in the United States. They began at about the same time. The first rudimentary cable systems went into operation in the 1950's, and the first experiments with communication by satellite were conducted toward the end of the decade. Telstar, the first practicable communications satellite was launched in 1962, and in the same period, cable systems began moving into urban areas. In the ensuing years, each mode has solved the technical problems involved in the deployment of reliable operational systems. Each has embraced its most obvious initial markets and has grappled with threshold regulatory issues. Each is facing a period of exponential growth, but in directions not altogether clear. These prospects emerge when, for the first time, there is a growing sense that communications policy is too important to be left to the technicians. It is altogether appropriate, therefore, that the Sloan Commission on Cable Communications should examine the interrelations between these two increasingly important communications modes.

Some Technical Background

In a satellite communications system, the satellite in orbit acts as a relay, picking up signals transmitted from an earth station, amplifying them and sending them on to a receiving earth station.* Two principal kinds of systems are now in use: random orbit, exemplified by the Russian Molniya system, and synchronous orbit, which is the form adopted by the International Telecommunications Satellite Consortium (INTELSAT).

In the random orbit system, the satellite revolves in an elliptical orbit and is visible from any particular point on the earth's surface for only a portion of each day. In order to have continuous communications between any two earth stations the system must include a number of satellites spaced so that when one disappears over the horizon of one of the stations another is already visible to both. Earth stations in such a system must have at least two antennas, and they must be capable of tracking the satellite as it makes its passage across the sky.

In a synchronous orbit system the satellite travels in an orbit 22,500 miles above the equator. At this altitude, the orbital speed is equal to the speed at which the earth rotates on its axis. The satellite therefore appears to hang motionless in the sky above a single point on the earth's surface. A synchronous satellite is simultaneously visible over a third or more of the earth's surface - from about 75° north to 75° south latitude through 150° of longitude. Three properly positioned satellites, as in the

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*The statement is true for all existing operational systems. Early experimental work was done with passive satellites (the Echo series), which simply reflect the signals without performing any amplification function. For the future, direct interconnection between satellites can be envisioned, without an intervening ground link. The passive satellite is unlikely to be of much practical significance in the communications field, but direct satellite-to-satellite links may become increasingly important in interconnecting satellite systems.

INTELSAT system, can cover the whole planet, except for the polar regions. A synchronous satellite permits simpler earth station design, with a single, fixed antenna. On the other hand, emplacing the satellites is more complicated, and the equatorial orbit at 22,500 miles (the geostationary orbital arc) is in some sense a limited resource.

To date, the power used by the satellite has been furnished by arrays of solar cells mounted on the surface of the satellite. Nuclear power systems are in prospect for the future and will greatly extend the life and power of communications satellites. The communications capacity of the satellite is governed by the payload of the booster and the efficiency of the power delivery system. Since there has been rapid growth along both of these dimensions, capacity has been growing exponentially. Early Bird, the first INTELSAT satellite, launched in 1965, provided about 240 trans-Atlantic telephone channels. Even so, it practically doubled the capacity then available on submarine cables.* INTELSAT III, until recently the most advanced vehicle, has a capacity of 1600 voice circuits, and the first INTELSAT IV can deliver 3000 to 9000 voice circuits, depending on the configuration of its beams. The first member of this series, launched in January of this year, and positioned over the Atlantic Ocean, provides about 5000 voice circuits or 12 TV channels or any

*The first trans-Atlantic cable was laid in 1956, only a year before Sputnik I went up. Cable capacity is also increasing rapidly. The most recently authorized trans-Atlantic cable, TAT-5, provides 750 voice channels. Much larger capacities seem to be technically feasible but it is not clear that they will be competitive with satellites at intercontinental distances.

combination of these. One of the developments contributing heavily to this capacity expansion is the growing ability to focus the beam transmitted from the satellite on a relatively small area of the earth's surface, thus increasing the effective power delivered and providing important flexibility in other dimensions as well.

Institutional Framework

The first practical applications of satellite communication were in the field of long distance international telecommunications, where the comparative advantage of the space route seemed high. In response to President Kennedy's call for timely policy action, Congress passed the Communications Satellite Act of 1962,* establishing a federally chartered Communications Satellite Corporation (Comsat) as the chosen instrument for United States participation in a global system. Under the Act, Comsat, although a private corporation, is subjected to extensive regulation and policy guidance from the President, the FCC and NASA.

