APPENDIX IV

THE WIRED CITY

A. INTRODUCTION

1. SCOPE

The concepts of "wired community" and "wired nation" have proven important in this study. In Appendix I. G the wired community was advocated as a means for delivering the telecommunications services applicable to the solution of urban problems identified by HUD. In Appendix V. C-7 the costs and investments required for HUD program initiatives to implement wired communities on a national scale are presented. In Appendix III. A terrestrial telecommunications systems concepts, incorporating wired communities and cities in a national interconnection, were configured to meet user requirements.

A working definition of a wired city is a community (or a group of communities sharing an urban area) that is interconnected to disseminate informational services. It is the purpose of this Appendix to further develop the concept of the wired city in terms of representative city models, to assess the technology and resources required for implementation. The wired city models thus developed are then used to make rough estimates of the costs to implement wired cities nationwide. Such estimates are made and documented by HUD in Appendix V. C-7. The assumptions and constraints imposed here are different; therefore the results are not, and were not intended to be, identical.

Attention is focused on the dissemination of a variety of local services to a wide variety of users. National services addressed in Appendix III. A are not specifically addressed here, except to ensure that the wired city can be connected to a national interconnection and can carry the communications load arising from such an interconnection.

The remainder of this section contains a statement of the assumptions and constraints imposed on this part of the study, and the rationale for the selection of the two city models. In Section B the telecommunications services to be implemented by the wired city are summarized to arrive at channel capacity requirements. Section C is devoted to a discussion of subscriber terminals and their capabilities, organized into three general categories of subscribers. Terminal equipment costs are given, as well as equipment complements for various subscribers both with and without the wired city.

Conceptual designs of cable distribution systems for two model cities are developed in Section D. Sufficient detail is given in materials, installation and engineering costs to arrive at realistic investment figures. An average investment in cable distribution per subscriber is determined, and is assumed to hold nationwide. Using the cost figures generated in earlier sections and the statistical mix of subscribers for the city models, total investment figures are estimated in Section E. These figures are then projected on a national scale to arrive at rough estimates of the costs involved in wiring all the urban areas.

2. ASSUMPTIONS AND CONSTRAINTS

In the development of any conceptual system model conflicts naturally arise among requirements, realism and practicality. The services needed by the user agencies were not necessarily determined in terms of available resources or technical feasibility within the next decade. In resolving such conflicts, the following assumptions and constraints were observed in the development of wired city models:

a. The effort is consistent with the remainder of the report, unless otherwise noted. In particular, the service requirements are consistent with those indicated in Appendix I and the consolidation of services to achieve scalar economies indicated in Appendix II. For example, services to the home are based on HUD requirements given in Appendix I. G, with Class I services anticipated for 1976, and classes II and III for the 1980-86 time period, while differences from assumptions underlying Appendix V. C-7 on HUD initiatives were noted earlier in the introduction.

b. Realism was introduced by judgement. The result was to postpone the introduction of a few desired services, either because of insufficient demand for them (e.g. home computer terminals) or because they would be too expensive for wide adoption (e.g. computer-aided instruction in the home). On the other hand, although it is realistic to anticipate urban growth, this factor was ignored in the interest of simplicity.

c. Only the cost of equipment and services introduced as a result of wiring the city is included in total wired city costs. Thus equipment and services which would be introduced even if the city was not wired, such as remote computer terminals and home TV receivers, are included in the terminal capabilities but not included in the cost of wiring the city.

d. Services which can be obtained directly from common carriers (e.g. Picturefone) or which use common carrier transmission facilities (e.g. remote fire alarm) are not included in total wired city costs.

e. Nearly all technology currently exists either in product or in proven prototype form. All costs are 1971 costs or current estimates based on prototype experience. No allowances are made for inflation, scalar economies, or any future decline in costs. An exception in the case of cassette video recorders (and frame grabbers) has been made for reasons explained later.

The services, capabilities and equipment complements discussed in this Appendix are all believed to be realistic and technically feasible.

They are assembled from components which currently exist or are widely known to be already well into the prototype stage. This makes estimates of costs and benefits real but probably conservative.

It is predictable that there will be far-reaching changes in the cost, performance, and basic nature of electronic equipment in the next 15 years. The technology for recording devices, bubble memories, display systems, LSI, etc. is in a state of flux. Equipment such as home computer terminals, video recorders and frame-grabbers, display devices, information retrieval systems and other, presently unknown, devices will surely be perfected.

Even a highly visionary person in 1956 would not have predicted the present status of computers, desk-top calculators, color TV, audio cassette recorders, or spacecraft. Predictions about home computer terminals, educational technology, frame-grabbers and other information retrieval devices are equally susceptible to error. Even so, it is likely that the wired city will have sufficient capability for any probable device except full motion, home-to-home television. The latter is feasible but requires greatly increased cable and switching capacity. Thus we know there will be other benefits of the wired city (such as home computer use) which we can neither predict nor cost.

3. CITY MODELS

Two cities were selected for development into wired city models: Hagerstown, Maryland and Rochester, New York. These were selected for their representative sizes and because detailed statistical information on them was readily available.

A graph of population ranking of the cities with more than 100,000 inhabitants* is shown in Fig. A IV-1. Note that population figures used are those within (legal) city limits rather than the larger urban areas. Even so, more than a quarter of the U.S. population, nearly 55 million people, lives within cities so defined. Using the Bureau of the Census definition of an urbanized area, which comprises at least one city of 50,000 inhabitants (central city) plus contiguous, closely settled areas (urban fringe), one finds that 72.4% of the population lives in such areas.**

Statistical profiles of the two city models, as compiled from census figures and local authorities and organizations, are tabulated in Table A IV-1. Population statistics are listed for within city limits as well as for the greater urban areas. Hagerstown, with an urban population of 54,000, ranks just outside the class of cities encompassing

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*Source: Population of U.S. Cities of 100,000 or More, 1970 (preliminary) Census of Population, published in <u>The 1971 World Almanac</u> by Newspaper Enterprises Assoc., Inc., p. 406.

**Source: <u>Statistical Abstract of the United States</u>, 1969 by the Bureau of the Census.

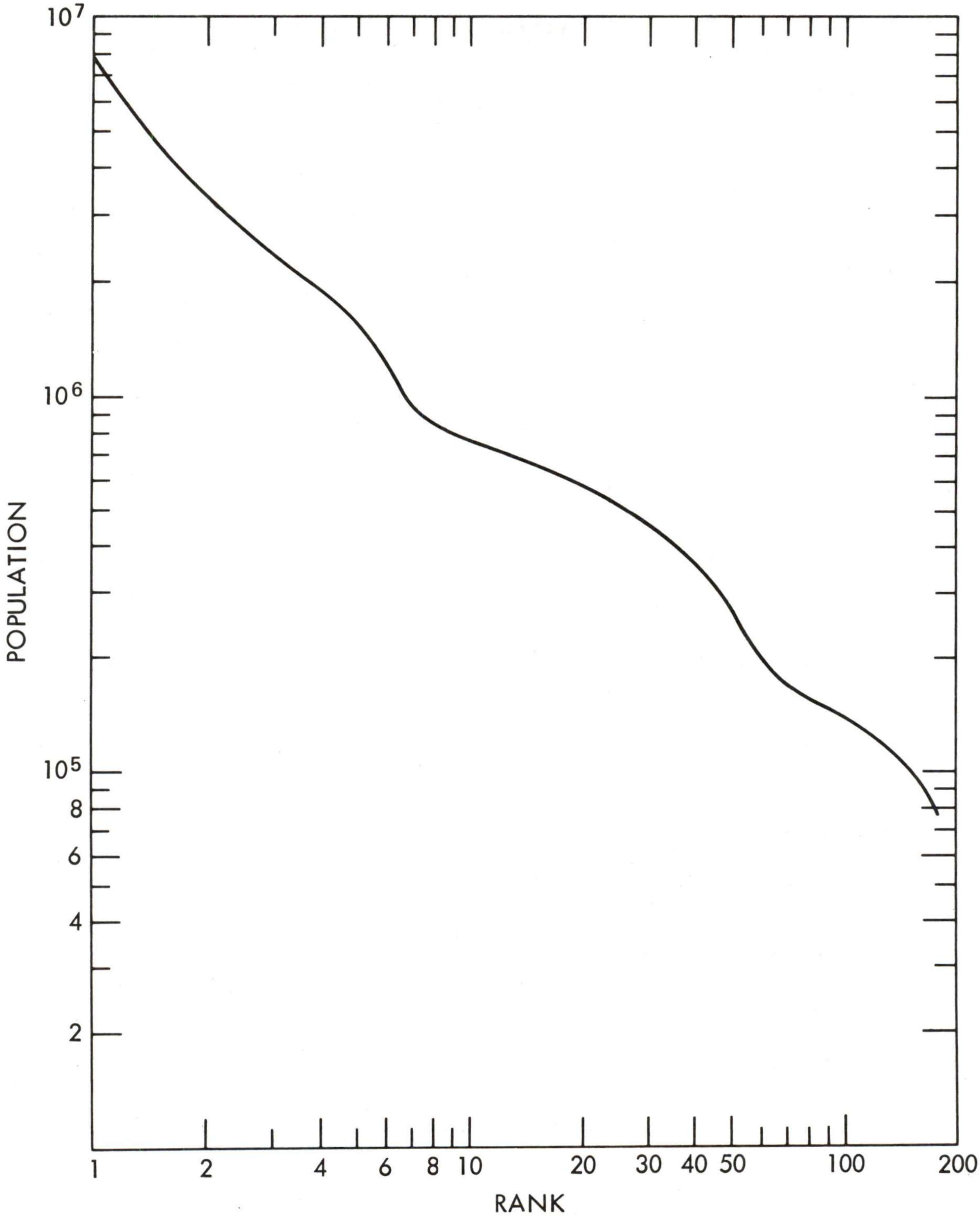

Figure A IV-1 Population Ranking of U.S. Cities

Table A IV - 1

STATISTICAL INFORMATION ON CITY MODELS

Locality	Hagerstown Washington Co., Md.	Rochester Monroe Co., NY.
Population		
City	36,000	292,000
Urban	54,000	706,000
County	91,000	
Users (urban)		
Homes	17,500	220,000
Misc. Business	1,584	8,511
Elementary Schools	27	200
Jr. High Schools	9	30
High Schools	5	15
Colleges	1	8
Hospitals	3	7
Doctors	99	2,000
Clinics	4	50
Nursing Homes	4	50
Medical Centers	0	1
Police Stations	2	30
Fire Departments	8	75
Town Hall / Court House	2	21
Utilities	3	1
Post Offices (EMH req)	0	1
TOTAL USERS	19,250	231,000

the majority of the population, and thus may be taken as a typical small city.

The remainder of the 91,000 population of Washington County surrounding Hagerstown lives in rural areas. Rochester, with a city population of 292,000 and an urban population of 706,000, may be viewed as a typical medium-sized city. Major cities such as Chicago or Los Angeles were not selected at this time to avoid the complexities of the megalopolis.

Statistics on the user categories are for the urban areas of the city models. Some are estimates which depend on the definition of the user category, (e.g. nursing homes were counted only if registered, while clinics were taken to involve more than sharing of common offices by a group of doctors.) Others are hard numbers, such as medical centers which are defined as hospitals associated with medical schools.

B. SERVICES AND CAPACITIES

1. EDUCATION

Education requirements were identified in Appendix I. A above. In particular, communications services to implement the education resource distribution service were outlined in Section 3 of that Appendix. The role of the wired city is to interconnect the community learning centers (CLC) to the various learning stations (LS).

A small city like Hagerstown may be expected to have one CLC connected to its learning stations by telephone lines and TV cable. It may also be expected to have one cable TV system, since by FCC regulation one such system may serve up to 36,000 subscribers. In order to facilitate communications and logistics, it will be particularly convenient to co-locate the CLC with the cable TV head end.

Similarly, a medium-sized city like Rochester will have several CLCs served by one district learning center (DLC). It will also have several cable TV head ends in order to comply with the FCC regulation. It is convenient to establish a one-to-one correspondence between the CLCs and the head ends, and to co-locate them. It is assumed in the remainder of this appendix that each CLC will be co-located with a cable TV head end.

Channel capacities for educational services between the CLC and the LS are assumed to be:

- One TV channel 24 hours per day for frame-grabber service
- 60 channel-hours of TV on a time-shared basis with PBS
- Duplex-voice order wire, common carrier
- Low-speed data for CAI and other needs, teletype on common carrier or on TV cable.

2. PUBLIC BROADCASTING

The wired city serves to connect the city PBS outlet (if any) to the national network and to distribute PBS educational and cultural programs to the subscribers. Connection to the national network will be via a dedicated cable to the PBS outlet, or by a dedicated channel on the distribution cable serving the outlet.

The PBS capacity requirements are set forth in Appendix I. C-2. Commonality of these requirements is developed in Appendix II. F, resulting in a total of 10 video channels between the head end and the subscriber (see Fig. A II-15, recalling that no program assembly requirement exists between the head end and the subscriber). The same 10 channels are used on a time-shared basis to supply the 60 channel hours of education programming listed in the previous subsection. Scheduling flexibility at the community or subscriber level can be achieved by use of video recorders.

