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ABSTRACT

The Federal Communications Commission has asked that companies seeking authorization to construct and operate communications satellite facilities for multi-purpose commercial uses in the United States give consideration to the communications needs of schools. In response to this request, MCI Lockheed Satellite Corporation proposes a low-cost telecommunication service for use by schools beginning in the 1970s. The service would offer satellite information transmission capacity equivalent to five television channels for school use at no cost for five years after the satellite goes into operation, and at a fraction of the prevailing commercial rates thereafter. This low-cost satellite information transmission capacity would be sufficient to provide many combinations of service. For example: three channels could provide at least one computer terminal full time in each U.S. school district; one channel could distribute instructional television and radio lessons nationwide to schools; and one channel could interconnect existing and planned noncommercial public broadcasting stations. School users will obtain access to the service through earth stations operated by the schools, the community, or the commercial common carriers. Capital costs for school-operated earth stations could be on the order of 1¢ per student-day for school districts of average size. (Author/JY)

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# SATELLITE COMMUNICATIONS FOR U.S. SCHOOLS

## A Proposed Public Service Offering By Private Business



Prepared for
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## CONTENTS



MCI Lockheed Satellite Corp. has requested authorization from the Federal Communications Commission to construct and operate communications satellite facilities for multi-purpose commercial uses in the United States. The FCC has asked that companies seeking such authorization give consideration to the communications needs of U.S. schools. Along with its other services, the Corporation proposes to provide a portion of its satellite capacity for low-cost telecommunications services to schools in all fifty states of the United States. Students throughout the nation can thus begin to obtain some of the potential benefits of satellite telecommunications during the decade of the 1970s.

MCI Lockheed Satellite Corp. has retained Stanford Research Institute to explore the developing public interest in satellite telecommunications to serve U.S. schools.

This publication was prepared to introduce a wide audience of educators, parents, businessmen and government officials to some of the ways in which satellite telecommunications can enrich instruction to achieve a higher educational yield from U.S. school resources, and to interpret MCI Lockheed's proposal to offer such telecommunications services at low cost.


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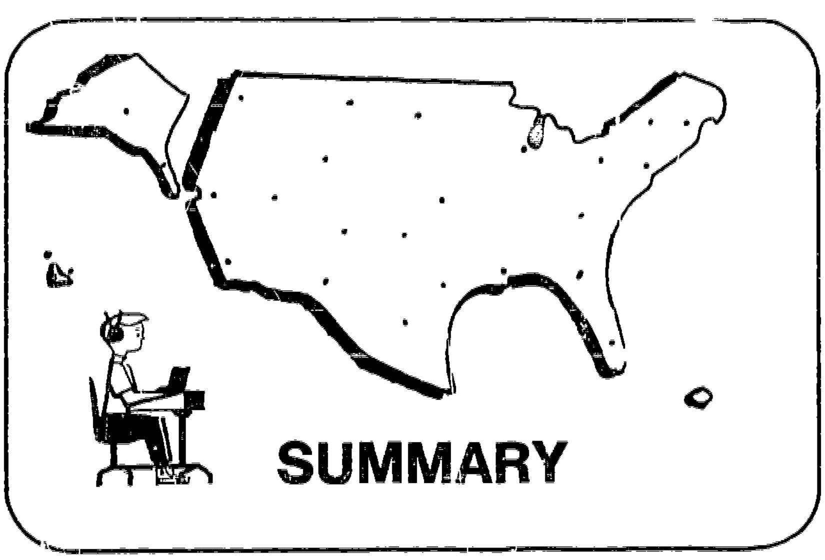


# SUMMARY

• Low-cost telecommunication service for use by U.S. schools throughout the 50 states, beginning in the mid-1970s, is proposed by MCI Lockheed Satellite Corp., in its application to the FCC to provide commercial telecommunication services by satellite in the United States.

• The high costs of long-distance telecommunications—annually more than $300 per mile for a single channel for educational TV programs and $10-$25 per mile for telephone data circuits—have restricted the use of school information services that could enrich instruction and facilitate school management.

• The domestic telecommunication satellite, with appropriate low-cost terrestrial facilities, can give schools and students located in rural communities, towns and cities throughout the United States—including Alaska and Hawaii—low-cost, timely access to educational information resources located elsewhere throughout the entire nation. These information resources can serve elementary, secondary, collegiate, adult, and advanced professional education needs.

• Low-cost satellite communications service can be used for television and computer services. Television uses include nationwide distribution of programs and lesson materials to schools for live use or in conjunction with schools' recording and playback equipment, employing tape cassettes or other storage media. Two-way transmission, while more expensive, will permit conferences and interactive computer services. Conferences can be conducted with nationwide participants remaining in their own communities. Schools throughout the United States can obtain access to computer services for use in vocational and professional instruction and counseling, and in school management record-processing.

• MCI Lockheed proposes to offer satellite information transmission capacity equivalent to five television channels for school use at no cost for five years after the satellite goes into operation, and at a fraction of the prevailing commercial rates thereafter. This inducement—along with low-cost surface facilities—will encourage experimentation by the educational community in the use of long-distance telecommunications.

• Rates for long distance telecommunications are expected to decline significantly from present levels during the next decade as common carriers install additional conventional and satellite transmission capacity and as competition is created by the entry of new carriers. The MCI Lockheed offering of free satellite transmission capacity will make it possible to develop and experiment with new educational resource materials, for wide use at the lower rates that will prevail in the following decade.

• The low-cost satellite information transmission capacity proposed—five channels—is sufficient to provide many combinations of service. For example:

- Three channels could provide circuits adequate to serve at least one computer terminal full time in each U.S. school district for experimental access to school computer services,
- One channel could distribute instructional television and radio lessons nationwide to schools for direct use and for dissemination through state and regional school telecommunication networks, and
- One channel could interconnect existing and planned noncommercial public broadcasting stations, as recommended by the Carnegie Commission on Educational Television.

The five-channel capacity can, of course, be employed in many other combinations of uses to provide a mix of services having tremendous scope and flexibility.

• School users will obtain access to the satellite transmission service through earth stations operated by the schools, the community, or the commercial common carriers. Capital costs for school-operated earth stations could be on the order of 1¢ per student-day for school districts of average size. Surface communication links to connect the school user with satellite earth stations can be provided by special-service common carriers, school telecommunication networks, telephone lines, and cable television lines. The MCI terrestrial carriers have recently offered low-cost link facilities for educational users. All terrestrial communication links would be separately obtained by the schools. The configurations best suited to a given school's needs must be determined individually.

• The availability of low-cost telecommunication service can be expected to accelerate the use of school information services, to stimulate the development and production of equipment and program materials by business, to attract private capital for these purposes, and to encourage the dispersal of U.S. population and activity by enhancing educational opportunities outside of metropolitan areas.

• Potential users and suppliers of equipment and program materials for school information services employing the proposed communications satellite can carry out needed planning and development during the first half of this decade, while the satellite facilities are being constructed. Such planning should begin now and should be accelerated when the proposed satellite system is authorized.

# INTRODUCTION

The communications satellite affords attractive potential benefits for U.S. schools, for it can efficiently provide widespread access to a broad variety of information resources for education. These potential benefits have not been realized in the United States. Communications satellite service between points in the United States has not been available, and existing long-distance telecommunications services and facilities have been too costly for wide use by schools. Until now, the principal efforts to use satellite communications for educational purposes have come from countries outside the United States, such as Brazil and India.

Much has been said and written of the potential use of communications satellites in U.S. schools, in anticipation of their eventual availability. Most attention has been directed toward a satellite that would be dedicated wholly to educational uses, or to commercial television plus educational uses. However, a single satellite requires huge capital outlays; costs of existing systems range upward from $20 million, and the associated risks are substantial. Furthermore, the U.S. school system is diverse and highly dispersed among some 20,000 school districts, none of which can alone muster sufficient resources or derive sufficient benefits to undertake a dedicated communications satellite.

The formidable administrative burdens of forming joint or cooperative ventures among numerous school districts located throughout the United States have precluded this approach toward pooling resources for a dedicated educational satellite. Witness, for example, that high costs and administrative difficulties in joint funding and frequency assignment led to discontinuance of a cooperative venture to provide an aircraft to relay educational television broadcasts to schools in several Midwestern states. Heretofore, the private business sector has not provided a dedicated communications satellite for U.S. schools because of delay in the formulation of domestic satellite policy, because of the absence of an established U.S. school market for long-distance telecommunications, and because of the huge initial capital outlay required.

Earlier proposals for commercial communications satellite services in the United States did not explicitly provide for the particular needs of U.S. schools. Now, however, a multi-purpose, high-capacity communications satellite is being developed for commercial service in the United States. A portion of the large capacity of this commercial satellite can be made available on terms that will be attractive to U.S. schools.