With Comsat and the United States taking the lead, a group of countries primarily from the developed areas, established INTELSAT on an interim basis, beginning in the summer of 1964. This consortium has now grown to a membership of almost 80 countries. It finances, owns and operates the space segment of a global system, consisting of three operating satellites in synchronous orbit over the Atlantic, Pacific and Indian Oceans and associated tracking and control equipment. Some 50 earth stations in about 30 countries, locally owned in accordance with the laws of the place where they are built, connect

*47 U.S.C. §§ 701-744 (1964).

with the space segment to provide a basic global net for international telecommunications. By the end of 1971, it is expected that the number of earth stations will have increased to about 70 in 40 countries. The agreements establishing the consortium vest the control over its activities in a Committee representing the members. In practice, the Committee has been dominated by Comsat, not only because the corporation has had a majority of the votes under the weighted voting system,* but also because, under the agreements, it is the manager of the consortium. This dominating position has been a source of friction from the beginning, and in the definitive arrangements recently concluded among the members of the consortium, the powers of Comsat will be reduced. In particular, a date certain is set for the termination of Comsat's managerial role and the transfer of these functions to an international group that will be the creature of and solely responsible to the consortium.

The negotiatons for definitive arrangements have clarified a second important problem, this one concerning the scope of the consortium's jurisdiction. In the early days of satellite communications, there was much talk about "a single global system," some of which was susceptible of the interpretation that a single entity, presumably international in character, should have a monopoly of all space communications activities. These views in part reflected the feeling, which has since proved erroneous, that the capital requirements of space communications systems would be astronomical

*Special voting provisions prevented Comsat from unilaterally imposing its will on major questions.

(no pun intended). In any case the phrase "single global system" found its way into the United States legislation and the preamble to the INTELSAT agreement. This gave rise to some question whether domestic or regional or special purpose systems could be established by INTELSAT members outside the framework of the consortium. For a long time the official United States position on this issue was in the negative, at least for regional systems, but the decision in the negotiations was in favor of permitting independent systems, after limited technical and economic coordination with the consortium.

This decision recognizes the direction in which events were proceeding in any case. The separate Russian system has already been mentioned, and negotiations are under way to expand it to an international system (INTERSPUTNIK) linking East European countries and perhaps others. Developing countries, led by India and Brazil, are formulating ambitious plans for domestic or regional systems for education and other development-related purposes. Canada is going forward with a domestic system, to forge stronger links with the northern provinces. A number of European systems have been mooteo, but they seem more politically than practically motivated.

The question of United States policy toward domestic satellite systems was projected against this setting. In 1966, ABC made application to the FCC for a satellite system to provide networking services for its television programs. The Ford Foundation intervened in this proceeding, raising the question of whether substantial savings from providing networking services to the major television networks via satellite might not be realized in the form of a "public dividend" for the support of public television. There was little progress in this proceeding until January 1970, when the White House sent a memorandum to Chairman Burch of the FCC, proposing a policy of relatively free licensing of domestic satellites to applicants with technically sound proposals and sufficient initial financing. The market was to be the arbiter of which of these systems, providing what services, would survive. The FCC did not adopt the White House approach completely, but it issued a Notice of Inquiry, pursuant to which some eight major applications for domestic systems were filed by the deadline this spring. Most of these list interconnection among cable systems as one of the services to be supplied, and the application of Hughes Aircraft/General Telephone proposes service to cable systems as one of two major functions. The applications are pending as this is written.

The prospect of a multiplication of satellite systems, most of them of the synchronous type, has raised anew the question of coordination among systems, which had been abated during the period when it appeared that most of the activity might take place under the aegis of INTELSAT. Debate has focussed on whether the frequency spectrum available for satellite communications and the geostationary orbit are adequate to support all the claims upon them. Many countries, particularly in the developing areas, are concerned that the advanced space powers will pre-empt these resources. The United States has argued in general that, with wise management, spectrum and orbit will be adequate to all conceivable demands. This position is not universally accepted in principle, and in any case, it is not clear that the international community has or can create institutions capable of effective management. The International Telecommunication Union (ITU) has basic international responsibility for designating those portions of the frequency spectrum that are to be used for satellite communications. It also prescribes such coordination as exista.