3. HEALTH

The wired city serves to interconnect the city hospitals, medical centers (if any), doctors and health professionals. The communications requirements for health services are set forth in Appendix I. B-3. In the wired city, they are accommodated as follows:

- One duplex video channel between the hospitals and medical centers, used infrequently and in a privacy mode
- Many duplex voice links, common carrier
- Low and medium speed data links, by common carrier or on the TV cable distribution net

The duplex video link would be implemented on the cable TV distribution network by including a limited number of return video channels on all cables. This return capability has the added benefit of enabling future services not presently required.

4. URBAN DEVELOPMENT

The HUD service requirements were identified in Appendix I.G. It should be emphasized that many of these requirements are repetitions of those already identified by other users. The three classes of services are summarized below, highlighting the communication capacities.

a. <u>Class I Service</u>

Monochrome or color TV, 3 commercial channels (min.), plus one channel each for education, public broadcast, public access, state and local government, and restricted service

b. Class II Service

In addition to TV reception, narrow band data channels for:

- Protective services
- Utility monitoring
- Public preference polling
- Computer services

c. Class III Services

In addition to Class II services, two video channels for interactive, computer-controlled, information television including frame-grabber capability (This enables both governmental and commercial services) Three video channels for user-selected programming

5. TOTAL CAPACITY

There will undoubtedly be new uses found for the wired city once it is implemented. It is wise to accommodate such expansion at this stage of system conception. The greatest expansion may well be in use of the return video capability and sizing. Fortunately, the inherent capacity of the cable and, to a lesser but sufficient extent, of the repeater amplifiers permits such expansion. Cable TV systems have been installed with more than 30 channels. It is assumed in the remainder of this appendix that the cable distribution network will have 30 video channels in the forward (normal) direction, and three in the return direction. This will more than suffice for the existing requirements.

A few words on electronic mail handling (EMH) are appropriate in view of the large channel capacities involved (see Appendix I. E). This is fundamentally a national service that the wired city does not specifically address. However, where the wired city happens to have a central post office with EMH capability, it is accommodated by means of a dedicated cable connected to the national interconnection.

C. SUBSCRIBER CAPABILITIES AND TERMINALS

1. GENERAL SUBSCRIBERS

General subscribers are a broad category of users requiring limited telecommunications services and terminal capabilities. This category includes homes, businesses, clinics, nursing homes, police and fire stations, town halls/court houses, and utility companies. It excludes schools and hospitals/medical centers which require greater services and capabilities.

Table A IV-2 summarizes terminal equipment and capabilities for the general subscriber, keyed to the HUD requirements of Appendix I. G. Discussion of various equipment elements from this table is presented in the following subsections.

a. TV and Stereo Receivers and Telephones

It is assumed that each subscriber will have, as a minimum, a commercial TV receiver (monochrome or color), and telephone service through the common carrier. Commercial stereo receivers are available as options to the subscriber. The following statistics serve to justify these assumptions.

Total households in U.S.	63.8M
Percent of households with TV:*	
Monochrome only	52.2%
Color	43.3%
Total	95.5%
Percent of TV households with color*	45.3%

The percentage of TV households with color receivers is rapidly increasing. While it may be argued that the advent of cable television will accelerate this process, it is felt that by 1980 the relative mix will not be materially affected. Thus, in accordance with the assumptions and constraints, no home TV receiver costs are charged to wiring of the city.

*Source: _Television Fact Book_, 1971-72 Ed. Pub. Television Digest, Inc. based on NBC Research estimates.

Table A IV-2

GENERAL SUBSCRIBER TERMINAL EQUIPMENT & CAPABILITIES

Equipment	Cost	Capability	Availability
FOR CLASS I SERVICE			
Commercial TV Receiver	B & W $100 Color $375	Commercial, PBX, ETV, State & Local Broadcast	Many Commercial Models Available
Telephone	$13/Month	Audio Request for Special Programming, Public Preference Polling	Common Carrier
Stereo Receiver	$200	Receipt of High Quality Stereo Sound	Many Commercial Models Available
Cable Subscriber Unit	$12 ($6/Mo. Subscription)	Receipt of Cable Programming	Based on Hagerstown CATV Co. Units, Made Special By Job Shop
Cable Privacy Unit	$10	Receipt of Limited Distribution Programs	Development Item (frequency Translator)
ADDITIONAL FOR CLASS II SERVICE			
Touch-Tone Telephone Modification	$1.50/Month Extra	Subscriber Response Unit	Common Carrier Mod. to Present Touch-Tone Telephone
Fire and Intrusion Sensors	$500(1)	Fire and Intrusion Monitoring	e.g. Walter Kidde Co. Beltsville, Md. ABC Burglarm Systems, Landover, Md.
Utility Meter Reading Gas, Electric, Water	$45(2)	Automatic Utility Meter Reading	H. Baker-HB Eng. Co. Silver Spring, Md. for PEPCO
Computer Remote Terminal	$140/Month	Low Speed Computer Terminal	Memorex 1240 Term. per. B. Mead of COMNET Co.
Computer Time	$7/Hr. Connect Time(3) $8/Min. CPU Time	Computer Access	Same Source
ADDITIONAL FOR CLASS III SERVICE			
Video Cassette Recorder	$1200 Now $400 By '86	Video Record and Playback	1973-Ampex, Sony From 10/22/71 Electronic Design Quantum Science Corp.
Frame-Grabber Modification	$55	Local Storage/Display of Single-Frame Video	Development Item -- Estimate By Mitre Corp.

(1) Average figure, prices depending on installation charges and number of sensors.

(2) For 2 meters, now under development.

(3) Typical charges by computer time-share companies.

The percentage of households in the contiguous U.S. with telephone service is cited at 91.5%, as of the end of 1970*. This is a result of wiring of the cities, and indeed the nation, which has already taken place, so that no telephone service costs are charged to future wiring of the city. Limited subscriber response capability is available through the telephone. This requires minor modification of the telephone set and/or the telephone plant to enable the transmission of dial-data after completion of the connection. It is felt that this is most conveniently done with the touch-tone telephone.

Stereo sound receivers have been available commercially for some time, but their market penetration has been minimal in comparison with TV and telephones. This may be attributable to consumer taste, and it is felt that the wired city will not alter this situation significantly. An interesting technical possibility exists for future receivers, wherein stereo sound is multiplexed onto the video signal, so that the stereo receiver merges with the TV receiver. This would raise certain problems of equipment compatibility which would have to be solved before widespread acceptance of the capability.

b. Cable Subscriber and Privacy Units

Cable TV systems utilize a carrier frequency spectrum optimized to permit distribution of the large number of channels provided. This is done in such a manner as to preclude interference, be reliable, and be cost-and power-effective. This spectrum is not identical with the channel frequencies in the user's TV set. Hence a frequency translator is required to convert CATV channel frequencies to the channel frequencies of TV sets (which are not all contiguous in spectrum). The CATV Company charges the user a one-time installation charge ($10-$35) and then a monthly rental fee ($5-$6). The "little box" translator is included and amortized in this service.

Private video channels for restricted audiences (e.g. professional medical or law enforcement material) can be accommodated with special translator boxes. Special cable channels can be assigned for such purposes, with the extra translator capability supplied only to authorized subscribers. The added costs of $5-$10 would be charged to the subscriber either at installation or through rental. Interlock capability for added privacy is technically feasible, but would require development.

* Source: American Tel. and Tel. Co.

c. Home Protection Monitoring and Utility-Meter Reading

Automatic intrusion and fire monitoring services are available today, and will be used in some homes. Utility-meter reading devices are being developed at the request of the utility companies, and may be installed in most homes by 1980. Since telephone lines can be used for these services, introduction of the wired city will probably not alter the market penetration by these devices and services. A system to provide fire and intrusion monitoring and utility meter reading would cost about $700 per home. Fire and intrusion sensors will cost an average of $350. The meter reading equipment is priced at $15 maximum per unit. The cost of installation of the hardware in the home will be dependent upon whether the home is finished or still under construction. An average installation charge would be $300.

Utilizing CATV lines, a 100,000 home system under development is projected to have a one-time charge of $30-$35 which amortizes the cost of the various monitoring equipment required. This cost when added to the other equipment and installation price adds up to $700 per home. The following specifics serve as background for these figures.

A prototype meter reading unit was recently tested by H. B. Engineering Company of Silver Spring, Md. This unit is a passive device connected to the consumer's telephone line. Shaft coupling of the utility meter output dials to resonant circuits in the reading unit provides the measuring device. The unit is interrogated by a pulse of energy on the telephone line sent from the central station to the home, and the echo from the reading unit is interpreted for the measurement of the utility service used.

The unit is priced, by request of the utility companies, at $15 maximum per unit. This is a one-time charge to the consumer for the hardware itself and the installation. This price is contingent upon having a meter already in service. If the installation were new, the meter cost of approximately $15 would be included. The central office equipment cost would be amortized by the home installation at $1 to $2 one-time charge.

Fire and burglary detection system for a private home would cost between $400 and $900, depending upon the amount of protection afforded and the installation procedure used. A typical alarm and burglar protection system for a three-bedroom ranch house, with attic and basement would cost $350 for the hardware alone. Installation of the system utilizing hidden (within-the-wall) wiring could cost more than $500 for a house to which the system is being added after construction has been completed.

A representative of A.B.C. Burglarm Systems, Landover Hills, Maryland indicated a typical home system would cost $350 to $650 for hardware and installation. A charge of $6 per month is made to monitor the system 24 hours a day. An additional charge is necessary for phone line leasing (nominally 75¢ per quarter mile per month). The monitoring equipment costs approximately $150 per home being monitored.

Honeywell Fire Detection and Alarm Systems, McLean, Virginia has recently developed a new Central Receiving Unit, the Alpha 3000. This unit utilizes digital techniques to keep track of up to 39,000 data points (sensor terminals). Two data points are necessary for each home to be protected (1 each for fire and burglary); thus, 19,500 homes could be monitored with this system. Budgetary estimates for a 15,000 point system (monitor console only) is $120,000.

H. B. Engineering Company is developing a system to operate in 100,000 homes over the CATV cables, providing a 16 bit data train from each home to monitor fire, burglary, utility meters, and numerous other uses such as in-the-home credit card buying. The data train is at low audio frequencies. Groups of homes are multiplexed into a single signal which is upconverted to an H. F. frequency which is multiplexed with other group signals and sent to the monitoring station. Projected cost per home of the system is $30-$35. It must be noted, however, that this system includes only the monitoring station and the interface box at the home. Any protection sensors, meter reading equipment or data transmission systems (for credit cards, etc.) would have additional cost.

d. Video Recorders

The competition between many companies in developing an inexpensive cassette video recorder has resulted in at least a dozen variations of five basic designs for the first-generation home cassette video recorders.* Several of these recorders should be on the market within the next year. This competition has made standardization impossible until the first recorders are marketed and evaluated, thus accounting for high estimated prices. Sony and Ampex

* "Electronic Design," pub. Quantum Science Corp., 25 October 1970.

Corporations have released some preliminary information. The Ampex "Intravideo" recorder will provide a playback-only capability for about $900, with full record and playback in black and white for $1000. The color record-and-playback unit will cost about $1100. The Sony recorder will cost $1200-$1500 for full color playback and record, and will also include a built-in video modulator and FM tuner with a stereo-audio amplifier. AVCO is also developing a similar cassette recorder which may be marketed by Philco-Ford and/or Magnavox. The AVCO cassette electronics will cost about $500 to the other vendors. The AVCO cartridges will cost from $10 for a 15 minute tape to $34 for a 114 minute tape. The Mitre Corporation has independently estimated that these cassette video recorders should cost from $400-$700 in large production quantities.

These cassette recorders are designed to operate from baseband output jacks which will be provided on new TV sets in the near future. These cassette recorders are not being designed for frame-grabber use in the first models, but the transport and electronics should be adaptable for future use.

Color EVR is another video recording and playback system which has been developed by CBS laboratories for the commercial market. It uses a reel of black-and-white film images coded and packaged in a thin disk to record and playback the color video. This disk requires film processing after recording and before playback can be achieved. Playback-only systems are now in commercial use, and cost about $800. The playback-only capability could be competitive with magnetic recorders, but the record/film development problem makes this technique less desirable for home use.

Presently, reel-to-reel video recorders are available for home use with prices ranging from seven hundred to several thousand dollars depending on the quality and color vs. black-and-white capabilities.*

To summarize, inasmuch as cassette recorders are not yet on the market and since there are different techniques evolving, before standardization an estimated present cost of $1200 will be used. This recorder will include: color record and playback capability, FM stereo tuner, stereo audio amplifier, a video modulator, and a suitable cabinet.

* See <u>Electronics World</u>, Feb. 1971 for a listing.

In trying to predict the cost of a cassette video tape recorder in the 1980's, it may be safely assumed that the price will become competitive with that for a reel-to-reel machine. In the past two years a similar trend has been observed with respect to audio recorders. Cassette and reel-to-reel audio recorders of the same quality, with similar features, are now available at the same price.

Two different methods were used to estimate the cost of a cassette video recorder in the 1980's when produced in the millions. The first method involves the use of a standard learning curve with a constant of 0.85. This represents a good choice for electronic apparatus, including consumer products. Assuming that 5000 of these units will be produced the first year at $1200 each, a million will cost $460 each to produce.