Private business will provide the organizational momentum, and bear the costs and risks of creating the necessary satellite communication capability. A portion of the satellite's capacity will be made available to schools at rates below those now available from existing terrestrial common carriers and below those proposed for commercial users of satellite communications. This action will open new vistas for educational innovators in America. Satellite telecommunications will provide widespread access to educational resources located anywhere in the United States, thereby affording wide variety and diversity of resources to school districts that can now afford only a limited range of offerings and resources for their students. Educational telecommunication promises to enrich and individualize instruction in a variety of ways. Almost all school districts can benefit from it; the poorer, smaller, or more remote and disadvantaged districts may benefit even more dramatically than the large, wealthy, and privileged ones.

The technology necessary for communications satellites has been developed by massive public investment during the last decade. Furthermore, satellite transmission capability will, in the future, become a scarce resource because the supply of orbital "parking spaces" and radio frequencies is limited. The public investment in technology that created the valuable but scarce resource of satellite communication capability therefore creates an obligation to use available natural and man-made resources efficiently and beneficially. Thus the provision of satellite communications by private business is responsive to social need, and manifests a voluntary constructive ordering of social priorities by private business and its governmental regulators.

The offering outlined here is intended to stimulate innovation and experimentation in the use of long-distance telecommunications for access to educational information resources. It could bring important educational benefits to small communities throughout the United States. It will stimulate many lines of business, including the manufacture of information terminals, television receivers, and audio and video recording and play-back equipment, as well as the production of instructional program resource materials, the provision of local telephone and cable television communication circuits, and the manufacture of satellite earth stations. The educational telecommunication system can be a boon to students, parents, educators, and taxpayers in school districts throughout the United States.

# THE PROPOSED OFFERING

The Federal Communications Commission, in its Report and Order in Docket 16495, adopted on 20 March 1970, 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 systems should define the terms and conditions under which satellite channels will be made available for noncommercial broadcast networks, if the applicant's proposed service includes commercial television or radio program transmission.

The high costs of present long-distance communications have resulted in their scant use in U.S. schools. Very few schools use such services—and then only in limited experimental operations. If the potential educational benefits of long-distance telecommunication are to be realized, a considerable amount of experimentation and development will be required so that teachers and administrators can gain experience with these resources.

To encourage and stimulate such experimentation and development, MCI Lockheed Satellite Corp. proposes to make available for school use a significant amount of long-distance information transmission capacity at no charge for the first five years beginning in 1975, and at very low rates during the balance of the 10-year design life of the satellite.

A similar approach was employed at Dartmouth University during the 1960's to stimulate the development of computer time-sharing by numerous distant users through remote access. Computer service was made available free, or at negligible costs, to a variety of new users. Time-sharing quickly came into widespread use. Similarly, during the 1960's, IBM made computer services available to universities at charges well below the prevailing commercial prices.

It appears that multipurpose, high-capacity communication satellites that are now technologically feasible can be financially viable in commercial long-distance telecommunication service when operating at less than full capacity and under less than present-day common-carrier price structures.

The channel capacity to be provided for educational users is approximately 10% of the total capacity of the satellite. This transmission capacity should be available for full time use by U.S. schools throughout the design life of the satellite. Thus, for a 48-channel multipurpose satellite, up to five channels would be provided for school use. Each channel would be capable of transmitting television program material at quality levels comparable to or better than present-day commercial television networks, or each channel could provide about 600-1800 circuits—depending upon earth station design—equivalent to presently used common-carrier voice circuits. Terrestrial facilities and services for use with the satellite transmission link—which determine the signal quality obtained by the schools—would be separately procured by the schools, as would the equipment and programs employed in school information systems.

The channels provided for free use during the first five years of satellite operation would stimulate experimentation and innovation in the development of educational information resources. The experimental phase in which a specified number of satellite transmission channels will be provided to U.S. schools at no cost would be followed by an operational phase in which channels are provided to schools at a nominal cost well below then prevailing commercial rates for comparable service.

Rates in the operational phase for a satellite circuit with capacity equivalent to a present-day telephone circuit should be available to school users for access to information resources at a monthly cost no greater than a present-day local business telephone subscriber's cost—nominally \$15 to \$20 per month. A significant difference, however, is that local telephone service covers a distance of a few miles, whereas the satellite circuit would cover the entire United States, including Alaska and Hawaii.

During this phase, high-volume channels for uses such as television transmission would also be available at favorable rates. Present-day cost of television transmission service for each of the three major television networks to transmit programs to most cities in the United States is about \$10-\$15 million per year for leased interexchange channels, plus a lesser amount for occasional-use interexchange channels. Nonprofit public service institutions may, in the next few years, obtain a more limited capability to distribute noncommercial broadcasts to selected cities at yearly costs of about $5 million, perhaps ranging as low as $1 million. MCI Lockheed proposes that satellite transmission channels for television program distribution to schools throughout the entire United States should be available to U.S. schools during the operational phase at rates well below then prevailing rates for comparable commercial service.

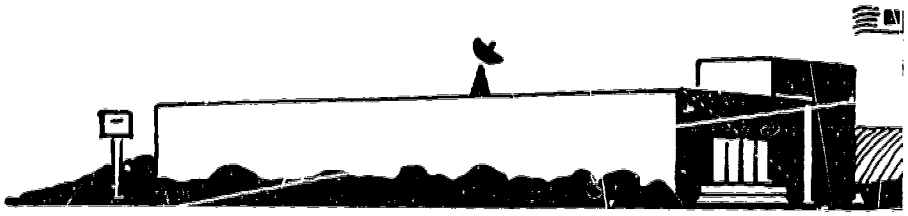
Since five channels are allocated for educational use at no charge for a period of five years, consideration should be given to providing one of these channels to serve the interconnection needs of public broadcasting. The Corporation for Public Broadcasting was established by the U.S. Congress in the Public Broadcasting Act of 1967 to develop noncommercial broadcasting in the United States. The Corporation is intended to serve the needs of a broad cross section of the public, including—but not limited to—U.S. schools. Seventy noncommercial stations are now interconnected by terrestrial common-carrier facilities for the distribution of television programs. The corporation is presently negotiating for nationwide facilities and services to interconnect 101 of its 204 stations and envisions that in time its network will include more than 327 stations.

Priorities for the allocation of the offered transmission resource for U.S. schools can be developed by the U.S. educational community in conjunction with governmental entities responsible for telecommunication policy and regulations.

It appears likely that prices for long-distance telecommunications will decline during the coming decade. Public policy decisions and private business actions already begun will result in competition among providers of telecommunications and increased capacity for long-distance telecommunications by means of satellite, terrestrial microwave, and cable.

The satellite communication common carrier will, of course, provide only information transmission for U.S. schools and *will not in any way influence the content* of the information transmitted. The educational resource information transmitted by means of the carrier's facilities will be fully controlled by the users and providers of these resources.

In summary, MCI Lockheed proposes to offer satellite information transmission capacity equivalent to five television channels for school use at no cost for five years after the satellite goes into operation, and at a fraction of the prevailing commercial rates thereafter. Terrestrial facilities and services for access to the satellite link would be separately obtained by the schools.



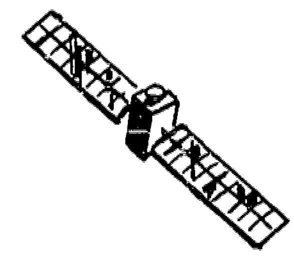
Long-distance telecommunication, as proposed by MCI Lockheed, makes possible important scale economies in educational resources by assembling markets large enough to afford low costs per user, even for programs that are costly to develop, and for which the users at any one location are few. Many information resources that could be of great benefit to schools require significant initial investment for program materials and equipment. In many cases, the use of these resources is feasible and attractive only if these fixed costs can be spread over a large number of users to reduce the unit costs.

In some cases, material stored on tapes or other media can be transported to enlarge the number of users among whom costs can be shared. For some uses, transportation of materials may be preferable to telecommunication, because sometimes transportation costs are low and service characteristics are adequate. In other cases, the service characteristics afforded by telecommunications are much to be preferred, but cannot be enjoyed unless the cost of telecommunication is low enough.

As noted, low-cost, long-distance telecommunications can give schools broad access to information resources available throughout the United States. Conversely, those who provide educational information resources can gain access to school users throughout the United States, thereby lowering costs per user, and enabling a much wider variety of resources and providers. The present-day high costs of long-distance telecommunication tend to limit school users to those information resources that can be obtained with local telecommunication service. Low-cost, long-distance telecommunication can expand the area for reciprocal access from a few hundred square miles to more than three million square miles. The larger user markets that can be assembled by means of this greatly broadened access can make feasible a number of desired educational information resource services that are presently infeasible.

The availability of low-cost telecommunications will enable schools to experiment with television, radio, and computer services to better learn their own needs and how these can best be filled. It will also enable schools to send and

# POTENTIAL USES OF SATELLITE COMMUNICATIONS FOR U.S. SCHOOLS



receive documents of many types over long distances, to retrieve information from distant research libraries, and to participate conveniently with distant research centers in multi-school educational research projects.

## COMPUTERS FOR SCHOOLS

The computer has found many uses as an information-handling tool in business and government. It is less used in schools, even though information-handling is central to the school's function. The high cost of owning and operating computers and developing the necessary program materials are formidable obstacles to most school districts.