The issues of spectrum/orbit adequacy and the desirability of additional regulation of the use of these resources were intensively debated without resolution in the World Administrative Radio Conference in June, 1971. They will again be on the agenda at the ITU Plenipotentiary Conference in 1973.

Communications Characteristics of Satellite Systems

Before the advent of satellites, long distance telecommunications had been essentially point-to-point. In the words of Walter Hinchman:

> All [previous transmission modes] might be characterized as single-route, fixed capacity transmission links. That is, a particular set of transmission facilities is capable of linking together only two points on the earth's surface (single-route), and the message carrying capacity of this link, determined by its particular design parameters, is fixed and cannot be reallocated to or shared with other routes.

Hinchman recognizes that radio broadcast technology is to some extent an exception to this generalization, but he notes that "the limited coverage and capacity of these early radio systems foreclosed any possibility of utilizing such capabilities for large-scale two-way telecommunications services." These limitations have been even more acute in conventional television broadcasting with its extremely short range propogation characteristics.

Hinchman identifies some of the technical and economic characteristics of the pre-satellite communications modes:

> Some of the principal characteristics of single-route, fixed-capacity transmission facilities are worthy of note, for they have profoundly affected the development of institutions and the formulation of policy dealing with both domestic and international telecommunications. First, the cost of such facilities is typically a direct function of distance along the earth's surface; thus it is desirable to minimize the total length of transmission links used. Second, the cost per circuit of such facilities tends to decrease with increasing number of circuits per link; thus it is desirable to amalgamate all the traffic destined to or from a sizable area for transmission over a few high-capacity links rather than many low-capacity links. Also high-capacity facilities shared by many customers with random needs can be used much more efficiently than can multiple low-capacity facilities.
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> These characterisitics lead to an optimum configuration for terrestrial communication services which consists of a hierarchy of transmission links of ever-increasing capacity, interconnected via intermediate switching and routing facilities, generally referred to as a communications network or grid. For international communications, this network typically culminates in from one to a very few international routing centers for each nation, which are then interconnected via either HF (high-frequency) radio (if traffic volume over a particular route is very low), micro-wave radio relay (if volume is high between adjacent nations), or submarine cable (if volume is high between particular regions on separate continents).

By contrast to all earlier systems, Hinchman asserts, "Satellite communications facilities (both earth and space stations) are inherently capable of serving multiple routes through a single facility, and of reallocating channel capacity flexibly among these routes . . ." He calls this a "multiple-route, allocable-capacity capability." The implications of this capability are the reverse of those noted above for terrestrial facilities: cost of transmission is no longer a function of the distance on the earth's surface between sender and receiver; and there is no need for a gathering system to support a few high capacity long distance links.

Existing satellite communications systems* have not yet exploited very fully these inherent advantages of multiple-route, allocable-capacity capability. The INTELSAT system has operated very much along the lines of a conventional long distance communications carrier. Its principal traffic has been telephone, telegraph and data transmission. The principal routes have been across the North Atlantic and the North Pacific, between the United States and other developed countries with high density communications.

Less developed countries have derived some benefits from the unique characteristics of the satellite system. Once the satellite was up, any country could hook into the system simply by building an earth station. Although there have been complaints that the \$3 - \$5 million cost of the standard INTELSAT earth station is unnecessarily high, it is within reach of many countries with long-distance traffic density far too low to justify the capital cost of terrestrial links with major centers. Of the approximately 80 members of INTELSAT, perhaps 50 are in the category of developing countries and over 20 of the earth stations in operation at the end of 1970 are located in such countries. Thirteen more are scheduled to come into operation during 1971.

On the other hand, the design of the first three generations of INTELSAT satellites was such that users had to buy capacity in units no smaller than a half circuit, which was connected with a

*Putting aside military systems, about which little is known.

matching half circuit in another earth station on an essentially permanent basis.* These circuits were for most practical purposes linear in character, and shared the characteristic of terrestrial links that cost per message declined sharply with the traffic volume. This arrangement met the needs of high traffic routes and of countries, like the United States and perhaps a few others, that generate enough traffic to support continuous links with a number of different countries. A country with lighter, more diffused requirements, however, had to select a single connection, usually with London, Paris or New York, and route traffic to other destinations through these centers. Even so, the circuit might be empty much of the time. The result was not much different from that in the pre-satellite period, when all traffic from colonial or dependent areas was routed through the appropriate metropolitan center.