The second method involves a breakdown of the $1200 present cost for each recorder. A reasonable breakdown is:

	Cost of Materials		Labor
Circuitry (Electronics)	$100.		$50.
Mechanical Assembly (Transport)	$250.		$100.
Cabinet	$50.		-
Assembly of Complete Unit	-		$50.
Adjustment & Alignment	-		$50.
	$400.		$250.
SUBTOTAL		$650.	
Recovery of Design & Development Costs		$100.	
Overhead		$100.	
Profit		$350.	
TOTAL		$1200.	

The cost of components and materials used decreases with large quantities. This will be particularly true of parts used in the mechanical assembly or transport, such as motors, tape heads and other mechanical parts. The cost of a cabinet is not expected to change. Labor costs in assembling the circuitry may be cut in half with automated printed-circuit-board construction. It is felt that the cost of assembling the transport mechanism will remain unchanged. Very little of this can be automated and any benefit realized from technological advances will be offset by increasing labor costs. For the same reasons, labor involved in assembling the electronics, transport and cabinet will not change significantly. The use of automatic test equipment will tend to cut adjustment and alignment costs by about half.

In quantities of millions, there will be very little cost incurred in development that will be passed on per unit. Also, a 30% profit margin might be adequate. Thus an estimated cost breakdown in the 1980's for production in the millions of units might be:

	Cost of Materials		Labor
Circuitry (Electronics)	$50.		$25.
Mechanical Assembly (Transport)	$100.		$100.
Cabinet	$50.		-
Assembly of Complete Unit	-		$50.
Adjustment & Alignment	-		$25.
SUBTOTAL		$400.	
Recovery of Design & Development Costs		-	
Overhead		$240	
G and A		$64	
Profit		$192	
TOTAL		$896 (or about $900)	

In conclusion, it is felt that a cost of $900 per cassette video recorder is a reasonable estimate, for the 1980-86 time frame.

e. Frame Grabber

The "frame grabber" system consists of a simplex video channel used on a time-share basis by many subscribers to request and display single-frame video images on the TV screen. A narrow-band control channel from the subscriber's home is used to instruct a computer which transmits one television picture field to the subscriber's home. The coded field received by the requesting subscriber is recorded on video tape and repetitively played back into the subscriber's TV set at a standard TV field rate which results in normal TV display.

An experimental frame grabber that has recently been demonstrated is the Time-shared, Interactive Computer-Controlled Information Television (TICCIT) developed by the MITRE Corporation.* The home system may be operated in a public or private mode. In the public mode the system receives continuous programming. In the private or interactive mode, the user instructs the system by touch-tone telephone (12 buttons required) as to what program and what frame of the program should be sent to that particular receiving station.

In addition to the TV set and telephone, a video recorder and a coupler/decoder are required. The video recorder used in the experiment is a Sony AV-3400. A video cassette recorder of the kind discussed above would be adequate for the purpose. The coupler/decoder unit consists of a VHF tuner, IF amplifier, video detector and address decoder. It is estimated that this unit can be reproduced commercially in large quantity for about $55.

In the TICCIT experiment an IBM 360/50 controlled the frame grabber system. In an operational system, this function could be fulfilled by a low-cost mini-computer. The cost of the mini-computer and peripherals is estimated to be $70,000. Also in TICCIT, a TV character generator is controlled by a Honeywell PVP-516. The cost is $40,000. The TV characters are generated by two Data General computers: a 32-K byte ($35,000) and a 12-K byte ($15,000).

* John Volk, "The Reston, Virginia, Test of the MITRE Corp. Interactive Television System," May 1971, Report MTP-352 of the MITRE Corporation.

Total computer costs are $160,000. Discs and other peripheral equipment cost about $100,000 for 128 subscribers.

At the present time only three TICCIT terminals are installed. Hardware exists for 128 more but is awaiting installation.

f. <u>Typical General Subscriber Equipment</u>

Typical general subscriber equipment complements for 1976 and 1980-86 are summarized in Tables A IV-3 and A IV-4 respectively. Equipment that is likely to be present even if the city were not wired is listed under "unwired city", while the full complement of equipment is listed under "wired city". The differences in capabilities and costs are also summarized.

In Table A IV-4, only additional equipment over that for 1976 is listed. While video cassette recorders are listed under wired city, the intent is to treat them in two ways: it is estimated that 30% of general subscribers will acquire video cassette recorders by 1980-86. Another 40% will be induced to do so by wiring of the city which will offer frame-grabber capability. This is based on past experience with similar appliances or devices. The difference in cost charged to the wired city is then either $955 for a recorder and frame grabber modification, or $55 for the modification alone in the case of the subscriber already equipped with a recorder. It will be noted that the overall cost estimates for the 1980-86 period made in Sec. E of this Appendix are sensitive to these market penetration estimates (30%/40%), but they are considered to be realistic.

2. SCHOOLS

Table A IV-5 summarizes terminal equipment and capabilities for schools. Discussion of various equipment elements from the table is presented in the following subsections.

a. <u>School Video Systems</u>

This subsection describes instrumentation used in schools to pick up programs from the air or off the cable, and to distribute and display video in the classrooms.

The basic building block, and a principal element of cost, is the TV receiver of institutional quality. Price, quality and size vary over a large range for both monochrome and color. The RCA "Lyceum" ETV color set (model JP 968) is priced at $375, and is presently used in school systems. This set can also be used for closed-circuit systems.

Table A IV - 3

TYPICAL GENERAL SUBSCRIBER EQUIPMENT FOR 1976

Unwired City

B & W or Color TV Receiver	$100 - 375
Stereo Sound	200
TOTAL	$300 - 575

Wired City

B & W or Color TV Receiver	$100 - 375
Stereo Sound	200
Cable Subscriber Unit	12
TOTAL	$312 - 587

Difference: Greater Amount and Variety of Program Material

Improved Reception Free of Natural and Man Made Disturbances.

+ $12 Per Subscriber.

Table A IV-4

TYPICAL GENERAL SUBSCRIBER ADDITIONAL EQUIPMENT FOR 1980 - 86

Unwired City

Fire and Intrusion Alarms	$ 500
Remote Utility Meter Readers	45
Computer Services	RENTAL
TOTAL	$ 545 + RENTAL

Wired City

Unwired City Services	$ 545 + RENTAL
Video Cassette Player/Recorder	900
Frame Grabber Mod.	55
TOTAL	$1500 + RENTAL

Differences

Schedule Flexibility

Interactive Learning and Information Retrieval

+ $455 Per Subscriber (40%), or

+ $55 Per Subscriber Already Equipped With Video Cassette Recorder (30%)

Table A IV-5

SCHOOL TERMINAL EQUIPMENT AND CAPABILITIES

Equipment	Cost	Capability	Availability
Base Station	$1600	1 required per school building or complex. Receives signals from cable, amplifies, converts frequencies to convenient channels and provides wiring to the classrooms. Consists of: wiring to 24 classrooms 1 channel converter 0 receivers Add on costs:	Presently installed at these prices in Baltimore County schools.
	25	provides wire connection to one additional room	
	167	provides frequency conversion for one additional channel	
Antenna System	800	Enables a school to receive signals directly over the air. It consists of antenna, signal amplifiers, rotators, and a broad and receiver	Present cost for Baltimore Co.
TV Receiver	375	Institutional quality 23" color TV	Available at this price now (e.g., RCA. JP968)
TV Recorder and Playback	1200	Allows storage for later use of received video programs	Estimate Average of Sony, Ampex and AVCO for 1973.
Recorder Tape	2000	TV recorder tape will typically cost much more than the recorders. A ratio of 100 hours of storage per recorder is assumed.	AVCO Cassette estimates for 1973

Table A IV-5 (cont.)

SCHOOL TERMINAL EQUIPMENT AND CAPABILITIES

Equipment	Cost	Capability	Availability
Stereo Sound receiver	200	FM multiplex stereo reception, including adequate speakers.	Currently commercially available
Frame Grabber Mod.	55	Accessory to a TV recorder permits retention of single TV frames for an unlimited duration.	
Computer Aid Instructor		Sample costs: 1. A modified Teletype Model 33 terminal at \$750 each and a concentrator (modem to interface to a transmission line), \$2000 for up to 20 terminals.	Essentially the Stanford approach
		2. A complete CRT terminal system \$75,000 for a station buffer and \$2750 each for up to 32 student stations.	Pennsylvania State University Installed Cost

The Stetchell Carlson ETV receivers currently on the market are listed below for comparison with the RCA unit.

TYPE	INPUTS	OUTPUTS	PRICE
Monochrome	VHF/UHF/Video/Aud	-	339.50
"	"	Video/Audio	364.95
Color	VHF/UHF	-	759.95
"	VHF/UHF/Video/Aud	-	771.95
"	"	Video/Audio	808.95
RCA Color	"	"	375.00

It should be pointed out that the Carlson units are Solid State and the RCA unit is tube-type.

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Monochrome	VHF/UHF/Video/Audio	-	$339.50
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"	VHF/UHF.Video/Audio	-	771.95
"	"	Video/Audio	808.95
RCA Color	"	"	375.00

It should be pointed out that the Stetchell Carlson units are solid-state and the RCA unit is tube-type.

Dr. Robert Gifford, head of ETV programs for Baltimore County schools, provided information on present facilities and costs of Baltimore County school video systems. The average Baltimore County school has 24 rooms with one RCA "Lyceum" type set per six rooms. Future goals will be to have one set per 3 classrooms.

The Baltimore ETV system receives channel 67 and converts it to channel 4 for distribution within each school to alleviate tuning and distribution problems. Each school has a master antenna and converter, with all of the 24 rooms wired with coax cable. The cost of these systems is $2,400 per school. Extra drops for additional rooms are $25 each, including materials and labor.

The cost of $2,400 per school should decrease to $1,600 once cable TV is provided because of deleting the antenna and RF booster. The average video school system with one channel can be supplemented with additional channels for $167 each (i.e. 3 more channels will cost an additional $500).

The average school video system is composed of standard commercial video destribution equipment such as the following list of Winegard components:

T28M	300 ohm to 75 ohm Transformer	$2.30
CS-775	Antenna Lead Separator to UHF-VHF	5.96
DA-875A	Distrubutor Amplifier	44.90

VTF-73	Line Tap-Off	3.78
	Channel 2-83 Antenna	$15 to $75
	Rotor	40.00
75	RG59 Coax	$23.90 per 500 feet

School systems which utilize video recorders will require the addition of a remodulator to access the cable distribution system on a selected channel. The cost of this remodulator should be minimal (less than $10), and is assumed to be included in the recorder cost. In contrast to those for the general subscriber, no reduction in the cost of school video recorders for 1980-86 is projected. This is because it is felt that institutional quality requirements will keep the cost up by trading manufacturing economics for improved picture quality.

b. Computer-Aided Instruction

Computer-Aided Instruction (CAI) facilities, as part of the "wired city" and in remote areas, are discussed in this subsection. At the present time there are a variety of differing approaches to Computer Aided Instruction with widely differing communication requirements. For the purpose of illustration two of the more developed systems will be discussed: the Pennsylvania State University experimental system which has fairly sophisicated terminals and is comparable to that proposed for "wired cities" and the University of Illinois PLATO IV system which is more applicable to remote rural areas. It is generally acknowledged that costs of software, training and the required computer itself will far exceed the school terminal equipment cost. Although CAI appears quite expensive, there are indications that some form of CAI will be widely adopted by the 1980's. In any case, it is felt that the spread of CAI will not be materially affected by wiring of the city. Such a small portion of the cost of CAI will be affected by wiring the city that any school which will have CAI in the wired city will have it without the wired city at essentially the same cost. The use of a CAI system with low data rate up-link requirements in remote rural areas in conjunction with satellites will not materially affect the satellite characteristics as the bandwidth and power demands will be small even for a large number of terminals.

(1) CAI in the "wired city".

In the Pennsylvania State University experiment, the CAI terminal consists of a station buffer and the individual student station. The station buffer maintains the information for each station, (i.e. refreshes the CRT display). This buffer can handle 32 student stations. Each station consists of a CRT, keyboard and a light pen, and may have an image projector and audio system as optional equipment.

For tutorial material the CRT and keyboard are required. If there are no special characters and no light pen, the student station can consist of a typewriter. This is a very slow system; tests indicate a 25% reduction in line time if a CRT and keyboard are used instead of only the typewriter.

For high quality still color video (e.g. photographs of microorganisms) an image projector is required and added to each station. The projector is loaded locally but is controlled by the buffer (i.e. from the central computer). The quality is equivalent to 16mm film.

For audio material (e.g. music lessons) an audio-recorder is loaded locally and is also controlled by the computer, as is the image projector. This unit also records for playback so that the student may hear and compare.

All three units, the CRT with keyboard and light pen, the image projector and the audio-recorder comprise the complete station. Following is the cost breakdown for the system.