With low-cost, long-distance telecommunications, schools or districts throughout the United States can obtain services from computers located outside of their locality. Conversely, organizations that provide computer services can serve schools throughout the United States. This reciprocal breadth of access can profoundly affect the development and availability of the computer as a tool for U.S. schools. The computer utility concept for schools can become a reality, providing computer service to numerous users remote from the computer.

Schools in smaller communities outside of major metropolitan areas can have access to the same information resources as metropolitan schools. This equivalence of access can become an important factor in the emerging national policy of encouraging dispersal of U.S. population and activity instead of further concentrating it in the overcrowded metropolitan areas of today.

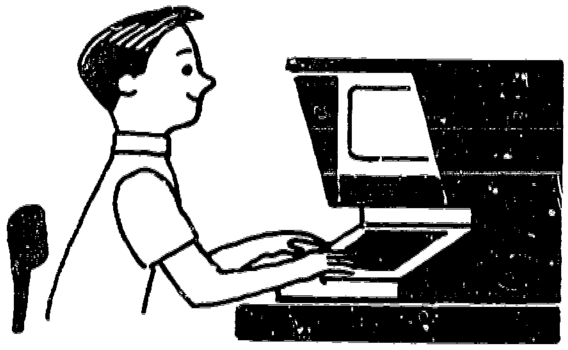
Organizations that provide computer service for schools can reach larger markets by means of low-cost, long-distance telecommunications. Instead of being restricted to those offerings of equipment and programming that can be supported by schools within a single locality—that is, the range of local calls—they can now undertake to provide services to schools throughout the United States. Because larger markets can be assembled for any particular service offering, it becomes possible for such organizations to innovate and provide a greater variety of offerings that can better suit the individual needs of schools.

With low-cost, long-distance telecommunications, each school can—with little cost and low risk—try a variety of services available elsewhere in the United States to find those best suited to its needs. As low-cost telecommunications enable schools throughout the United States to gain experience in using computers, their needs and the kinds of school information service offerings that are most useful to them will become clearer. Then it will become possible to create viable computer service offerings for operational use by schools.

Without long-distance telecommunication that gives access to distant resources for familiarization and experimentation, the development of the use of computers as a tool for schools will proceed much more slowly, because schools would have to commit to a full-scale computer facility in their locality even to experiment. The costs of this approach rule out all but the most limited experimentation.

In summary, low-cost, long-distance telecommunication can vitally affect the use of computers as a tool for U.S. schools. It can give schools broad access to a variety of computer services available throughout the United States at low risk to the individual school and thereby enable the schools to experiment and gain experience in meeting their individual needs. By the same token, those who provide computer services for schools—businessmen and others who will make up the school-information service industry—can innovate more boldly and provide a wider variety of service because they can assemble large markets from throughout the United States, rather than being confined to offering only those services that can be supported within one locality.

Computers can serve two basic needs in schools—instruction and school management. Instructional uses include conversational or interactive modes, usually termed computer-assisted instruction (CAI); progress monitoring, known as computer-managed instruction (CMI); and instruction in the operation and use of computers, or computer instruction (CI). School management uses principally involve the processing of school records and data such as attendance, grades, payroll, schedules, and planning information.



**Computer-Assisted Instruction**

In computer-assisted instruction, the student works at a computer terminal—such as a typewriter or keyboard and screen—that affords communication to and from the computer. The computer presents information to which the student responds, and the lesson proceeds at a pace that depends on student comprehension.

At present, this mode of computer use in schools is largely limited to experimental activities, often aided by financial support from government or foundations. In its present state of development, it is a rather expensive means of instruction. Even so, some present-day CAI systems are cost-effective for compensatory education of disadvantaged students. Development of the necessary computer programs involves many man-months of effort and substantial dollar costs. Operation of the system usually entails significant costs for computer processing time—on the order of several dollars per student-hour of instruction. Lease costs for terminal devices range from several hundred dollars to a few thousand dollars per terminal year. If the computer is distant from a student, telecommunication costs can be substantial, ranging upward from one dollar per mile each month for a circuit that can serve about a dozen slow-response terminals, or one to a few fast-response terminals; costs thus amount to at least several thousand dollars per circuit-year for access to a computer as far as one thousand miles distant.

The large initial costs of programs decline dramatically on a per-student basis when sizable markets can be assembled by low-cost, long-distance telecommunications. Larger markets for a computer program can, of course, be assembled by sending the program, on tape or cards, to other compatible computers. This method of operation often is complicated by differences between computers and by difficulties in uniformly incorporating changes into programs at different computers. A program that costs $500,000 to develop might provide 100 hours of instruction, averaging $5,000 per hour. If that program can be used by 500,000 students during its useful life of perhaps a few years, the cost per student-hour is only one cent. The cost of computer time can also be expected to decline with economies of scale and specialization—both of which require the assembly of large markets—and with the declining costs of computer capacity that are promised by developments in microcircuitry. Costs of terminals can also be expected to decline in the coming decade with continued development and large-scale manufacture for a wide variety of business and other uses that are emerging.

**Other Interactive Uses**

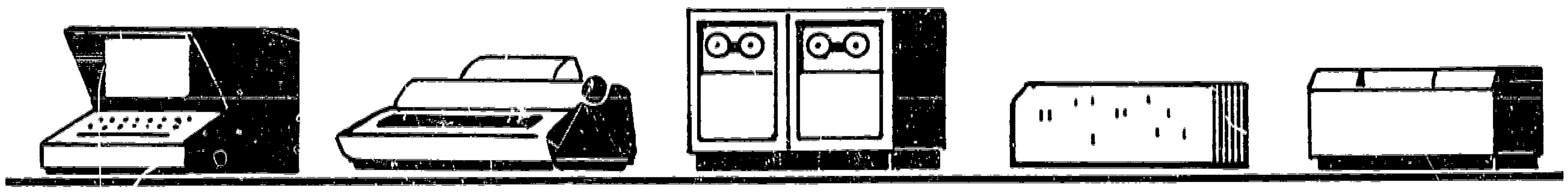
Interactive computers can also provide instruction through simulation games that permit the student to interact with simulated behavior of groups, such as consumers in the market place, voters, or legislative and adjudicatory bodies. The interactive mode of computer usage is also employed at present to provide basic data for counselors in experimental forms of student counseling for vocational, academic, and personal guidance.

Schools in areas where direct student access to a computer is not feasible can use remote computers for instruction in computer programming and usage. Remote computers can also be used directly as a student tool to aid lesson preparation and reduce some of the drudgery that can impede the learning process.

**Computer-Managed Instruction**

The concept of computer-managed instruction (CMI) is under development at this time. In this concept, the computer is used to record a student's progress, diagnose his individual needs, and develop his daily course and lesson schedule. The teacher is freed from much of the burdensome detail required to pace each student's progress according to his individual abilities. By assembling the large markets made possible by low-cost, long-distance telecommunications, the large costs of program development can be spread over many students to achieve low unit costs. Another attractive feature of this approach is that it uses the telecommunications system during night hours, when other demands for it are minimal.

This instructional tool holds great promise for individualizing instruction. The curriculum materials for each student, such as books and problem sets, are presented to him, according to his achievements to date, as determined by frequent tests of his progress. Thus, students in any given classroom at any given time may be working on widely different things, depending on their interests, abilities, and previous achievements. Each student might daily receive a statement that assesses his previous day's work, indicates



remedial assignments and tutorial material to help him in areas where he is found inadequately prepared, and presents new, individual assignments of reading and exercises in the student's textbooks and workbooks. Student papers would be handed in daily and processed by the computer overnight.

The CMI concept might in some areas be operable by transporting records daily between schools and a central computer. However, the use of low-cost telecommunications provides a much better means of data transfer, and—especially in rural areas—can be much less costly. The cost and time required would make record transportation infeasible for much of the rural population.

### School Management Data Processing

Computers are also coming into use for school management data processing. Very large schools and districts in some cases can justify one or more computers for their sole use. Most smaller schools and districts cannot. For these smaller schools and districts, the shared use of computer equipment and programs with other districts can be attractive. In Minnesota, a cooperative organization serves 29 districts with a total of about 250,000 students, using a single computer, to provide payroll, attendance, grades, scheduling, and other school management data. Data terminals in each of the districts served provide access to the central computer via local telephone lines. The total present data transmission load is served by about 12 voice-grade telephone circuits at the computer; each circuit thus serves about 20,000 students on average. Schools participating in this cooperative system pay about $5 to $6 per year for each student.

Additional school computer service centers are planned for several other locations within the state. Schools and districts in the regions served by these additional centers would obtain service mostly by local telephone circuits. The costs of present-day, long-distance circuits are judged to make it necessary to establish these additional centers in locations around the state rather than serving these areas from computer facilities at a central location, where program and equipment operation and maintenance might be simpler and perhaps less costly.