Similarly, television transmission via satellite to date retains a good many conventional characteristics. In the INTELSAT system, television is still a minor, though growing source of traffic. Transmission is basically point-to-point, from the earth-station in the originating country through the satellite to earth stations in receiving countries. The sending earth station gets the signal through conventional terrestrial links. On the receiving end, distribution is also by conventional facilities - land lines or microwave relay, to existing over-the-air broadcast stations and thence to the sets of ultimate viewers.

*A half circuit is an uplink, from earth station to satellite and a down link from the satellite to the earth station. It requires a comparable half circuit at the other end to complete a two-way communications link.

The Soviet system has concentrated much more heavily on television, but the operational mode is fundamentally the same. Two principal ground stations near Moscow and Vladivostok presumably account for most of the originations. The 22 other earth stations, although they are completely equipped for telephone and data communication, have in fact served primarily as distribution points for television signals, much in the manner described for INTELSAT.

Current Technical Developments

From the foregoing account, it appears that the new technology has yet to confound the early detractors who said a communications satellite was nothing more than "a cable in the sky" or a "microwave relay tower 25,000 miles high." Two major current developments, however, conduce to the exploitation of the unique advantages of satellite communications. They are random access techniques and broadcasting from satellites. Both have large importance for the relation between cable and satellite communications.

Random access techniques will make it possible for any earth station to communicate on demand directly with any other earth station in the system. The requirement of a fixed half circuit, described above, would be eliminated, together with the concomitant need for routing all a smaller country's traffic through one major distribution center. INTELSAT IV, which has just gone into service, incorporates the first operational system of this type, called SPADE. 800 of the satellite's voice circuits will be allocated to this system. A central control device is constantly scanning these

800 circuits, and when a particular earth station wants to make a call, the central station, using a control channel, notifies both calling and called stations what frequencies they will use for the message. Both stations then switch to those frequencies. In principle, the operations can be performed very rapidly using automated equipment. The effect for the participating earth stations is exactly the same as though the satellite contained switching facilities. The immediate importance of this capability for countries with low density, diffuse traffic is apparent. At a further remove it provides the possibility for two-way switched interconnection among cable systems.

Broadcasting from satellites is the second important development now on the horizon. There is a certain amount of terminological confusion in the field that should be cleared up at the outset. Interest first focussed on the prospect that, with increasing satellite power, a communications satellite could be used to relay television programs directly to the sets of individual viewers, without the intervention of any other earth station on the receiving side. This possibility raised very important political, economic and legal questions, especially in the international field, and these in turn led the United Nations Committee on Peaceful Uses of Outer Space to establish a Working Group on Direct Broadcasting.

The Working Group concluded that there was no prospect of satellite broadcasting directly into unaugmented home receivers until after 1985. However, it identified two other modes of broadcasting from satellites on a scale much wider than the delivery of signals to a relatively few large central earth stations for distribution, as described above. The first of these is broadcasting directly to home sets augmented with a special antenna and front end converting equipment. The cost of augmentation was estimated in the range of $150 per set, and the figure has already been validated in detailed planning for single channel systems in developing countries. The other new mode discussed by the Working Group was broadcasting from the satellite to community receivers in a village square, school or market, or to community antennas for further distribution. Both satellite broadcasting to augmented home sets and community broadcasting are well within the current state of the art.

Serious doubts have been expressed whether satellite broadcasting direct to the home - either to augmented or unaugmented sets - will ever be widely realized on an operational basis, at least within the current general technological framework. In the developing countries, the cost of equipping the population with home receivers on a scale comparable to the United States or Europe would be enormous, and the matter is likely to be far down on the scale of economic priorities. In the developed countries, direct broadcasting appeared to offer some relief from the limited channel availability of terrestrial systems. In Europe, it remains a possibility that this route will be taken. For the United States, however, this particular problem of channel availability is being met by cable systems on what looks to be an effective, flexible and economical basis. None of the applications for satellite systems now before the FCC proposes a broadcast service direct to the homes of viewers. That probably means there could be no realization of such a service until the end of the decade, at the earliest, by which time cable will be even more firmly entrenched.*/

Implications for Cable Communications

The two developments just sketched hold out important prospects for cable communications that deserve some further elaboration. The implications of broadcast satellites will be discussed first, since they seem to be on the immediate horizon, while random access and switching possibilities are somewhat further in the future.