IBM 1500 Student Station

CRT, keyboard & light pen		$ 2,755
Image projector		3,455
Audio-recorder		4,260
		$ 10,460
Station Buffer		$ 75,000
Central Programming Unit	IBM 1130	$108,000

(2) CAI for Remote Rural Education

The PLATO IV system used for the illustration of a rural CAI system uses a large central computer in conjuction with simple less expensive terminal equipment. The computer has the capacity to service 4000 terminals sinultaneously. The terminal consists of a keyboard for communication to the computer and a dynamic display for pictorial images and alpha-numerics. For the purpose of illustration, it will be assumed that each rural school contains 10 user terminals allowing up to 400 schools to have access to the computer.

The spacecraft, such as that described in Section III. B-1-C (2), will have an antenna with a 9 foot diameter aperture covering about a time zone at the 2500-2690 MHz band. The user return link to the central terminal will be at an average of 2 to 5 bps with a peak of about 60 bps. Thus the bit rate per school is 600 bps. The forward link from the central computer to each terminal requires on the average 60 bps for alpha-numerics and 1200 bps for pictorial material, for a total maximum rate per school of 21 bps.

The modulation schemes are chosen on the basis of minimizing cost of user ground terminals. Assuming PCM/PSK for the return link, it is estimated that the required rf up-link power per user terminal will be approximately 2 watts, assuming the ground antenna configuration given in Section III. B-1-C (2). For the forward link to the user, PCM/FSK modulation will be assumed with simple limiter/discriminator detection. This approach while not minimizing satellite EIRP, does result in having simple and reliable ground equipment. The links between the spacecraft and the centralized computer will be in the 11.7-12.2 and the 14.0-14.5 GHz bands. For communication between the satellite and small receiver the DAMA bands of 2500-2535 and 2655-2690 MHz will be used.

Data from the computer facility will be assembled into a serial time-division multiplex format with a frame length of 400 ms. This allows a transmission time per frame of slightly more than 1 ms per school. Data from the user keyboard is compiled in a similar format.

c. <u>Typical School Equipment For The "Wired City"</u>

Typical school equipment complements are projected for 1976 and 1980-86 in Tables A IV-6 and A IV-7 respectively.

It is assumed that schools in the unwired city will typically be able to receive one channel of broadcast educational TV but not to originate local programs. It is further assumed that in 1976 there will be at least 60 hours each week of programming which a school district would like to receive if adequate transmission facilities existed. Note that much of the programming may be locally generated (Hagerstown currently generates 35 programs averaging 30 minutes each, i.e., 17.5 hours, per day.) It is further assumed that by 1980-86 educational TV programs for schools will be developed on a national basis and that scheduling conflicts will increase the desire for local video storage.

A second area of assumptions relates to the development of frame grabbers and associated software. Technology to implement this consists of a cassette recorder and a simple attachment. It will enable certain forms of interactive education via TV. It is assumed that sufficient software will exist in 1980-86 to justify limited use of this technology in schools where it is available.

Table A IV-6

TYPICAL SCHOOL EQUIPMENT FOR 1976

Unwired City (modeled from Baltimore county)	
Distribution System For 1 Channel to 24 Classrooms (includes antenna system)	$ 2,400
8 TV Receivers @ $375 Each	3,000
	5,400
Wired City	
Distribution System for 4 Channels to 24 Classrooms	$ 2,100
24 TV Receivers	9,000
1 TV Recorder/Playback Unit	1,200
100 Hours of Tape Storage	2,000
	$14,300

Differences

4 Channels in Place of 1

TV Set in Every Classroom

Video Storage Capability

+ $8,900/School

Table A IV-7

TYPICAL SCHOOL EQUIPMENT ADDITIONAL FOR 1980-86

Unwired City

CAI Facilities

Wired City

CAI Facilities Plus

2 Additional Video Recorders	$ 2,400
200 Additional Hours Of Recording Tape	4,000
6 Frame Grabbers Including Recorders	7,530
3 Additional Channels	500
TOTAL	$14,430

Differences

6 Simultaneous Channels Of TV
(3 broadcast, 3 recorded)

Additional Program Storage

Frame Grabbing Capability

+ $14,430/School

3. HOSPITALS AND MEDICAL CENTERS

Table A IV-8 summarizes possible terminal equipment and capabilities for hospitals and medical centers. Some of the equipment elements were discussed in the previous section. Discussion of various other equipment elements is presented in the following subsections. In the following specific equipment products are given by name for the purpose of costing. The listing of a specific product by name should not be considered as a recommendation for its use.

a. Television Cameras and Transmitters

A monochrome television camera transmitter can provide remote interviews, X-ray presentations, medical monitoring and instruction, etc., where mobility and low cost are required. The system consists of a camera, microphone, and transmitter.

The camera considered is a medium quality, black-and-white, portable, self-contained unit. These are available in indoor and outdoor models. Both models have a 5000 to 1 automatic light range and lens. They use a random interlace technique. The standard 2 to 1 interlace is available at a slight additional cost. The microphone is of medium quality to provide, if required, real-time audio to accompany the video.

Two types of transmitters are considered. One type interfaces with TV cable and is a modulator and up-converter. The second type is for microwave transmission. It is available in the 2 GHz-13GHz frequency range. The cheapest model (Microwave Associates model MA-12C) provides less than broadcast quality but is acceptable for institutional applications. It has video pre-emphasis, audio sub-carrier modulator, summing network, wideband FM modulator, power amplifier, 100 feet of cable and a four foot parabolic antenna. This equipment has been type-accepted by the FCC for 10,55 GHz operation in mobile or temporary installations (e.g., emergency ambulance or area clinics).

The model numbers and costs of these elements are summarized below:

TV Camera - Cohu Company:

Indoor model	4300-000	$ 725.00
Outdoor model	4200-000	$ 775.00

Microphone Lafayette 99R46039	$ 11.00
Modulator/Up-converter	$200 to 300.00

FM Transmitter:

Micowave Association MA-12C	$2,575.00
RHG Elec	$3,350.00

For other possible uses, other types of TV cameras are available. Two versions of low-light cameras are considered, both from the Cohu Company. One version, a silicon array, has the advantage that it is virtually indestructible. The second version is an intensified vidicon, but the tube can be damaged by high light levels.

For high quality color transmission, two cameras were investigated. Both units include sync. generators, encoders, and control. The Plumbicon camera (Norelco Model LDH-1) provides broadcast-quality color video. An economy model, the vidicon camera (Norelco Model LDH-1) gives lower quality color video.

The costs of these cameras are summarized below:

Low-light Camera

Cohu Model 2800

Silicon Array	$1,935.00
Intensified Vidicon	2,910.00

Color Camera

Norelco Model LDH-1

Plumbicon (Broadcast quality)	25,000.00
Vidicon (Economy model)	15,000.00

Table A IV-8

HOSPITAL OR MEDICAL CENTER TERMINAL EQUIPMENT AND CAPABILITIES

Equipment	Cost	Capability	Availability
Color TV Receiver	$ 375	Medical Education, Medical "Muzak", Patient Education	e.g. RCA JP-968W
Stereo Sound Receiver	200	Hi-Fi Sound With or Without Video Program	Commercially Available
Internal Cable Distribution	2000	Video and Stereo Distribution From Entry Point to 24 Locations, 3 Channels	See Details In Table A IV-5
Monochrome TV Camera and Transmitter	1200 - 3000	Originate B/W Medium-Quality TV Transmissions	Cohu Co. Model 4300-000
Color TV Camera and Transmitter	15,000 - 25,000	Originate Good Quality Color TV Transmissions	Norelco Vidicon or Plumbicon
Teleprinter	500 - 4000	Low Speed Remote Computer Terminal, Receive/Transmit Medical records, etc. (10 - 30 char/sec)	See Modern Data May '71 for Models, Price, etc.
Remote Card Reader	2500	Low Speed Remote Computer Terminal, Transmit Medical Records, etc. (10 - 105 char/sec.)	e.g. Hewlett-Packard 2760 A
Low Speed Modem	350	Interface Teleprinter or Card Reader to Transmission line (100 - 300 bps)	See Electronic News, Sept. 6, 1971 and Telecomm. June 1971 for Models, Prices etc.
Remote Line Printer	5000 - 20,000	Medium to High Speed Computer Terminal, Receive Medical Records, etc.	See Modern Data, Feb. 1971 for Models, Prices etc.
Medium Speed Modem	1500 - 5000	Interface Line Printer to Transmission Line (2400 - 4800 bps)	See Electronic News and Tele-Comm., ibid
Graphic Display Unit	1600	Receive & Display Line Data on CRT, Polaroid Photo for Hard Copy	e.g. Tektronix Type 601
Video Recorder	1200	Allow Storage for Later Use of Received Video Programs	See Table A IV-5

b. Remote Printers

Most hospitals are expected to acquire computer facilities, including input/output devices, within the next decade. The smaller ones may find it more economical to share such facilities with other hospitals in the same urban area by use of remote interconnection. In this case, they will need remote computer terminals with hard-copy capability. This includes teleprinters, remote card readers, and remote line printers. A great variety of these devices exists on the market, and typical costs are taken from the literature.*

c. Digital Data Modems

Remote data terminals, such as remote printers and graphic-display units, require a digital-data modem to interface them with the transmission line. As a result of the recent decision permitting connection of digital-data devices not supplied by the common carriers directly to the telephone lines, a great variety of such devices has been introduced on the market. A wide variety of capabilities, speeds and options are now commercially available** with a resulting wide spread in prices. The following average prices*** are used in the study.

Bits-per-second	Average Price 1971	Average Price 1970
0-300 bps	$ 350	$ 450
1200-1800 bps	600	800
2000-2400 bps	1500	2000
4800 bps	5000	6000
9600 bps	10000	12000

The future trend is for modems to be integrated into the terminal equipment they serve. This is already evident

* See: "Printers," Modern Data, Feb. and Mar. 1971, and "Teleprinters," Modern Data, May 1971.

** See "Third Annual Survey of Modems," Telecommunications, June 1971.

*** Source: Electronic News, September 6, 1971.

in many graphic-display units on the market. Another indication of this trend is a device marketed on an OEM basis by Modex, Inc., of Costa Mesa, California. It is fabricated using MOS/LSI techniques, operates at 122 bits/sec., and costs between $109 and $140.

d. Graphic Display and Facsimile Units

Graphic display units are needed in a hospital wherever remote access to line data is required. Line data display distinguishes a graphic display unit from a remote printer, which is capable of displaying alpha-numeric data only. Typical applications of a graphic display unit are at a nurses' station and a physician's office. It can be used for rapid viewing of medical records, line drawings, EKG or X-ray pictures. It is especially useful for the unit to have the capability of yielding hard copy of the displayed material (facsimile capability). Three classes of graphic display units are presently available on the market, and are reviewed briefly below.

(1) Class I

(a) Costs - $15,000 and up

(b) Requirements

- Modem (not included)
- Dedicated phone line or cable
- Computer at data center

(c) Uses

- Addresses central computer and receives data
- Displays on 10" x 10" screen and produces a hard copy within 18 seconds at 8 cents a copy
- Converts input data to standard TV format with optional scan converter

(d) Medical Applications

- Diagnostic aid and record keeping
- Remote access to medical records and articles, operational procedures, etc.
- EKGs and X-rays with modified copier

(e) Typical Systems Presently Available

- Graphic Computer Terminal Type 4002 (Textronix)	$8,800.00
- Hard copy unit (Textronix)	$3,750.00
- Optional Scan Coverter for TV Type 4501 (Textronix)	$2,500.00
Total Approximately	$15,000.00

(2) Class II

(a) Costs - Approximately $5K

(b) Requirements

- Telephone
- Telephone coupler (acoustic or modem)
- Facsimile unit for hard copy
- Facsimile equipment:

Alden	$4,000.00
Century	$4,000.00
Textronix copier model 4601	$3,750.00

(c) Capabilities - Receive only. Manual request over telephone will require data source to transmit data over same line to terminal.

(d) Medical Applications - Same as Class I, however, hard copy (photos, line drawings, printed matter) may be received in about three minutes time for 10 cents for a 8" x 8" copy.

(3) Class III

(a) Costs - Approximately $1.5K

(b) CRT Display - Store, display, then photograph the scan

(c) Requirements

- Regular telephone
- Storage Display
- Camera (fixed)

(d) Uses - Same as Class II

(e) Typical Unit

- Textronix Type 601 Storage Display $1,200.00
- Polaroid Camera - Textronix Type C-10 $ 400.00

e. Typical Hospital and Medical Center Equipment

Typical hospital equipment complements are projected for 1976 and 1980-86 in Tables A IV-9 and A IV-10 respectively, using the same format as before. The following capabilities and facilities are assumed present in the hospital in 1976, even in the absence of the wired city:

- All rooms connected to CATV for commercial TV and internal transmission/reception of a variety of signals
- Hospital equipped for closed-circuit TV (serves professional education, patient monitoring, security, etc.)
- Interconnection via telephone line and teleprinter or graphic-display unit to remote computer (communicate patient records, health insurance transactions, etc.)

Similarly, the following additional assumptions are made for 1980-86:

- Hospital equipped for closed-circuit color TV of less than broadcast quality
- On-site computer facility, or interconnection via telephone line or cable to remote computer. Terminal capability includes card reader, line printer, and graphic-display units (serves accounting, housekeeping and scheduling, patient monitoring, patient records, and management)

While interconnection to remote computers is assumed even in the absence of the wired city, it is felt that modem costs should be charged to wired city since they will be closely identified with the cable distribution plant.