The effects of user group size and length of telecommunication links upon cost-per-student are evident in the experience of another school computer service center operating in a Pacific Coast state. Eighty thousand users located throughout a larger geographic region are served by this system. A number of the users are located beyond local telephone service areas and, therefore, must use long-distance circuits. The average cost under these circumstances for similar computer service is reported to be about $10 to $12 per year for each student. This cost difference between the two systems indicates the effect of sharing the computer equipment and program costs among a smaller number of users and of incurring larger communication expenses because long-distance rather than local circuits are used. Thus, it is seen again that costs per user can be lowered when larger user markets can be assembled by use of telecommunications, provided low-cost services are available for this purpose.

### Economic Analysis

A hypothetical future school computer might cost $1,000,000 to acquire and $100,000 per year to maintain, with a useful life of ten years; it could serve 200 terminals without excessive user delays. Each terminal might be used for 200 hours per month, for 10 months, or 2,000 hours per year for a total of 400,000 terminal hours per year. The capital cost of this computer would be 25¢ per terminal hour; the operating cost would also be 25¢ per terminal hour. Thus, the total computer cost would be 50¢ per terminal hour.

Future terminals might cost $2,000 each to acquire and $200 per year to maintain, with a useful life of ten years. The capital cost of these terminals would be 10¢ per terminal hour; the operating cost would also be 10¢ per terminal hour. Thus, the total terminal cost would be 20¢ per terminal hour. The present-day telephone network requires use of a circuit interface device with computer terminals, at a cost of approximately $20 per month per telephone circuit, serving perhaps 10 terminals. This device would add about 1¢ per terminal hour. This cost may decline as a result of future regulatory decisions that could permit incorporation of the necessary circuitry directly in the terminal. The future terminal cost used here is assumed to include such circuitry.

The communication link cost for each terminal would vary with terminal response speed and distance from the computer. A link equivalent to a present-day telephone voice circuit would cost about $20 per month for local call distances or $200 per month for a 100-mile distance at $2 per mile per month. One circuit could serve perhaps 10 terminals similar to electric typewriters at a circuit cost of 1¢ to 10¢ per terminal hour, depending upon distance. A multiplexer needed to serve 10 terminals from a single cir-

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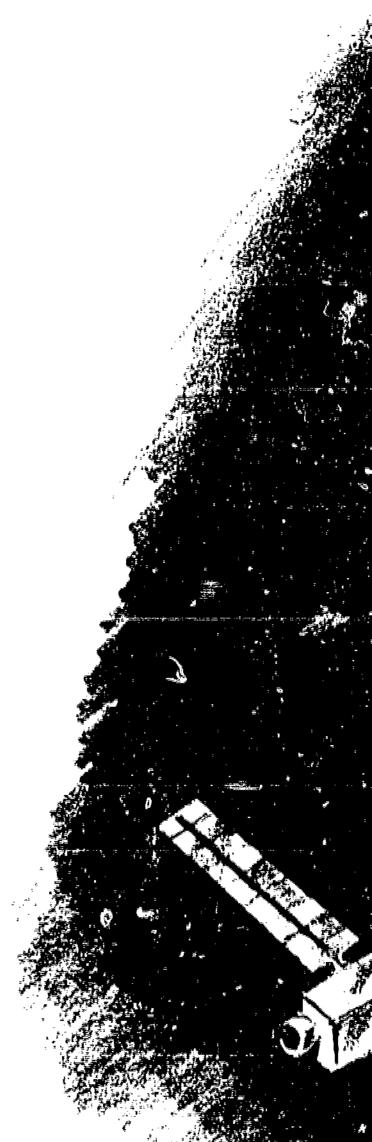

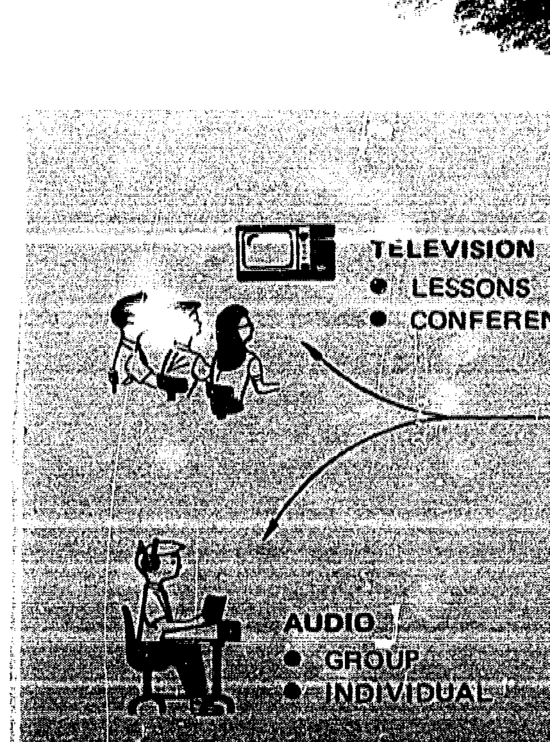

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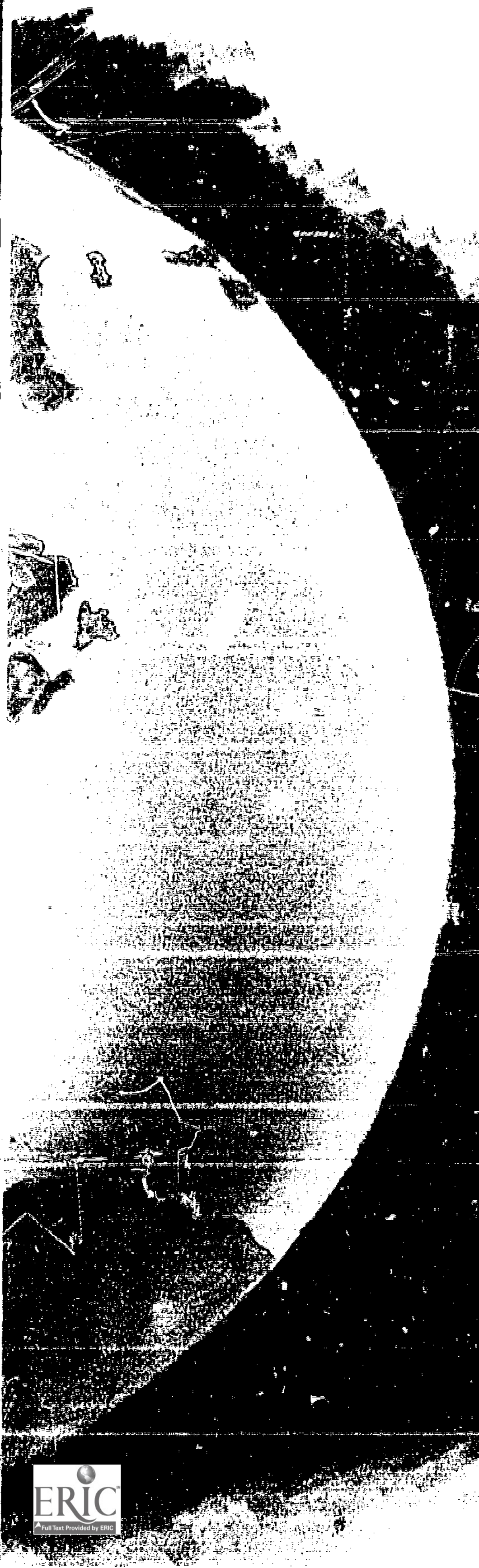
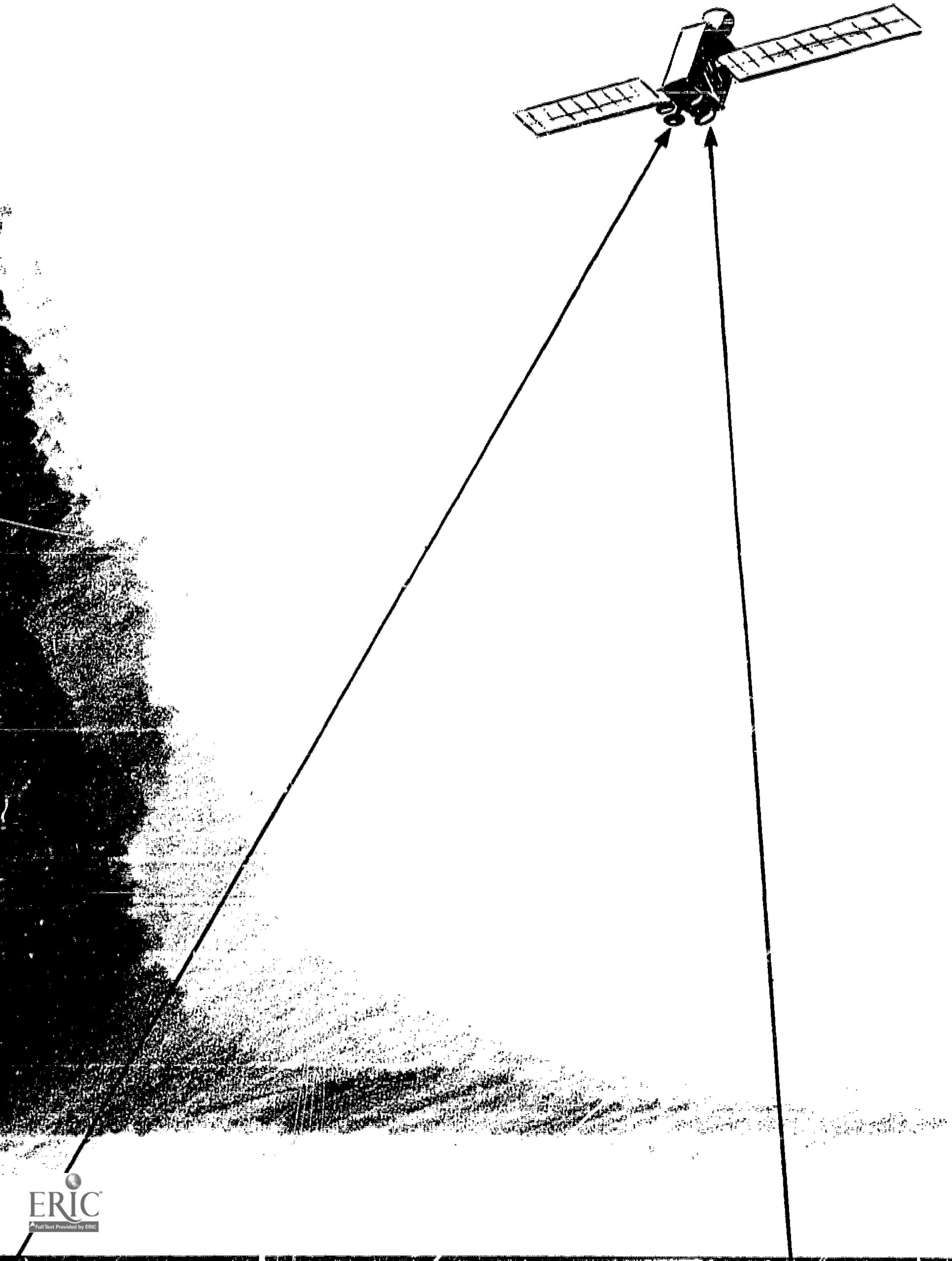