Interconnection of systems by satellite - The predictions about the development of satellite broadcasting suggest that satellites will not be competing with cable as a mode of providing communications services directly to the customer's home or office. They suggest instead a complementary relation between the two modes: satellites would provide within the very near future, a cheap and effective method of interconnection among cable systems.

As noted above, a number of the applications for domestic satellite systems now pending before the FCC expressly contemplate interconnection of cable systems. The Comsat multipurpose system, for example, comprising

*/An exception may be the use of satellite-to-augmented-home-receiver to provide a basic broadcast service for remote places out of range of over-the-air broadcast stations and where CATV would be ineffective or too expensive. Canada's Telesat is expected to perform this function for the northern provinces, although much of the time the transmissions will go to an intermediate earth station for final distribution. Similarly, one of the objects of the proposed Japanese domestic system is to bring service to remote and otherwise inaccessible regions. It is thought that United States areas falling into this category might contain as much as 15 - 20% of the population.

two operating satellites with 24 transponders each,* contemplates that two of these channels will be absorbed by CATV in addition to two that would be allocated to the Corporation for Public Broadcasting and eight for commercial TV networks.

The Hughes Aircraft application presents the most extensive proposal for satellite service to cable systems. As such, and because it provides a concrete setting for considering some of the possibilities and problems of cable interconnection, it is worth reviewing the Hughes application in some detail, although there is no way of estimating the likelihood that it will be granted. The system proposed would have two operating satellites of 12 transponders each, providing full coverage of the 48 contiguous states, Alaska and Hawaii. There would be two major two-way earth stations, one in the New York area and one in the Los Angeles metropolitan area. These would account for all program origination in the early years of the system. The application also seeks approval for the construction of seven prototype receive-only earth stations, at an estimated cost of $100,000 each. These would be the forerunners of a full scale network of several hundred such terminals to provide coverage for all United States cable systems. Eventually some of these would have a transmit capacity as well, to provide for local and regional origination.

Of the 24 transponders in the two operating satellites of the system, eight would be leased on a long-term non-interruptible

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*/In the following discussion, one transponder is the equivalent of one TV channel or comparable communications capacity.

basis to General Telephone & Electric Service Corp. for its general communications use. This is intended to provide a stable revenue base for the system. 16 channels would be left for television programming or other use by cable systems. One of these channels would be assigned free of charge to the Corporation for Public Broadcasting. As for the rest, Hughes proposes to sell and distribute program packages to cable systems at a rate of $0.25 to $1.00 per month per subscriber. These charges together with the payments made by GT&E would provide the system's income. Although Hughes reserves the right to accept advertising, subject to applicable FTC regulations, it expects this to be a minor source of revenue.

Hughes itself is applying for earth station ownership, at least of the earth stations covered by the initial application. The principal advantages urged for this arrangement are (1) equal access of cable systems to the earth station; (2) equitable spreading of capital and operating costs throughout the system; (3) technical efficiency in some system operations; and (4) rapid deployment of the system because of Hughes superior access to capital funds. But the application expresses willingness to consider earth station ownership by users if these desiderata are met, and Hughes is already conducting discussions along these lines with large cable operators.

As to program content, Hughes argues that sale of time on interconnecting channels to independent producers, either on a high bidder or a common carrier basis, would not achieve desirable diversity. "Each would compete for the largest audience, and would produce an overlap of similar program content instead of a balanced package of diverse programs." The alternative put forward in the application is for Hughes itself to assemble the program package. But the application recognizes the problem of "concentrating control over the program package in a single organization." Hughes undertakes "to provide assurance that unbiassed diversity will be achieved" by "delegating a portion of the program selection to an independent organization representing the public interest." The structure and procedures of this organization are not specified.

The technical and financial aspects of the Hughes proposal present no serious problems. The satellites to be used are, in essential features, replicas of those Hughes is already building for Canada's Telesat system. The earth stations appear to be well within the state of the art. One might have some questions if Hughes insisted on sole ownership of all the earth stations in the system, but it is not yet possible to specify with confidence an alternative form of earth station ownership, and the Hughes application seems adequately flexible and experimental on this score. Again, it is perhaps too early to be very clear about pricing systems and levels. The White House memorandum opts for the judgment of the market, and Hughes is content to rest on this, provided equal access of cable operators to the system is assured. At least in the early stages, while experience is accumulating there seems no good reason to prefer another basis for pricing, although this feature will bear careful watching.