Typical medical center equipment complements are projected for 1976 and 1980-86 in Tables A IV-11 and A IV-12 respectively. The status of a medical center in 1976, both in the wired and unwired cities, is assumed to be that of the hospital in 1980-86. The following additional capabilities and facilities are assumed for the medical center in 1980-86, even in the absence of the wired city:

- Closed-circuit color TV of broadcast quality, with one fixed camera (e.g., in operating room) and one portable camera
- On-site computer facility, as above, but capable of serving several nearby hospitals

Table A IV - 9

TYPICAL HOSPITAL EQUIPMENT FOR 1976

Unwired City (modeled after Hagerstown hospital)	
Distribution System, 3 Channels	$2000
Monochrome TV Camera	3000
Graphic Display Unit (with facsimile)	1600
	$6600
Wired City	
Unwired City Facilities Plus (4) Color TV Receivers	$1500
Low Speed Modem	350
Video Cassette Recorder	1200
100 Hrs. Tape Cassettes	2000
	$5050

Differences

Color TV Display

Video Storage Capability

Remote Data Input/Output
+ $5050/Hospital

Table A IV - 10

TYPICAL HOSPITAL EQUIPMENT ADDITIONAL FOR 1980 - 86

Unwired City	
Distribution System Expansion	$ 700
Color TV Camera	15,000
Remote Line Printer	5,000
Remote Card Reader	2,500
(24) Graphic Display Units (no facsimile)	28,800
TOTAL	$54,000
Wired City	
Unwired City Facilities Plus (20) Color TV Receivers	$ 7,500
(2) Stereo Sound Receivers	400
Medium Speed Modem	1,500
(2) Video Cassette Recorders	2,400
200 Hrs. Tape Cassettes	4,000
TOTAL	$15,800

Differences

More Color TV

Stereo Sound

Medium Speed Data I/O

More Video Storage
+$15 800/Hospital

Table A IV - 11

TYPICAL MEDICAL CENTER EQUIPMENT FOR 1976

Unwired City	
Distribution System	$ 2,700
Color TV Camera	15,000
Remote Line Printer	5,000
Remote Card Reader	2,500
(24) Graphic - Display Units (no facsimile)	28,800
(1) Graphic - Display Units (with facsimile)	1,600
TOTAL	$55,600
Wired City	
Unwired - City Facilities Plus (24) Color TV Receivers	$ 9,000
(2) Stereo Sound Receivers	400
Low Speed Modem	350
Medium Speed Modem	1,500
(3) Video Cassette Recorders	3,600
300 Hrs. Tape Cassettes	6,000
	$20,850

Differences

Color TV

Stereo Sound

Medium Speed Data I/O

Video Storage
+ $20,850/Medical Center

Table A IV - 12

TYPICAL MEDICAL CENTER EQUIPMENT ADDITIONAL FOR 1980 - 86

Unwired City:	
Distribution System (advanced)	$ 4,400
Color TV Camera (B/C quality)	25,000
(24) Graphic Display Units (no facsimile)	28,800
TOTAL	$58,200
Wired City:	
(24) Color TV Receivers	$ 9,000
(2) Stereo Sound	400
Color TV Camera (B/C quality)	25,000
Medium Speed Modem	5,000
(3) Video Cassette Recorders	3,600
300 Hrs. Tape Cassettes	6,000
TOTAL	$49,000

D. CABLE DISTRIBUTION

1. WIRING APPROACH

This section ciscusses the technical and cost characteristics of the cable system to be used in wiring the "wired city." For this purpose cabling system designs are made for Hagerstown, Maryland, and Rochester, New York, and their dependently associated urban populations totaling 55,000 and 750,000 respectively. Factors such as population density, aerial versus buried cable, types of pavement that must be dug and replaced, etc., were considered, as well as the costs of the various components that are required. Details are presented in following subsections, however a brief summary of findings is given here.

First, a study/design of a reasonable cable distribution system for Hagerstown, Maryland was completed. This was done in considerable detail, considering street maps to determine cable routing and population density. The analysis indicates that an investment of $152 is required for each house or other location to be connected. The differences involved in wiring a relatively large city, (Rochester, New York) are also considered. Major differences are the increase in population density and the increase in number of miles of cable that are buried under thick city pavement, although other factors are also considered. The investment per installation inside the city limits is estimated at $146. Thus the variables seem to compensate for each other an an average price of $150 per installation is assumed for any city size. It should be noted that this estimate is based on short term studies of only two cities. Special situations such as the lack of physical space for cables in New York City or geographic influences such as excess bedrock or swamps could seriously distort this estimate.

2. DISTRIBUTION FOR HAGERSTOWN

a. Statistics

It was initially necessary to determine a basic design and estimate the cost of a video distribution system for a community of about 50,000 population. The requirement is for not less than 30 video channels from the center to the users and sufficient capacity in the opposite direction to permit utility metering, selection of single frame video transmissions, etc., by the user without interference to the needs of other users. Limited capacity to transmit video from any point on the network toward the CTV head is also required.

The study is restricted to consider only the cable transmission system between the center and the users. The cost of channel-driving equipment and central-office or user equipment is not included in this section but is discussed elsewhere in the Appendix.

Hagerstown, Washington County, Maryland, and the communities surrounding it were chosen as the model. The area extends to Williamsport, Funkstown, Sycamore Acres, Spring Valley and Maugansville. Available statistics on the area show:

Population	55,000
Residence Units	17,500
Miles of Road	275

Maryland State Highway Administration authorities in Hagerstown and Baltimore were contacted for city and county road and street mileage data. A "Typographic Map of Washington County, Maryland, Geological Survey 1968," was also used as a reference. Further it is assumed the service will be made available to every residential unit, and 10% was added as an estimate of the number of non-residential users, bringing the user total to 19,250. Figure A IV-2 shows a map of Washington County with a shaded area showing Hagerstown and the associated urban region of system coverage.

b. Choice of System

Cable TV systems are already available in Hagerstown that use the band from 5 to 300 MHz. The amplifiers for these systems divide this spectrum into two bands, 54-300 MHz (41 six MHz channels) from the center to users and 6-26 MHz (3 six MHz channels plus 2 MHz) from the user to the center. Since the center will logically be located in the center of the area to be served, main cables will radiate from it so that the return capacity will not be limited to 20 MHz, but will be 20 times the number of main cables radiating from the center. The "hub design" will also make it possible to dedicate some outgoing channels in each group to the specific high density usage requirements of certain users without serious reduction of the availability of genera use and low density private use to all points on the network. It will also lend itself to providing users having critical continuous availability requirements with access to more than one of the major distribution grids at favorable costs.

Since this system appears to meet requirements for both

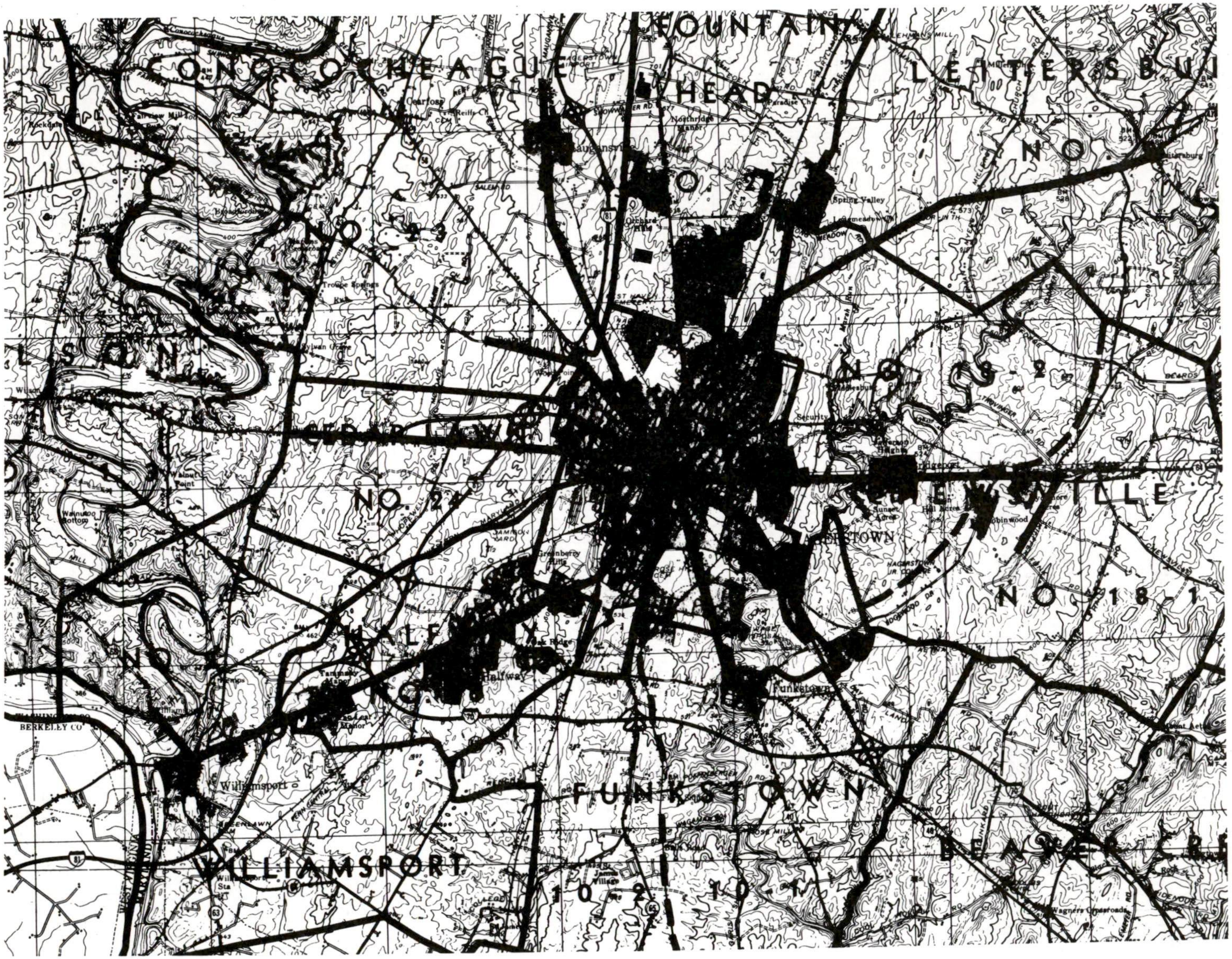

FOUNTAIN
CONOCOCHEAGUE
HEAD
FUNKSTOWN
WILLIAMSPORT
BERKELEY CO
NO. 18-1
Williamsport
Funkstown

Figure IV-1

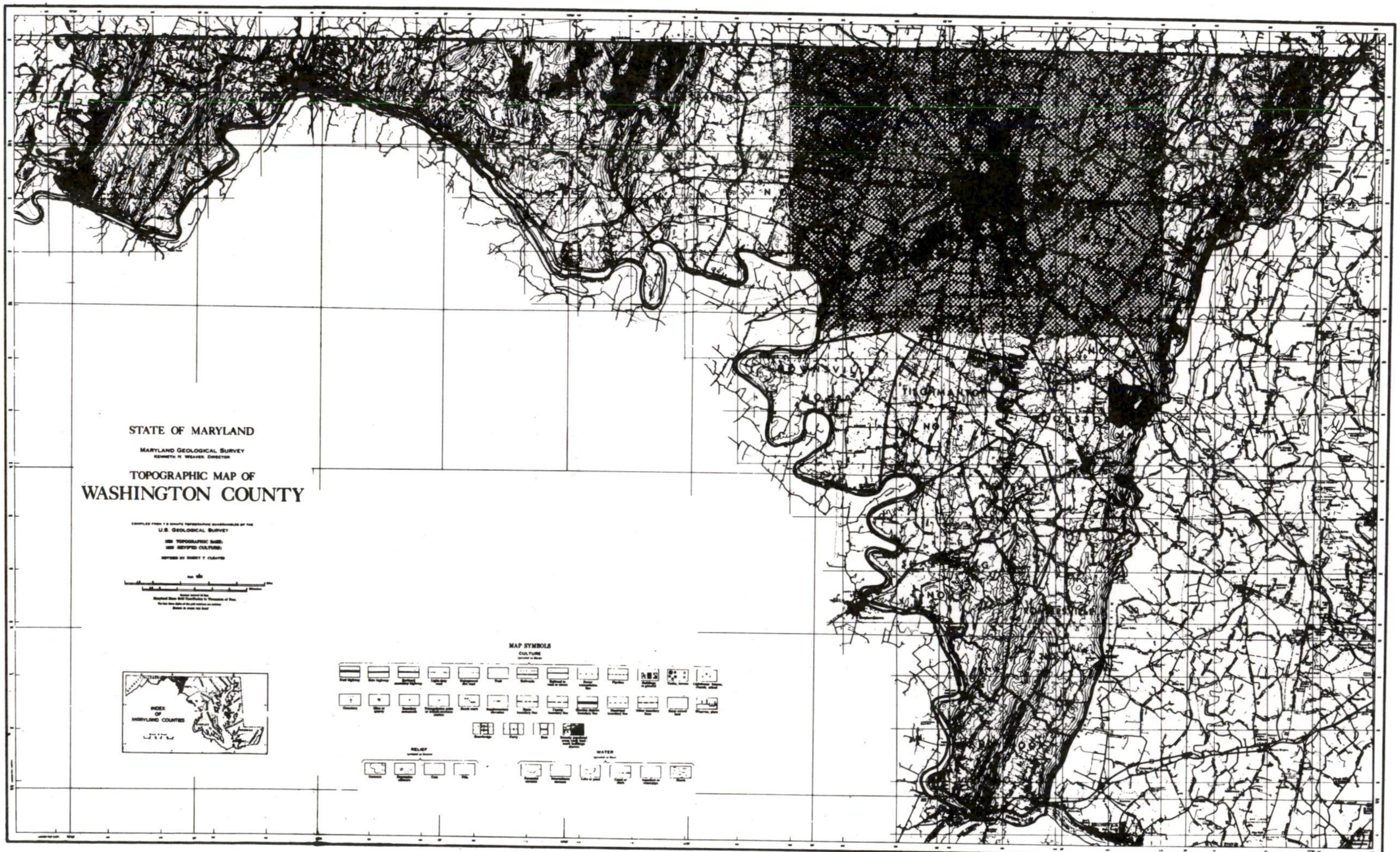

STATE OF MARYLAND
MARYLAND GEOLOGICAL SURVEY
KENNETH N. WEAVER, DIRECTOR
TOPOGRAPHIC MAP OF
WASHINGTON COUNTY
U.S. GEOLOGICAL SURVEY
MAP SYMBOLS
CULTURE
RELIEF
WATER
INDEX OF MARYLAND COUNTIES