cuit might cost on the order of $1,000 to acquire, averaging about $100 for each of the 10 terminals served, thus accounting for about 5% of the terminal cost.

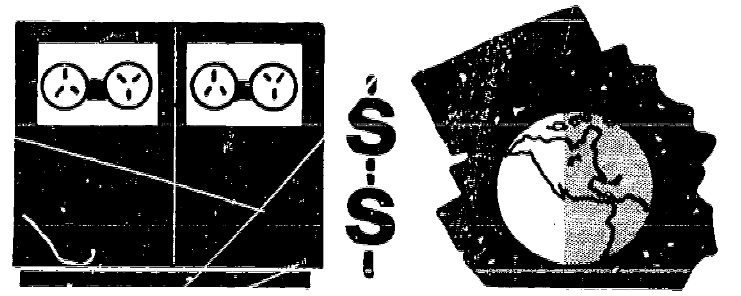
The combined total cost might be 70¢ to 80¢ per terminal hour, including the costs of computer, terminal, and communication links for service within a 100-mile radius. Terminals that operate with faster responses—such as those employing a keyboard and an electro-optical display similar to a TV tube—might increase these costs by a factor of two or more, because a smaller number of such terminals could be served by the computer and by each communication circuit. Such terminals can increase the rate at which the computer sends information to the student. However, the overall rate of information exchange with the computer, and hence the total number of terminals that can be served, is paced largely by the student, in time spent thinking and transmitting information to the computer.

A ground station to provide access by satellite link to a computer such as that postulated here might become available at about $40,000 to acquire and a few thousand dollars annually to maintain, with a ten-year useful life. If its full costs were allocated to serving the computer terminals, and were not shared with other uses, such as video program transmission, these costs would amount to about 1¢ to 2¢ per terminal hour.

The costs of programming for computer-assisted instruction are approximately $200,000 for a 40-hour course, or $5,000 per hour of instruction. If the useful life of such a program is five years and the program is used by 100,000 students in each of those years, cost could be spread over 500,000 students for a unit cost of 1¢ per student-hour. If only 5,000 users could be assembled, these costs would amount to $1 per student-hour.

A computer system like that considered here could provide 40 hours of terminal usage each year for 10,000 students, at a cost of $30 to $40 per student-year. This usage intensity is equivalent to a 4-hour-per-week course for one 10-week academic quarter each year, about 3% of the student's classroom hours. During 12 years of school, a student would complete 480 hours of computer-assisted instruction.

The national average cost for U.S. schools at present is about $800 per student-year, for about 1200 hours of conventional instruction. The average cost per student-hour is slightly under 70¢, approximately equivalent to that for computer instruction in the example presented here. The school computer system capital costs per student, on a yearly basis, would be about $10 for the computer and about $4 for terminals, equivalent to the costs of two or three conventional text books. Capital costs for the postu-



lated earth station would be 40¢ per student, yearly, under these same assumptions.

The hourly costs above are predicated upon 2,000 hours of usage annually. The cost per terminal-hour, and hence the cost per student served, can be lowered further if this equipment can be used for more hours during each year. One possibility for such extended usage is adult education on nights and weekends. The computer would become a valuable adjunct to the adult education programs that are conducted by a growing number of school districts. Of course, such programs also spread the costs of other school facilities, such as buildings and equipment. As with other school capital facilities, usage during a larger portion of the year—such as the summer recess period—can also reduce unit costs by spreading total costs over a larger number of usage hours.

Costs used in this example for surface communication links to connect school terminals directly to the computer or to the ground station linked to the computer via the satellite are based upon present-day telephone line rates and a surface area of 100-mile radius. A surface area of this size would encompass approximately 30,000 square miles, nominally 1% of the surface area of the United States. A student population of 10,000 in this surface area corresponds to a density of one student in three square miles. Nearly all U.S. students live in areas with a population density greater than this. Sparsely populated Montana, for example, has a student population averaging slightly more than one student in each of that state's 147,000 square miles. There are few U.S. schools where less than 10,000 students in grades 1-12 would be found within a 100-mile radius.

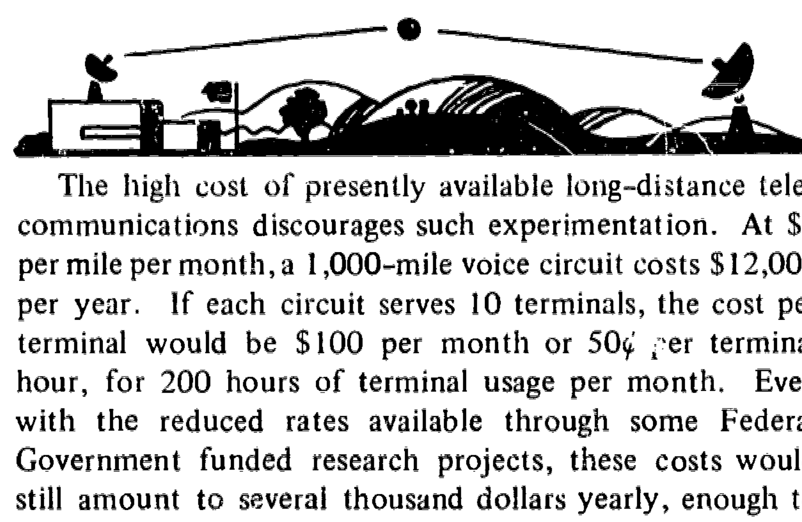
It can be seen again that the economic viability of these high-fixed-cost instructional methods depends critically upon the ability to assemble large enough groups of users to spread these fixed costs so that the potentially low unit costs can be realized. Low-cost, long-distance telecommunications by satellite can make an important contribution toward this end, especially during the period when such uses are under development.

Although the school computer usage described here does not exist now, it could come about in the future. Much of the equipment needed for schools will come into being because it is similar to that being developed for non-school use. But the programming must be developed strictly for school use. Schools are unlikely to invest in computer equipment until a great enough variety of suitable programming is available for use. The high initial costs of programming cannot be undertaken until a sufficient number of schools are prepared to use it, so as to spread the costs over a large number of users. A business enterprise that might invest its capital in the development of programming would have to wait a long time for a return on that investment under present conditions. That long delay in return on investment may well discourage most entrepreneurs from entering this field. Conversely, a school district might not wish to undertake acquisition of computer equipment until an adequate variety of suitable programming is available.