The principal policy issues center on the question of control of program content. Studies of cable communications have generally assumed that interconnection of systems is in the cards, without exploring very carefully how it is to be accomplished. And they have on the whole adopted a benevolent attitude toward the prospect, without very precise definition of the benefits to be expected. The Hughes proposal puts forward one answer to the first of these questions: interconnection by satellite. But its effort to answer the second raises on the national scale all the problems of access of producers to the system, program diversity and control of content that cable itself has raised so intractably in the local context.

The argument that cable will lead to greater diversity and improved quality of programming takes as a premise that if channels are available at slight cost it will be possible, once the mass audience is sated, to cater to the varied needs of smaller audiences. Since cable systems have been geographically limited, the smaller audiences to be served have also been geographically defined. Thus to date, the focus has been on local origination of community oriented programs - local sports events, political contests, cultural performances, and the like. The accounts of the first experiments along these lines make them sound, with some notable exceptions, like neighborhood gossip on an extended scale. Making allowances for the pioneer character of these efforts, and giving full marks to the powers of local programs to help forge a genuine sense of community, it is still difficult to be very hopeful about the quantity or quality of the material of this kind that will be forthcoming. On the basis of the experience to date, it cannot be said to represent a great leap forward in realizing the potentialities of the television medium.

Interconnection of cable systems should make it possible to escape the existing limits and to assemble non-mass audiences that are functionally rather than geographically defined. In this way, television could, for the first time, approach the flexibility of the print medium with its profitable nationally circulated specialized papers and magazine. The cable operator, like the magazine distributor, would distribute these programs to the local segments of a series of functionally defined regional or national audiences. The advantage for him would be in attracting the members of these local segments as cable subscribers.

If this is the principal benefit to be achieved from national interconnection, it does not necessarily follow, as Hughes suggests, that the benefit is to be realized through centralized control over programming. Hughes description of the competition among independent producers - "each would compete for the largest audience and would produce an overlap of similar program content" - sounds remarkably like network television today. It is not clear why these homogenizing competitive influences would affect the independent producer while Hughes itself would remain impervious to them. On the contrary, it would seem that the independent producer, anxious to make his own artistic impact or carry his own social message, would have the strongest motivation to reach and define the kind of specialized audience discussed above. If he failed to do so, his place would be taken, as in the world of print, by another, without major loss of investment or resources. The function Hughes defines for itself, on the other hand, is no different than that of the broadcasting network: to serve up a "balanced" menu of programs from which the operators of the individual cable systems may choose. It is hard to see the incentives for Hughes, in that role, to embark on artistic or journalistic innovation, any more than the networks have.

To put the matter somewhat differently, the advent of cable means that each local market will have available the three networks plus some major independent stations. In such circumstances it seems unlikely that independent producers would seek to compete for the same kind of mass audience as the networks. The only possibility of such competition would be from an entity that had the same access to large financial resources, talent and outlets as the networks themselves - that is a central program packager of the kind envisioned in the Hughes application.

As noted above, the application recognizes at least some aspects of the problem of centralized control over programming and offers to delegate a portion of this authority to an independent public interest organization. Apart from the lack of detail in this suggestion, it raises the specter of program selection by committee, hardly an augury of high quality, no matter how well meaning the committee might be.

One should not be unduly critical of Hughes. Its application has at least raised and addressed these issues. Moreover, if t e *a priori* case for freer producer access to the satellite seems strong, it is well to remember that the argument on both sides is wholly speculative. There is no relevant experience, and analogies from the world of broadcast television can be misleading.

It may be, therefore, that Hughes could adopt or the FCC require a more experimental approach to this question as well as some of the others. Particularly, in the early period of satellite interconnection, when channel availability is great, some portion of the capacity should be reserved for sale to independent producers in relatively small time segments on an auction or common carrier basis. This method would be in addition to the two forms of program selection proposed by Hughes, and would provide a basis for comparison.