Figure IV-2

analog and digital transmission in large quantities and is presently available, it has been chosen for this model. Only top quality cable and transmission devices are considered as these are prerequisite to a system providing high reliability with maintenance effort held to an acceptable level. Figure A IV-3 shows the "hub design" as applied to Hagerstown.

c. Costing Criteria

(1) Basic Design

The system design uses main feeders running along the main roads (Figure A IV-3). These use 3/4 inch cable with amplifiers at 2,000 foot intervals. Fifty miles of main line is obtained from map measurements. An estimate of half underground and half overhead cable is used.

The distribution cables from the main line trunks will be 1/2 inch cable with repeats every 1,200 feet. Since much of this will be in residential areas where the trend is to bury all utilities it was assumed 75% will be underground and 25% aerial.

All cables in the system are assumed to be rodent proof. All aerial cable includes build-in steel messenger to eliminate the need to string messenger and lash the cable to it.

All amplifiers are assumed to be the two-way bridging type since the difference in cost of these and line amplifiers is insignificant in the total cost and most of them will be bridging.

All percentages are judgment assumptions based on discussions held with personnel from Annapolis, Maryland, CATV.

(2) Quantitative Data

Population - 55,000

No. Homes	17,500	(Residence units)
	1,750	(Non-resident units - assumption)
	19,250	Total subscribers

Total Road and Street Miles - 275 (Actual in area considered)

Maintrunk Cables 50 miles (3/4" cable)

- 50% Underground 25 miles = 132 K ft.
- 50% Aerial 25 miles = 132 K ft.

Distribution Cables 225 miles (1/2" cable)

- 75% Underground 169 miles = 892 K ft.
- 25% Aerial 56 miles = 297 K ft.

Drops 19250 @ 150' = 2887 K ft.

- 75% Underground = 2165 K ft.
- 25% Aerial 722 K ft.

Amplifiers (All bridging type, 2-way 27 channel + 3 ch)

Mainline, spacing 2000". 264 K ft. 2 = 132

Distribution, spacing 1200' - 25%

$= \frac{1189 \text{ K ft X } .75}{1.2 \text{ K ft.}} =$ 750

Tap-offs = no. subscribers = 19250

Pedestals (weather housings for tap-offs)

Mainline (UG) 66

Distribution (UG) 572

UG Underground Cable Installation Criteria

Mainline UG Trunk Cable Mileage Breakdown

- 90% trenching in soil
- 10% trenching in rocky ground
- 100% Total Mainline UG
- 80% of mainline UG mileage requires replacement of asphalt paving.

Distribution UG Cable Mileage Breakdown

- 10% trenching in rocky ground
- 40% trenching in soil
- 50% can be plowed
- 100% Total Distribution
- 10% of Distribution UG mileage requires asphalt replacement

Buried drops

50% of buried drops require street crossings.

Right of Way Easements - no costs included

(3) Material Costs

The material types and costs listed below are considered as typical only and are not to be construed as recommendations for the specific products.

Cable - Superior Cable, Hickory, N. C.

Mainline - Aerial - Type AL75-750-M250	$330/1000 ft.
Mainline - UG - Type AL75-750-JA	$320/1000 ft.
Feeder - Aerial - Type AL75-500-M148	$160/1000 ft.
Feeder - UG - Type AL75-500-JA	$185/1000 ft.
Drop - Aerial - Type DP-6810	$34.50/1000 ft.
Drop - UG - Type DP-6059	$81/1000 ft.

Amplifiers 8 Tap-offs - Magnavox Craftsman, Manlius, N. Y.

2-way Bridging Amplifier Model FXTBA	$1,000.00 ea.
Modular type/AV. cost per user tap	$ 3.00 ea.

Pedestals and Housings - UG Cable Only - REA Experience

Pedestal and Housing for Amplifiers - Large	$64.00 ea.
Pedestal for Tap-offs - Small	$14.00 ea.

(4) Labor Costs - REA, Dept. of Agriculture

("National Average of Contractor Bids on Limited Units for Period 7/1/70 - 12/31/70 for Rural Telephone District")

° Aerial Cable	$75/ K ft
° Aerial Drop	$60/ K ft
° UG Cable asphalt replacement	$1000/ K ft
° UG Cable concrete replacement	$3800/ K ft
° UG Cable trenching in soil	$540/ K ft
° UG Cable trenching in rock	$1850/ K ft
° UG Cable plowing in soil	$70/ K ft
° UG drops (average includes 50% street crossings)	$200/ K ft
° Pedestals	$10/ ea

d. <u>Hagerstown Cost Estimation</u>

(1) Materials

Mainline cable 132 units aerial @ $330	$44,000
132 units UG @ $320	42,000
Subtotal	$86,000
Distribution Cable 892 units UG @ $185	$165,000
297 units aerial @ $160	148,000
Subtotal	$213,000
Drops aerial 722 units @ $34.50	$ 25,000
Buried 2165 units @ $81	175,000
Subtotal	$200,000
Repeaters mainline 132 @ 1000	$132,000
750 @ 1000	750,000
Subtotal	$882,000
Tap-offs 19,250 subs @ $3.00	$58,000
Pedestals & Housings for mainline and Distr. Cable UG repeaters 638 @ $64 ea	38,000
Pedestals for UG drops 3810 @ $14	53,000
Subtotal	$91,000
Material total	$1,530,000

(2) Installation Labor

Aerial Cable 132 + 297 = 429 units	
429 @ $75/unit	$32,000
Aerial Drops 722 units @ $60/unit	44,000
Subtotal	$76,000

Mainline UG Cable (132K Total)

80% X 132 = 106 units asphalt replacement	
106 @ $1000/unit	$106,000
10% X 106 or 10 units trenching in rock	
@ $1850	19,000
Balance (122 units) trenching in soil	
@ $540	66,000
Subtotal	$191,000

Distribution UG Cable 897 units

10% cross streets = 90 units of asphalt	
replacement @ $1000	$ 90,000
10% trenching in rock 90 units @ 1850	167,000
40% trenching in soil 360 units @ $540	195,000
50% plowing in soil 447 units @ $70	31,000
Subtotal	$483,000

Drops, buried 897 units @ $200	$180,000
Pedestals, total 4448 units @ $10	45,000
Installation Labor Total	975,000
Material & Labor Subtotal	2,505,000
Contingencies (10%)	251,000
Engineering (6%)	166,000
System Total	$2,922,000
Cost/mile = $2,922,000/275 miles	$10,620
Cost/subscriber = $2,922,000 ÷ 19,250 subscribers	$152

e. Hagerstown Cost Summary

A summary of the Hagerstown distribution network costs is shown in Table A IV-13.

The cost of material, which is slightly more than 50% of the total cost, is fairly accurate. The installation costs, which are controlled by environment, cable running conditions and municipal ordinances, may vary greatly. For example, costs obtained from REA indicate the price of aerial installation is increased by a factor of 13.3 for underground cable when asphalt paving must be replaced, 24.7 times when rock is encountered and 50 times when replacement of a large reinforced concrete highway section is involved.

TABLE A IV-13

HAGERSTOWN DISTRIBUTION NETWORK COSTS

Material	$1,530,000
Installation	975,000
Contingencies (10%)	251,000
Engineering (6%)	166,000
Total	$2,922,000
Cost per user	$152
Cost per mile	$10,620

3. DISTRIBUTION FOR ROCHESTER

a. Statistics

It was necessary to determine a basic design and estimate the cost of a video distribution system for a metropolitan area (a city and its suburbs) with a total population of 750,000. Rochester, New York, and the associated Monroe County has been chosen for this purpose. Basic assumptions for this metropolitan area are as follows:

User drops (metropolitan area)

Homes	210,000
Special	1,912
Miscellaneous	19,088
Total Subscribers	231,000

Maximum user drops per subsystem		36,000
Minimum No. subsystems required	6.4	
No. subsystems assumed	9	
Maximum capacity of 8 subsystems		288,000

Present load	231,000	(80.2%)
Available for growth	57,000	(19.8%)

*Road mileage in city	530
* " " in suburbs	860
Connecting road mileage	110
Total Mileage	1,500

b. Rochester Cost Estimation

(1) Rochester City

The procedure used to estimate the total cost is first to examine the problem within the city limits of Rochester. For this purpose it is assumed that city ordinances will prohibit aerial distribution and that all streets will be asphalt paved, which will require cutting the paving, trenching in the cables, and replacing the paving. The market price costs used for these purposes, as well as for the required wiring material, are the same for the Rochester model as for the Hagerstown model. The number of subscribers within the city limits is estimated to total 86,000. A city mileage of 530 miles is used. Accordingly the cost estimation for Rochester City is as follows:

Material Costs	($K)
Trunk cable 190 K ft @ $320/K ft	$ 61
Distribution cable 2610 K ft @ $185/K ft	483
Drop cable 13,000 K ft @ $81/K ft	1043
Amplifiers 1400 @ $1000 ea	1400
Taps 86,000 @ $3 ea	260
Pedestals housing taps 213,000 @ $14 ea	300
Pedestals housing repeaters 1400 @ $64 ea	80
Total materials	$3637

* City road mileage is for Rochester, N. Y., and was obtained from City Traffic Engineer, Rochester. Suburban road mileage was furnished by the Superintendant of Highways for Monroe County, N. Y. The 110 miles of connecting road was estimated.

Installation Costs

Place cable, 280 K ft @ $1540/K ft	$4300
Place drop cable 13,000 K ft @ $2000/K ft	2600
Place pedestals 22,700 @ $10	227
Total labor costs	$7127

Total, Material and Labor	$10,764,000
Contingencies (10%)	1,076,000
Total	$11,840,000
Engineering (6%)	710,000
Grand Total	$12,550,000
Cost/mile = $12,550,000 ÷ 530 miles =	$23,700
Cost/city subscriber = $12,550,000 ÷ 86,000 subscribers =	$146

(2) Monroe County Including Rochester

In developing the total metropolitan cost, several apparent facts lead to the method of costing. First, for the non-city area there is essentially no difference between the Monroe County and the Hagerstown areas. Therefore Hagerstown costs are used in estimating Monroe County costs.

It is questionable if a more valid estimate can be obtained by attempting a breakdown of all the various cost factors involved in Monroe County as was done in detail for Hagerstown. The absence of the required specific data for Monroe County precludes a comparison exercise at this particular time.

A summary of the Rochester distribution network costs is shown in Table A IV-14.

TABLE A IV-14

COST SUMMARY ROCHESTER DISTRIBUTION NETWORK

Material	15.2 M$
Installation	14.4 M$
Contingency	3.0 M$
Engineering	2.0 M$
Total	34.6 M$
Total Subscribers	231,000
Cost Per Subscriber	$150

4. THE HEAD END SYSTEM

a. Description

The cable network distribution that interconnects the subscribers in the different city and metropolitan/urban areas requires "head end" electronics for inputing/outputing (driving) the video and/or narrow-band data information. The Head End System (HES) is the interface between the wired city subscribers and either off-the-air broadcast reception or transmission "to" and "from" an LSDC of the national interconnection cable. In addition to receiving the signals and translating them to the networks, the HES also has the capability to:

- Record, schedule and hold, and replay received video information
- Generate live or taped information
- Transmit single frame information
- Receive, transpond and redistribute limited video and narrow band information eminating from within the wired city distribution network
- Privately receive and distribute information

Figure A IV-4 is a block diagram for a typical HES. It shows a TV/FM receiver capable of acquiring off-the-air broadcasts and translating them for amplification (cable driver block) and cable distribution to the wired city. In a similar manner, information may be received from an LSDC.