A single program would not, of course, suffice for all students in a district, although some programs might serve several grades. At least one course suitable for each grade level would probably be required to serve enough students to justify the equipment costs involved, at least in smaller districts. For a smaller district, having a total of 10,000 students in grades 1 through 12, 40 hours of programming for each grade level would be needed, totaling 480 hours. At an average cost of $5,000 per hour this would require programming investments of $2.4 million. Each of these 12 programs would have to be used by 100,000 students each year, assuming a five-year useful life, to reduce program costs to 1¢ per student-hour. A market of 1.2 million students, equivalent to 120 districts of 10,000 students each, would have to be assembled in order to achieve this level of unit cost. A market of only 12 such districts, comprising 120,000 students, would result in program costs of 10¢ per student-hour. Such markets, necessary to absorb programming costs, could not be assembled until these districts had acquired computers and terminals such as those indicated here.

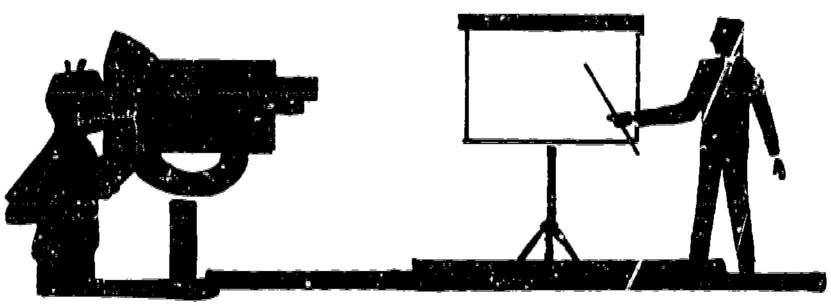
In the absence of program materials of demonstrated benefit, the districts would be understandably reluctant to commit large sums to capital equipment that could be justified only if it could serve usefully for a number of years. The lack of computers in schools precludes program preparation and the absence of programs precludes school acquisition of computers. Schools could, of course, lease computers to try programs without making the long-term investment commitment, but even that constitutes what is essentially a full-scale experiment that few schools are able to undertake. Furthermore, program development costs can be recovered only through multi-year use, and program developers would be unlikely to undertake the investment risks involved without some assurance of multi-year use sufficient to recover their costs and earn a return upon their venture investments. Such multi-year commitment would confront school districts with risks that many could not accept. A single large district with more than 100,000 students could seemingly absorb these costs. However, such a district would be undertaking a costly experiment in a full-scale commitment of several million dollars to program development and equipment acquisition for a system with which it has had no prior experience. Few districts can underwrite such a venture.

Low-cost, long-distance telecommunications can break these formidable barriers by enabling an individual school or district to try computer services on a limited, relatively low-risk experimental basis without need for large-scale, long-term commitment to program development and equipment acquisition. It can also enable program developers to reach a much larger group of potential users and thereby reduce the developer's risk. With low-cost, long-distance telecommunications, a school or district can explore computer use with as little as a single terminal leased on a short-term basis for a few hundred dollars.



The high cost of presently available long-distance telecommunications discourages such experimentation. At $1 per mile per month, a 1,000-mile voice circuit costs $12,000 per year. If each circuit serves 10 terminals, the cost per terminal would be $100 per month or 50¢ per terminal hour, for 200 hours of terminal usage per month. Even with the reduced rates available through some Federal Government funded research projects, these costs would still amount to several thousand dollars yearly, enough to discourage many potential experimenters. The proposed offering of several years of free service, followed by several years more at very low cost—a few hundred dollars per circuit year rather than several thousand dollars—will enable many schools that cannot now explore and benefit from computer services to do so. At the postulated rate of $20 per month for a voice-equivalent circuit, and using the same assumptions as above, the circuit cost per terminal hour would be 1¢; adding 1¢ to 2¢ for the hypothetical ground station cost would result in a total telecommunication cost of 2¢ to 3¢ per terminal hour, a small figure in comparison with either the combined total cost of 70¢ to 80¢ per terminal hour for computer and terminal, or the cost of present telecommunication service at 50¢ per terminal hour.

If three of the five channels in the proposed public service offering were available for computer access, these channels could provide perhaps 3,000 circuits that could serve about 30,000 terminals. On average, this is more than one for each of the 20,000 school districts in the United States.



## TELEVISION

The use of TV programs to supplement classroom instruction is increasing. TV lessons are used as a resource by teachers to encourage the learning process. Proponents of TV lessons find them useful to stimulate learning by supplying valuable lesson content and effective presentation. An enormous range of material can be conveyed in this manner, from static displays through excellently prepared classroom lectures and demonstrations by master teachers, to eyewitness presentations of action and events that can be brought into the classroom only by media such as film and TV.

Another foreseeable use for TV in schools—requiring two-way transmission—is the video conference or workshop that could become useful for teacher training, presentation of curriculum resource materials and teaching methods, and exchange of information and ideas between teachers or administrators at widely separated schools without the burdens of long-distance travel and extended absences. Such use, which could be made during seasons when school is not in session, could open the way to much more frequent and fuller interchange.

Distinctions in terminology are sometimes drawn between educational TV (ETV) and instructional TV (ITV). The term "ETV" has been applied to cultural and instructive programming broadcast to the general public by noncommercial standard television broadcast stations in a number of U.S. cities. It is viewed on standard TV receivers in homes or elsewhere, including schools; "public broadcasting," increasingly used, is a more descriptive term. "Sesame Street," for example, is a well-known current ETV offering designed to convey word and number concepts to very young children. The term "ITV" is more narrowly applied to TV lessons disseminated specifically for instructional use by schools or others.

TV lessons can be distributed "live," for simultaneous viewing by many persons at many different locations, and they can be stored on tapes for later presentation and further distribution. These attributes make it possible for large numbers of persons to view a given lesson. Since costs of lesson preparation can be spread over a large number of users, sizable investments can be justified for preparation of lessons and a high degree of excellence in presentation can be attained. Variety and specialization of lessons become possible. This can be especially important for smaller districts in rural or remote areas. TV lessons can efficiently bring to these areas excellent programs for instruction in subjects that could not be otherwise offered.

The use of TV—both ETV and ITV—by schools seems sure to continue and to expand in coming years as schools install more TV sets and equipment for video-tape playback and recording, as the variety of available programming grows, as teachers gain more familiarity with these resources, and as low-cost telecommunications become available for schools. The assignment of 30 additional television broadcast channels in the ITFS (Instructional Television Fixed Service) band, now pending before the FCC, would further stimulate television use by schools.

Many schools, teachers, and students do not yet have significant access to instructional TV. Most of those that use TV simply display ETV programs on sets in the schools as these programs are broadcast by ETV stations in the vicinity of the school.

Educational telecommunication networks are being established or planned in a number of states and regions to reach schools outside of the broadcast area of existing ETV stations. Terrestrial microwave communication links for transmitting ETV programs to outlying schools require investments on the order of $1,000 per mile; annual costs of ownership and operation are about $200 per mile. Telephone line charges for educational television transmission can range from about $30 per mile per month, or more than $300 per mile per year, for a single channel.

Broadcast stations are owned by some larger school districts. Los Angeles, for example—the second largest district in the United States, covering about 800 square miles, serving more than 950,000 students, including nearly 200,000 adults, and having a yearly budget approaching $1,000,000—plans a TV broadcast station and has filed an application with the FCC. This district already owns a studio for preparation of lesson programs for use in its schools. These programs can, of course, be recorded for later reuse and distributed to users in other districts.

Parochial schools operated under the auspices of the Catholic Church in a number of large U.S. cities use television extensively for classroom instruction, especially in the elementary grades, reaching well over a million children. In some cities, stations operated by these schools use as many as four channels in the ITFS frequency bands. In other cities the schools employ the facilities of noncommercial public broadcasters in their communities. Many of these schools have adopted television in order to cope with sharply rising costs of classroom instruction.

Very few schools or districts today possess equipment for playback of recorded TV lessons. Fewer yet possess equipment to record programs at broadcast time for later replay when it fits the school's operating schedule, and for storage and later reuse. Video playback and recording equipment, employing easily used tape cassettes, suitably priced for school use, is being actively developed by a number of firms and can be expected to be widely available by the mid-1970s when the proposed satellite goes into operation. Such equipment will most likely include TV sets that can play back video cassette tapes, in a manner similar to the audio cassette players in widespread use today.