If this method were to be adopted, it would raise additional problems of compensating the producer. Since, by hypothesis he would not be aiming at a mass audience, advertising would probably not provide the necessary support, at least in full. An alternative would be to permit the cable operator to select the programs he wanted and to share the fees between the satellite operator and the producer. Another possibility would be some form of pay TV. Still another would be to relate a producer's share of the revenue to audience size - perhaps measured by monitoring devices or the limited feedback capability envisioned for cable systems in the near future.

The Commission's choice among these alternatives, and indeed its consideration of all the foregoing questions, will be affected by its conclusions on the analogous problems arising in the context of local cable systems. In any case, the uncertainties are important and pervasive enough so that no decisions made now should be irretrievable. Any authorizations for cable interconnection that emerge from the present FCC proceeding should be strictly and effectively limited in time. This result may be somewhat easier to achieve in outer space than in terrestrial communications. The main capital components of the system are the satellites. At this stage of development, they have a limited planned useful life - in the Hughes system, about seven years. At the end of this time the satellites must be replaced in toto, in any case. The operator must plan to recover his capital costs within this period. The earth stations should be readily adaptable to changes in ownership or operation of the space segment. Thus, there should be no large overhang of fixed investment to inhibit a change of approach in the future, and the FCC should make it unmistakeably clear that it will feel free to do so.

There is one specialized audience that is already clearly defined: school children. Interconnection of cable systems with outlets at local schoolhouses would provide for the first time a national instructional TV network. This would in turn open up, also for the first time in this country, the possibility of full exploitation of the TV medium in public school education. With national networking, programming resources could be concentrated. Relatively inexpensive videotaping equipment located at each school or consolidated for a larger grouping would make it possible to record and store programs for presentation at convenient times. An instructional network of this kind would be an instrument of enormous range and flexibility. Technical virtuosity, no matter how dazzling, does not do away with the need for effective software, but it is my impression that all the significant plans for use of TV in the schools posit some kind of network like that which would be provided by interconnected cable systems.

This points toward two concrete recommendations that the Commission should make. First, all franchises for cable systems should require, as many of them now do, that outlets be provided free of charge at all school buildings within the franchise area. Second, any satellite interconnecting cable systems should also be required to dedicate an appropriate portion of this capacity, at least a channel, to educational and instructional television.

Random access and switching - The SPADE system, now in operation in INTELSAT IV, permits virtually instantaneous interconnection between any two earth stations over any of the 800 circuits allotted for this service. According to Comsat's present estimates, the equipment necessary for a 12-channel SPADE installation for a standard INTELSAT earth station would cost about $200,000. An additional capital investment of $5,000 is required for each additional circuit. Thus a complete 24-channel SPADE terminal capable of processing 24 random access calls at the same time could be had for a little over $300,000. It should be remembered that the earth station must have a two-way capability to begin with. The two-way earth stations in the Hughes system would represent a capital investment in the neighborhood of $5 million, and the cost of the standard INTELSAT earth station is of the same order of magnitude. Both are highly sophisticated installations, and no doubt costs could be considerably reduced for simpler terminals. But on the most optimistic assumptions they would remain for the next few years considerably in excess of the $100,000 cost of the receive-only earth stations projected by Hughes. The difference, whatever it is, would be multiplied by the "several hundred earth terminals [that] will be required" for the full system to determine the cost of providing switched interconnection to the entire system. Even so, the capability would be limited to a few voice circuits. To provide even one two-way video interconnection would require two full transponders, a very large fraction of the total capacity of the satellites in the system as currently planned. All these additional burdens must be added to the costs of providing switching capacity for the local cable systems themselves. It is apparent from this that the day of a fully interconnected national network of cable systems with complete switching capability is still well in the future.

Nevertheless, there is a potential, in the shorter term, for two-way video interconnection on a limited, exploratory basis. Again, using the proposed Hughes system as a model for illustrative purposes, in the next few years a number of additional two-way earth stations will come into operation in regional centers. During the same period there is likely to be excess capacity in the satellites. Some of the earth stations could be supplied with two-way interconnection equipment, perhaps with some subsidy. This would make possible two-party and even multi-party video conversations between facilities at the head ends of cable systems served by the earth stations.

The cost of this limited capability, though it might not be commercially justifiable, would probably not be very large absolutely. The question is essentially one of policy: are there types of interchange suitable for this format that are important enough to warrant force-feeding, either by way of a requirement imposed as a condition of authorization for a satellite system or by subsidization or otherwise.