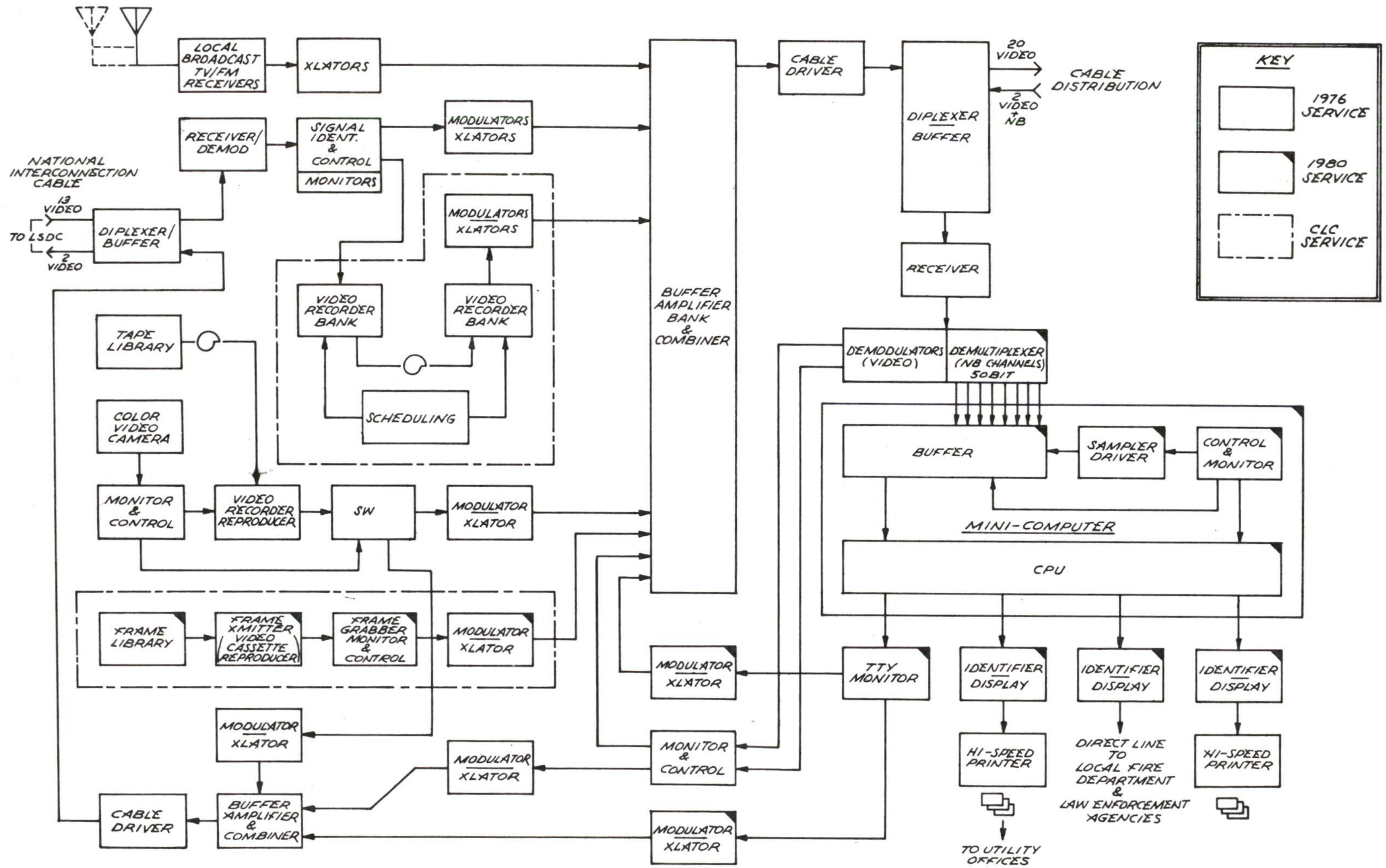

LOCAL BROADCAST TV/FM RECEIVERS
XLATORS
RECEIVER/ DEMOD
SIGNAL IDENT. & CONTROL
MONITORS
MODULATORS XLATORS
NATIONAL INTERCONNECTION CABLE
13 VIDEO
TO LSDC
2 VIDEO
DIPLEXER/ BUFFER
MODULATORS XLATORS
VIDEO RECORDER BANK
VIDEO RECORDER BANK
SCHEDULING
TAPE LIBRARY
COLOR VIDEO CAMERA
MONITOR & CONTROL
VIDEO RECORDER REPRODUCER
SW
MODULATOR XLATOR
FRAME LIBRARY
FRAME XMITTER VIDEO CASSETTE REPRODUCER
FRAME GRABBER MONITOR & CONTROL
MODULATOR XLATOR
MODULATOR XLATOR
CABLE DRIVER
BUFFER AMPLIFIER & COMBINER
MODULATOR XLATOR
BUFFER AMPLIFIER BANK & COMBINER
MODULATOR XLATOR
MONITOR & CONTROL
MODULATOR XLATOR
CABLE DRIVER
DIPLEXER BUFFER
20 VIDEO
2 VIDEO + NB
CABLE DISTRIBUTION
RECEIVER
DEMODULATORS (VIDEO)
DEMULTIPLEXER (NB CHANNELS) 50 BIT
BUFFER
SAMPLER DRIVER
CONTROL & MONITOR
MINI-COMPUTER
CPU
TTY MONITOR
IDENTIFIER DISPLAY
IDENTIFIER DISPLAY
IDENTIFIER DISPLAY
HI-SPEED PRINTER
TO UTILITY OFFICES
DIRECT LINE TO LOCAL FIRE DEPARTMENT & LAW ENFORCEMENT AGENCIES
HI-SPEED PRINTER
KEY
1976 SERVICE
1980 SERVICE
CLC SERVICE

Figure IV-3

This information (13 video channels) is demodulated, and, based upon monitoring, it is either remodulated and appropriately channeled for immediate cable distribution or else recorded on tape. As can be seen, if the information is taped, then according to a prescribed schedule it can be replayed and distributed to meet given local service requirements. These are the basic "receive" and "re-distribution"functions of the HES.

The HES also has a triple capability for generating and distributing information. The simplest form is by the use of tapes from a library (as shown) using a video reproducer with appropriate translation (modulator) into the cable driver. A color video camera capability (studio) is also provided to accommodate locally generated "live" programs which can either be immediately distributed or recorded for later replay. The third and most unique HES information generating capability is the Frame Transmitter. Single frames of video information, mostly for instructional purposes, are stored in tape fashion. By means of using the local telephone service as an "order wire", a subscriber can request a particular identifiable frame; whereupon the frame grabbing and transmitting equipment searches its library, acquires the proper picture and translates it to the cable driver with the requesting subscriber's address code for proper delivery. This frame grabber function together with the previously mentioned HES capability to record, schedule, and replay video information incoming from the LSDC, will perform the functional requirements of the CLC. The equipment associated with the CLC function is shown as group enclosures (dotted-lines) on the block diagram. The incorporation of the CLC function into the HES is accomplishable because the same types of equipment are necessary to perform other basic service functions. This incorporation will net a more cost-effective system. The equipment as shown is not necessarily all-inclusive for meeting long range time frame CLC requirements; but it is representative and is shown as an introductive capability. Predicated upon the foregoing, many sources translate information into the cable driver. This requires that the various information signals be appropriately combined and buffered (Buffer Bank and Combiner) as shown on the HES diagram. A distribution capacity of 20 video channels is shown.

As previously indicated, the HES can also receive and redistribute limited video and narrow-band information from points in the cable distribution system (Wired City). A two (2) video channel capacity is provided for this type of service. In order to accommodate for two-way cable service the HES is equipped with a diplexer/buffer between the cable driver and the wired city distribution network as shown. This type of received information (video and narrow band data) emanating from the wired city is diplexed into a separate receiver for subsequent processing. The video type of information which emanates from only a few specific points in the network, is demodulated and monitored for control and subsequent redistribution either back into the HES cable driver/distribution system or out to the associated LSDC. The control function (duty) also has a responsibility for assuring privacy of transmission. Descrete (private) information will be assigned to specific, dedicated channels for restricted distribution. These private channels will only be received by subscribers who are equipped with the proper channel tuner. The narrow-band type of information (50 bit digital), which can emanate from all network users, is demultiplexed and fed into a mini-computer. This type of information will, in general, be generated by means of subscriber devices such as utility meters, fire and burglary detectors, etc. The programming aspect, or central processing unit (CPU), of the computer identifies. sorts, classifies and assimilates the incoming data and "outputs" it for proper use (Utility Co., Fire & Law Depts., Misc. Business, etc.) in display, handcopy and/or further transmission formats.

The last feature of the HES is to retransmit information to the associated LSDC. For this purpose modulation translators, buffer amplifiers, monitoring, switching and cable driver equipment are required. Locally generated information (library tapes, studio, camera and video/narrow band wired city data) is the only material required to be transmitted to the associated LSDC. This information (2 video channels) is diplexed into the national interconnection cable for the associated LSDC.

b. HES Cost

Table A IV-15 lists the items and their unit cost for the Head End System, including the total required for 1980-86 service.

Table A IV-16 is a cost summary for both 1976 and 1980-86

Table A IV-15

HEAD END SYSTEM COSTS FOR 1980-1986 SERVICE

ITEM	NO.	UNIT PRICE	TOTAL
UHF/VHF/FM Antenna Preamp	1	$ 70	$ 70
Color TV/FM Receiver	23	375	8,625
Buffer Amp/Combiner	2	400	800
Cable Diplexer/Buffer	2	200	400
Color TV Monitor	9	325	2,925
Video Tape Recorder*	14	20,000	280,000
Color Video Camera	1	25,000	25,000
RF Switch	1	36	36
Modulator/Translator*	21	180	3,780
Video Cassette Player*	1	900	900
Frame Grabber Monitor*	1	1,630	1,630
Cable Driver	2	50	100
Mini-Computer	1	70,000	70,000
NB Demultiplexer	1	2,000	2,000
TTY Monitor	1	650	650
Storage Tube	3	1,700	5,100
Hi-Speed Printer	2	1,150	2,300
Control & Switching Equip.		5,000	5,000
Cable & Patch Paneling		2,000	2,000
Racks, Hardware		3,500	3,500
Total			$414,816 inc. CLC

*CLC Service (Community Learning Center)

Table A IV-16

HEAD END SYSTEM COST SUMMARY

	1976 SERVICE	ADD FOR 1980 SERVICE	TOTAL FOR 1980-1986 SERVICE
Basic	$ 96,066	+ $75,860	$171,926
CLC	240,180	+ 2,710	242,890
Total	$ 336,246	+ $78,570	$414,816

E. COSTS AND INVESTMENTS.

1. INVESTMENTS FOR WIRED CITY MODELS.

Wired city costs for Hagerstown and Rochester are presented in this section. The statistical mix of subscribers in each city is taken from Table A IV-17. Terminal equipment costs are taken from the appropriate tables among Tables A IV-2 through 12. Cable distribution costs are taken from Tables A IV-17 thru A IV-20 for Hagerstown and Rochester respectively. Costs for head ends are taken from the same tables.

Total costs for Hagerstown are presented in Table A IV-17 for 1976, and in Table A IV-18 for the 1980-86 period. The cable distribution network is assumed to be fully installed by 1976, in order to justify the growth of services and uses in the next decade. Even so, the investment required by 1976 appears affordable, being on the order of that required for building a new school. The 1980-86 costs reflect the estimates made in Sec. C-1-f above about the expected market penetrations of video recorders and frame grabbers.

Total costs for Rochester are similarly presented in Tables A IV-19 and A IV-20. Once again, the required investments in the two time periods do not appear excessive. It is to be remembered that the unwired city investments will have to be made to take maximum advantage of the new capabilities.

2. COSTS AND INVESTMENTS NATIONWIDE

The results of "wired city" studies are projected here to arrive at the estimated costs involved in wiring urban areas nationwide. As the detailed information presented earlier applies only to Hagerstown and Rochester, expansion of cost estimates to a national system of wired cities uses HUD assumptions made later in Appendix V. C-7.