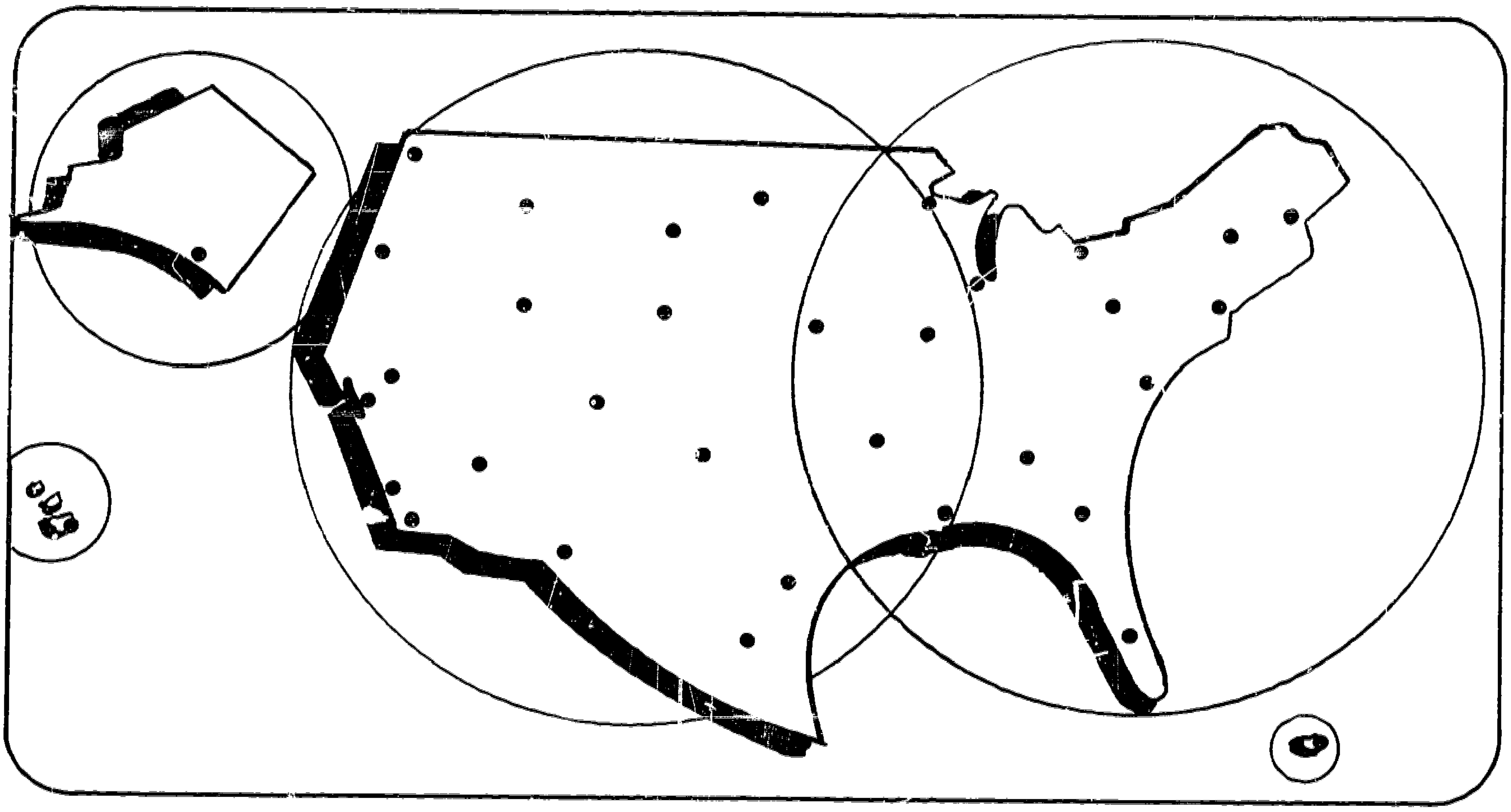
The communication satellite can contribute in a number of important ways to make TV more useful for schools. It can be used to interconnect existing and planned public broadcasting stations, which are an important TV resource for education, to make program materials more readily available to these stations, and it can be used to distribute lesson materials from many sources to schools throughout the nation.

Audio information transmission is useful for instruction in such subjects as music appreciation and vocabulary development. The spoken word can also be used to reinforce written material presented to the student. Audio programs, equipment, and program transmission are much less costly than television. Many forms of audio instruction can be satisfactorily provided from tapes or records played back in the schools, without need for long distance transmission. Low-cost satellite transmission, therefore, will have a lesser impact upon audio instruction. However, audio instruction services could be provided at small extra cost to schools equipped to receive television services by satellite transmission. A relatively small number of audio channels can provide at low cost a greater variety of music appreciation and language courses than is available by other means in most schools. These advantages are particularly important for smaller schools and rural areas.

#### Distribution of Lesson Materials

Long-distance telecommunication, because of its high costs, has not been used to distribute lesson materials to U.S. schools. Low-cost satellite communications can become highly useful for the efficient distribution of TV program lesson materials. A forerunner of this use has recently been organized to distribute ITV lesson materials by means of an existing terrestrial communication network that links together several public TV broadcasting stations in the upper Midwest. The communication links are used during non-broadcast hours to transmit instructional TV lesson materials from a central program library to schools in communities served by this network, upon request by the school. At the receiving end—a public broadcast station—the programs are recorded on tapes for local delivery to and use soon thereafter by the requesting school on its closed-circuit TV system. This method of distribution is, of course, limited to schools in or near communities served by the public broadcast stations that are connected by communication links to the central program library. The proposed low-cost satellite channels for school use will make it possible to provide service of this nature to schools throughout the 50 states from program libraries located throughout the nation. The resulting larger markets for lesson materials can be expected to stimulate lesson suppliers to offer a greater variety of materials in pursuit of their business objectives.

Lesson materials stored on tape or film can, of course, be distributed by mail or other methods of parcel delivery; it is likely that these methods will continue to be employed, along with low-cost telecommunications. Formidable logistic problems accompany the distribution of any significant number of different lessons by parcel delivery to thousands of U.S. schools. Many copies of each lesson must be produced and transported to users at many different locations and then stored there—with resulting costs of inventory acquisition, ownership, and disposal—or returned, posing similar inventory problems for the central library, including those of obsolescence, with resulting loss of value. Time



lags in transit cause capital to be tied up in materials in transit.

All of these factors combine to produce a high degree of inertia and high costs. In spite of their drawbacks, these methods of distributing resource materials to geographically dispersed users still make it possible, within limits, to assemble sizable markets—a larger number of users—to spread the fixed costs of program production and reduce the unit cost per user to acceptable levels.

Distribution by means of telecommunications eliminates most of these problems of inventory management and delivery time lag. There is far less inertia in a distribution system employing telecommunications. Inventories of film, tape, and records can be much smaller, with correspondingly smaller inventory investment, storage and handling costs, and obsolescence risk. A school district would receive by long-distance telecommunications transmission the program materials that it chooses to use, and record them on tape. The tapes could later be reused for different program materials. Instead of multiple copies of film, tape, or records becoming obsolete when program materials are changed, only the few master copies would suffer obsolescence. Consequently, there would be less reluctance to change programs and introduce new materials as it is found desirable to do so. Instructional resource materials could thus be most timely and relevant.

With the coming availability of low-cost, long-distance telecommunications by satellite, U.S. schools and the makers and distributors of educational resource materials will no longer be limited to the transportation and storage of films, tapes, and records. The inherent advantages of telecommunication for distributing information—the basic commodity of education—suggests that telecommunication, if available at low cost, will in many cases be the preferred method.

Distribution of lesson materials for tape storage and playback could be accomplished at any hour of the day, and would perhaps best be done in periods when the satellite channels are not otherwise used, such as nighttime. The satellite also affords an attractive opportunity to distribute instructional programming on a live basis during the day. For example, a single satellite channel could readily provide six hours daily of live broadcast lesson materials to schools in all 50 states. Each school could use the lessons of its choosing for live viewing, or record them for later use, or simply omit some or all. One conceivable plan would be to transmit 12 lessons, each of one-half hour duration—one for each of 12 different grade levels. In a five-day week, at least one 30-minute ITV lesson could be broadcast live to all 50 states for each of five different subjects at each of 12 different grade levels. In order to accommodate time-zone differences throughout the 50 states, this six-hour program could be completely rebroadcast twice each day or on a continuous basis. In that way, each of the 12 lessons could be received by schools anywhere in the 50 states at some time during a normal six-hour school day. This, of course, is only one of the many possible ways to use the available satellite transmission capability.

### Advanced Education

While principal attention in this report is given to the needs of elementary and secondary schools—because of the large numbers of students (about 50,000,000) in kindergarten through 12th grade—it is clear that satellite communication can also serve the needs of higher education and of continuing professional education and vocational training outside the schools. Televised college-level courses have been found effective in a number of fields, for some of the reasons already discussed. Excellent presentations by leading teachers, laboratory demonstrations, and appearances by professional practitioners and public officials are among the features that make TV an attractive medium for these purposes.

Some universities are beginning to televise live classroom sessions to off-campus viewers in the nearby communities by means of communication links from the campus. In some cases the off-campus viewer can participate in class discussions by means of a telephone link to the televised classroom. This practice enables employed adults to participate in college-level education without leaving their place of employment, with savings in time and stress; it can also ease problems of facilities and logistics—such as parking—on most campuses. Instructional networks of this type at present usually confine their offerings to those available on the local campus. Low-cost satellite communication would open many possibilities to import programs from and export programs to distant campuses, for distribution to viewers on the local unive[illegible] networks at either end. Such interchange between campuses, combined with off-campus program distribution networks, opens vast possibilities for continuing professional education and retraining of adults to cope with the changing needs of individuals and society.