There is a somewhat different way of looking at the same question: switched interconnection among cable systems is likely to appear on a limited basis at first. Should access to this facility be rationed by the market? Or are there certain kinds of communications that should have priority access to this service?

The question has bite, for beyond the limited, relatively near term possibilities lies the heady vision of a fully switched broad band interconnected system, combining cables and satellites to link homes and business places all over the nation. If this vision is realized, cables would become not so much the mode of bringing television programs to home viewers, but the capillaries of a basic communications network for the country. This network can be thought of as a communications grid, analogous to the power grid, delivering to the consumer fungible communications capability, as the power grid delivers fungible electric power. Just as the user can convert his power at his choice to light, heat, refrigeration, air conditioning etc., so the communications user would be able to convert the delivered capability into telephone (voice or video, two-way or multi-party), message or data transmission, television (including live or current programs as well as retrieval of past programs from storage banks), the whole range of data storage and retreival functions, including facsimile reproduction of output, etc. ad infinitum.

It is hard to imagine anything less than common carrier or public utility status - perhaps even public ownership - for the main trunk portions of such a system. But by that time the ownership question would be dwarfed by a host of other problems. The central issues that would then emerge would concern the access of producers to the system - not just producers of "programs" as now conceived, but all sorts of messages. And these could become the most profound and fundamental issues of our national life.

All this is, if not science fiction, at least several decades in the future. But it is worth being aware of the more distant prospect when considering how to handle the primitive and limited possibilities for switched interconnection of cable systems through satellites that are now at hand.

Summary and Conclusions

The foregoing discussion leads to the conclusion that the relations between cable and satellite communications will not be competitive but complementary. The comparative advantage of satellites lies in long distance communications; that of cable on a local level. Moreover, although the policy issues presented by the relationship are on the horizon and deserve consideration, they are not as immediately pressing as are some other issues with respect to cable communications. There is not now any domestic satellite system anywhere in the world, let alone a system designed to cater to the needs of cable communications. It is unlikely that the FCC will reach a decision on the applications before it for some time, certainly not less than a year. Again if the Hughes application can be taken as a model, a system would not go into operation for yet another two years or so after favorable FCC action. At fair guess, we will not see an operating domestic satellite system capable of serving cables until the mid-70's at the earliest and probably not before the latter half of the decade.

Still some very general conclusions about the role of such systems can be reached:

First, satellites can and probably will be relied on to bring basic broadcast service to homes beyond the reach of conventional broadcast or cable systems.

Second, satellites are likely to be the vehicle for large scale interconnection between cable systems on a national, regional or other basis, if such interconnection proves desirable, as it probably will.

Third, and much further in the future, it seems likely that if policy and economics point toward switched interconnection among cable systems, satellites could very well become the preferred vehicle for that function as well.

Most of the more immediate policy problems center around the second of these functions and chiefly concern control of access to the satellite network by program producers and others with messages to transmit. One recommendation that emerges very clearly is the establishment of a free national instructional TV network by requiring dedication of some capacity for this purpose in any authorization for satellites to serve cable systems. Outlets should be provided to local schools, also free of charge, as a condition of cable system franchise.

The implications of the third function - provision of switched interconnection capability - are both more remote and potentially more far-reaching. The possibilities are so extensive and so little understood that some experimentation is warranted in advance of market or other large scale demand, to get a better feel of the problem.

In fact, a similar prescription is probably advisable on most issues of satellite-cable relations. Little is now known and little thinking is being done; but the necessity for final decisions is still some years in the future. This dictates a flexible and exploratory orientation in any authorizations granted in the next few years for satellites to service cables. The Hughes application displays a willingness to try more than one approach to several of the important issues raised by its application. This is a healthy tendency and should be encouraged. The White House memorandum reflects something of this philosophy when it asks that a variety of satellite systems be permitted to submit themselves to the test of the market. On the other hand, it is unlikely that more than one authorization will be given for a satellite largely devoted to serving cables, or that the traffic would justify it. If that is so, perhaps the applicant should not be wholly free to bet on his own conception of how the service should be provided, but should be encouraged or required in the early phases of the system, to try out several of the most promising alternatives. Moreover, any authorization should be strictly and practically limited in time. This is not very fiery, but it will permit policy issues and potential solutions to be clarified before the time for making hard choices arrives.