Instruction could be especially beneficial in medicine, where new developments are rapidly emerging, trained personnel are scarce, and training is costly—because of the need for scarce, expensive facilities, and the high value of practitioners' time. Other important uses beneficial to the effective functioning of modern American society would be found in the retraining of technologists for socially relevant vocations, consistent with prevailing priorities. The employability of many adult technologists has recently been adversely affected by the rapid pace of new developments and by shifting national priorities reflected in changing demands for public sector capital goods.

# UTILIZING THE PROPOSED OFFERING

The offering of low-cost, long-distance telecommunication services via the common carrier satellite will encourage innovation and experimentation in educational information resources, to enable school systems and educational innovators to convert some of their hopes into realities. The potential uses of long-distance telecommunications in U.S. schools are significant, but present uses are slight, because of high costs. In order to realize these potentials a number of actions are necessary.

Much of the developmental activity needed to utilize the common carrier's offering to educational users must be accomplished by parties other than the common carrier. These parties include the manufacturers of video and audio receivers, recording and playback equipment, computers and peripheral equipment, data terminals for access to distant computers, and document transmission equipment; the developers, producers, and distributors of video and audio lesson materials and programs and of computer programs and services for instruction, counseling data, and school management; the producers of satellite earth stations; and the providers of terrestrial communication facilities to link school users with these earth stations.

The technology necessary for low-cost satellite earth stations and other school information system equipment will most likely be developed by manufacturers using private capital, but selective federal financial support for technology development may be beneficial. Federal financial support—in the form of loan guarantees, loans, or grants to states or school districts—might also be desirable for acquisition of equipment and facilities such as earth stations, computer terminals, and television receivers.

## SATELLITE EARTH STATIONS AND INTERCONNECTION

A variety of means will be available for school users to avail themselves of the proposed low-cost satellite transmission capability. Surface communication links required to connect the school user with satellite ground stations can be provided by telephone lines, school telecommunication networks where they exist, cable TV lines, or special service common carriers that may be authorized by the Federal Communications Commission. Not all of these options will be available in all communities, of course; the methods best suited to a given school's needs will have to be determined on a case-by-case basis. The satellite common carrier will establish and promulgate technical standards for users of the satellite transmission link.

### Commercial

Some schools will be able to obtain relatively inexpensive access to satellite transmission service through MCI Lockheed ground stations planned for operation in more than a dozen major metropolitan areas throughout the United States. A sizable proportion of the U.S. population can be served by these ground stations with relatively short terrestrial communication links that could be provided by local telephone or cable television circuits, or by local distribution links that will in the future be provided by new special service common carriers that are expected to be in operation by the time satellite service is available. The special service carriers affiliated with Microwave Communications of America, Inc.—the MCI terrestrial carriers—have recently proposed to the FCC an offer of low-cost terrestrial telecommunication link facilities for educational uses in most of the United States.

### Community

Some communities that are more distant from the MCI Lockheed ground stations will find it advantageous to install their own multipurpose ground stations to provide satellite transmission service for such uses as cable TV and information services for medical care, law enforcement, and business, as well as schools.

It is conceivable that future federal programs of financial assistance for community development might include funds for such facilities, in support of national policies that encourage growth of areas away from existing urban concentrations. Such ground stations could be owned and operated by public entities or by private business enterprises, such as cable television companies. Many communities already have cable television distribution systems, and cable television is rapidly being extended. Some communities, in granting cable television franchises, require that service be provided for school uses. It can be expected that more communities will in the future impose similar requirements. In some cases, a single community ground station could provide satellite transmission service to a number of school districts through the terrestrial telecommunication facilities of existing common carriers, special service common carriers, or school telecommunication networks.

### School

Some school districts may find it advantageous to acquire satellite ground-station facilities rather than to obtain service from a multipurpose community ground station. The simplest, least costly ground stations would have low transmission capacity and could receive audio program lessons or information from computers via teletype or similar terminals. These stations could not receive television programs nor transmit data to distant computers. Engineering development is underway for such ground stations to make them available at costs under $1,000 for use in developing countries. By 1975, when the satellite goes into operation, ground stations with somewhat more capacity could become available for use by school districts at somewhat higher costs. These stations could receive television and audio lessons and information from computers and perhaps could also transmit information to computers from terminals at the schools.

Such ground stations are not readily available today at costs that would make them feasible for most school districts. However, it can be expected that concerted engineering development efforts could make them available in the future. Furthermore, it is expected that the development and quantity manufacture of ground stations will be accelerated by the expansion of cable television systems during the next few years. While firm cost estimates for such stations cannot be made at this time, a cost objective of $40,000 for production quantities on the order of a few thousand stations may be a reasonable first approximation. With a 10-year useful life for such a station, the average capital cost per year would be $4,000 and—for ten months of use annually—would be $400 per month. For an average district of 3,000 students, such a station would represent capital costs of about 13¢ per student each month, or less than 1¢ per student each day. For a smaller district, where only 1,000 students could be served by the station, monthly capital costs would be 40¢ per student. These conjectures on capital cost are, of course, subject to considerable uncertainty. Furthermore, the operating costs of ground stations that can transmit as well as receive satellite signals may be substantial.

Engineering trade-off studies for particular locations will be needed to determine each school's proper choice between local ground stations or terrestrial communication links to the nearest community or commercial ground station. The preferred solution will vary from case to case and cannot be predicted *a priori.*

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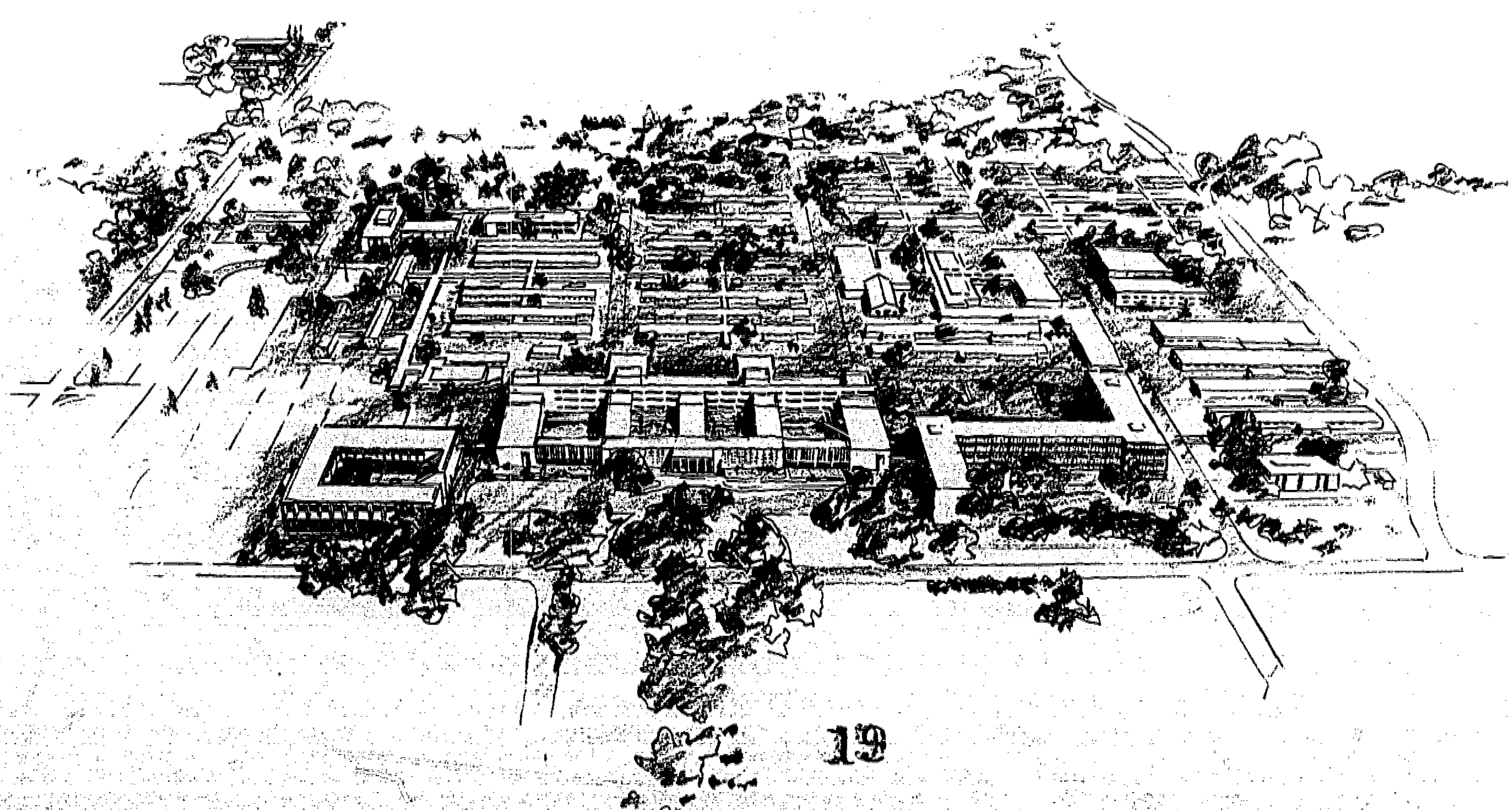

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