Estimates of the number of subscribers are based on the "Statistical Abstract of the U.S. - 1969." A list of cable subscribers is presented in Table A IV-21. The figure for business is the total of corporations, sole proprietorships, and partnerships. The figure for schools and colleges includes elementary, junior-high and high schools as well as colleges.

a. Investment

It was found that the total cabling and installation charges

Table A IV-17

COSTS FOR HAGERSTOWN BY 1976

Cable Distribution	$2,900,000
1 Head End	336,000
41 Schools @ $8900	364,900
3 Hospitals @ $5050	15,150
17.5K Homes @ $12	210,000
99 Physicians Terminals @ $22	2,178
1607 Other Subscriber Terminals @ $12	19,284
Total	$3,847,512

Table A IV-18

ADDITIONAL COSTS FOR HAGERSTOWN 1980-86

Cable Distribution	In Place
Head End	$ 78,500
41 Schools @ $14,430	591,630
3 Hospitals @ $15,800	47,400
19.2K General Subscribers	
30% Equipped with Frame Grabber	
Modification @ $55	316,800
40% Equipped with Frame Grabber	
Including Recorder @ $455	3,494,400
Total	$4,528,730

Table A IV-19

COSTS FOR ROCHESTER BY 1976

Cable Distribution	$34,650,000
8 Head Ends @ $336,000	2,688,000
253 Schools @ $8900	2,251,700
7 Hospitals @ $5050	35,350
1 Medical Center	20,850
220K Homes @ $12	2,640,000
2000 Physicians @ $22	44,000
8740 Other Subscribers @ $12	104,880
TOTAL	$42,434,780

Table A IV-20

ADDITIONAL COSTS FOR ROCHESTER 1980-96

	In Place
Cable Distribution	
8 Head Ends @ $78,500	$ 628,000
253 Schools @ $14,430	3,650,790
7 Hospitals @ $15,800	110,600
1 Medical Center	49,000
231K General Subscribers	
30% Equipped with Frame Grabber Modification @ $55	3,811,500
40% Equipped with Frame Grabber Including Recorder @ $455	42,042,000
Total	$ 50,291,890

Table A IV-21

CABLE SUBSCRIBERS

Households (75% of 60.4M)	45,300,000
Businesses	11,400,000
School and Colleges	123,000
Hospitals	30,600
Medical Centers	172
Doctors	322,000
Dentists	112,000
Post Offices	32,000
Police Stations	
Fire Departments	DATA NOT IMMEDIATELY AVAILABLE
Town Hall/Court Houses	DATA NOT IMMEDIATELY AVAILABLE
Utilities	DATA NOT IMMEDIATELY AVAILABLE
Total Subscribers	57.2M

Table A IV-22

INVESTMENT

Cabling and Installation (Including trunk lines and drops at $150/user)	$ 8.58B
Head Ends, 3000 at $415K each	$ 1.25B
Terminals	
Homes	
45,300,000 at $12 (basic charge)	$ .54B
30% of 45.3M x $55	.75B
40% of 45.3M x $832	17.30B
Doctors and Dentists	
434K at $22 (basic charge)	.01B
30% of 434K at $55	.01B
40% of 434K at $955	.17B
Schools and Colleges	
123K at $23,330	2.87B
Hospitals	
30.6K at $30,600	.64B
Medical Centers 172 at $69,850	.01B
Other subscribers (businesses, clinics, nursing homes, police, fire, town hall/court houses, utilities)	
11.4M at $12 (basic charge)	.14B
30% of 11.4M at $55	.19B
40% of 11.4M at $955	4.35B
Systems Engineering and Development	
10% of Investment	3.7
	$ 24.8B

Table A IV-23

OPERATIONS AND MAINTENANCE

Personnel, head end	
3000 at $174K	$ 522 B
Maintenance	
1% of Cable Investment	.086B
10% of other Investment	3.19 B
	$ 3.80 B

Table A IV-24

CAPITAL RECOVERY

Cabling and Installation:	
.10185 x \$8.58B	\$ .87B
(8% for 20 years)	
Other physical Investment:	
.14903 x \$28.2B	4.20B
(8% for 10 years)	
Systems Engineering and Development	
.14903 x \$3.7B (8% for 10 years)	.55B
	\$5.62B

averaged $150 per user for the two cities studied. Projections for the national system of wired cities are based on this figure. Terminal costs are detailed in Table A IV-22, and hook-up charges are given in the same table. It is assumed that 3000 head ends will be required and that 75% of the nation's households will be wired. The summary of investments is presented in Table A IV-22.

b. Operations, Maintenance and Capital Recovery

Operations and maintenance data are presented in Table A IV-23 and capital recovery data in Table A IV-24. Staffing required to run each head end is assumed to be that estimated by HUD in Section V. C-7.

c. Budget

The budget for the national system of wired cities is as shown on the following page. The costing methodology section in (Appendix III.C-I) gives the methods for distributing the budget. Investment is assumed to extend from 1975 to 1986.

WIRED CITY

DOLLARS IN BILLIONS

FY	75	76	77	78	79	80	81	82	83	84	85	86
Investment	1.14	2.98	4.08	4.08	4.15	4.15	4.07	4.07	3.94	3.94	2.87	1.03
Operations and Maintenance			.38	.76	1.14	1.52	1.90	2.28	2.66	3.04	3.42	3.80
TOTALS	1.14	2.98	4.46	4.84	5.29	5.67	5.97	6.35	6.60	6.98	6.29	4.83

APPENDIX V

PROGRAM DESCRIPTION

A description of current and proposed programs is contained in this section. It starts with a discussion of existing communications links, both groundbased and involving spacecraft V.A. The next part, V.B., describes communications experiments underway or currently planned. These two sections are intended to aid the reader in understanding the current state of the communications art.

The third section, V.C. discusses the experimental and operational programs proposed to implement the various user requirements. A description is given of how each service will be experimentally verified and then implemented. Descriptions of the various services and the reasons they are needed are contained in Appendix I of this report.

A. EXISTING, PROGRAMMED AND ANTICIPATED FACILITIES

1. TERRESTRIAL

The United States presently has the most comprehensive, economical, and flexible system of domestic terrestrial communications in the world. This includes extensive common carrier networks, broadcast stations and networks, private commercial systems, and CATV systems.

a. Telephone

Today there are more then 115 million telephones in the United States serving over 90 percent of the nation's 57 million households. This service is provided by the Bell Systems (approximately 80 percent) and the more than 1800 independent telephone companies. There are more than 360 million miles of intercity voice circuits derived from broadband carrier systems. In addition to public message telephone service, the telephone carriers also provide private line voice, data, fascimile, telemetry, telephotography, program (audio), and video services. Present and planned facilities to provide intercity connection of telephone systems are described in the next section.

(1) Intercity Telephone and Television Facilities

The Long Lines Department of the American Telephone and Telegraph Company provides the long-haul transmission facilities between and among the 23 AT&T operating companies and most of the independent operating companies. It is by far the largest distributor of existing and planned facilities.

The majority of the principal routes are part of the AT&T Long Lines network microwave radio relay systems. The initial long-haul transmission system, the TD-2 system operating in the 4 GHz band, was installed in 1951 and had a capacity of 2400 channels. Improvements in this system since 1967 have allowed expansion of the basic system capability from 2400 to 12,000 channels. A new development, the TD-3, is undergoing field trials in Arkansas and Oklahoma. The TD-3 system also operates in the 4-GHz part of the spectrum and has a capacity of 12,000 channels, but with lower investment costs, higher reliability, and less maintenance. The TH-3 system, introduced in field trials in 1969, is similar to the TD-3 system but utilizes the 6 GHz part of the frequency spectrum and has a 10,800 voice-channel capability. The TJ microwave system operates on the 11-GHz band over distances of 25 to 30 miles. This system has been in operation for a number of years and is used to meet short-distance low-capacity requirements. The basic system provides for 240 voice channels and is usually backed up with a 6-GHz system.

Coaxial cables have been used for long-haul transmission by AT&T for a longer period of time than have the microwave relay systems, but the present plant investment is much smaller.

The L-1 coaxial system, a two-tube system with a capacity of 1200 channels, was placed into operation in 1945, followed in 1953 with the L-3 system using 20 tubes with a capacity of 16,740 channels. The L-4 system, also using 20 tubes but providing a capacity of 32,400 channels, was placed into operation in 1967.

(2) Planned Capability

A new system called the "Pole Line" system is presently being tested at the Bell Laboratories in New Jersey. The test system is six miles long. This system includes mounting small suitcase-size packages atop 60-90 foot aluminum poles located three miles apart. The Pole Line system

Operates in the 18-20 GHz part of the spectrum and has a 32,000 voice-channel capability.

The L-5 coaxial cable system, now in the final stages of development, will permit the transmission of both analog and digital information. It will provide 90,000 two-way voice conversations on 20 coaxial tubes in a single cable.

The all-digital T-5 coaxial cable system is also in final stages of development. It will provide 80-90,000 voice channels. Both the L-5 and T-5 systems may be placed in service within the 1972-1973 time frame.

A 20-mile millimeter wave guide system is presently undergoing field testing. This system could provide more than 250,000 voice channels and may be installed for commercial service between 1974 and 1976.

Bell System research with lasers is developing an infrared light modulation which has a power requirement of less than one-tenth of a watt. Its real potential has not been determined, but it tests it has handled over 50,000 two-way conversations and 30 simultaneous television transmissions. AT&T expects this system, when refined and put into service, to have a capacity several orders of magnitude higher than achieved in test.

b. Television

Within the domestic telecommunication system, there are three full-time networks of television-grade facilities interconnecting approximately 370 TV stations in 220 cities. To coordinate national television broadcasting and to integrate as many as 23 segments of 110 to 120 seconds of local commercial advertising into the network schedule, 145 TV operating centers provided by the common carriers are scattered throughout the United States. There are about 500 independent TV stations in the nation which are not connected into the broadcast networks.

In 1970, there were a total of 862 operating TV stations with 581 assigned VHF-operating frequencies and 281 assigned UHF operating frequencies. Of these, 677 were commercial (501 VHF and 176 UHF) and 185 were non-commercial stations (80 VHF and 105 UHF). It is estimated that at the close of 1970 there were 90.5 million television receivers in use.

c. Radio

As of December 31, 1970, there were 4 nation-wide radio broadcasting networks in operation. The number of authorized broadcasting stations was as follows:

AM Commercial Stations	4,298
AM Educational Stations	25
FM Commercial Stations	2,181
FM Educational Stations	455

It is estimated that there were 345 million radio receivers in use.

(1) Record and Data Communications

The principal supplier of record and data communications in the United States is the Western Union Telegraph Company. This company has a transcontinental microwave network of over 7,000 route-miles with a capability of 80 million circuit miles. Additional facilities are leased from the telephone carriers.

Western Union which provides Teleprinter Exchange Service (Telex) and they recently acquired Teletypewriter Exchange Service (TWX) from the Bell System. These services permit direct-dialing to any of more than 75,000 network subscribers in the United States. A broad range of eletronic data communication services is also provided by Western Union. These services primarily involve "hard copy" communications, which permit the recipient of a message to retain a paper, punch card, magnetic tape or computer memory record of the information transmitted.

Telegram service is also provided by Western Union, but this service is undergoing a long-term downward trend in volume.

d. Private Systems

A number of entities, particularly those known as "right-of-way" companies such as railroads, gas and oil pipelines and electric utilities have constructed private microwave transmission facilities for their own inter-location telecommunications and control purposes. There are presently over 400 privately owned microwave networks, covering more than 110,000 route miles compared to approximately 72,000 route miles of microwave relay systems for the carriers. However, in channel miles the common carrier's capacity of 200 million is far in excess of the 2 and 1/2 million privately owned systems. Very few of the privately owned microwave systems carry more than 24 voice channels.

e. CATV

As of January 1, 1970, there were more than 2,490 cable television (CATV) systems in the nation serving about 4.5 million subscribers. Most of these systems were established to make possible the adequate reception of distant stations, serve a small number of subscribers (98 percent of the systems serve less than 10,000 subscribers), and provide small capacity (96.5 percent less than 12 channels), virtually all offer only one-way service. A tabulation of U.S. CATV systems by subscriber size and channel capacity is given below:

U.S. CATV Systems
By Subscriber Size
(As of Feb. 7, 1969)

Size by Subscribers	Systems
20,000 & over	8
10,000-19,999	50
5,000-9,999	144
3,500-4,999	123
2,000-3,499	279
1,000-1,999	423
500-999	427
50-499	730
49 & Under	40
Not Available	266
Total	2,484

CHANNEL CAPACITY
of Existing CATV Systems
(As of March 9, 1970)

Over 12	86
6-12	1,720
5 only	459
sub-5	61
Not Available	164
Total	2,490

2. EXISTING SPACE COMMUNICATIONS FACILITIES SYSTEMS

This section contains a brief description of the current operational spacecraft (INTELSAT), the proposed domestic satellite systems, and the current experimental spacecraft systems (ATS 1&3). This is followed by a discussion of the experimental spacecraft currently under construction and those proposed for the future. The experiments to be conducted with these spacecraft, their purpose, schedule, and major characteristics are described in section B-2 of this appendix.

a. Operational

The INTELSAT facilities must be considered in any study involving communications, since these facilities are already established. Existing as well as planned spacecraft and ground facilities should be utilized as applicable, not only during experimental phases but during operational phases as well, since they might well provide the most economical method of achieving the desired services. Similarly, the Domestic Communication Satellite System must be considered for services internal to the United States.

(1) INTELSAT Network

The first commercial satellite of the INTELSAT family, INTELSAT I, was placed in service in 1965. Nicknamed "Early Bird" and having a design life of less than 2 years and a total telecommunications capacity of either 240 voice circuits or a single FM-TV television channel, this spacecraft was the predecessor of three distinct generations of follow-on INTELSATS of progressively increasing capacity and improved lifetime. The successful launch of the first of the INTELSAT IV series of spacecraft in early 1971 represented a significant milestone in this development program, as the INTELSAT IV design, with its capacity of 9,000 voice circuits or 12 television channels and design lifetime of 7 years, is expected to be standard for international commercial communications throughout the 1970s.

A summary of the principal characteristics of the four generations of INTELSATS is given in Table A V-1. At present, 10 spacecraft are in operational or stand-by service as summarized in Table A V-2. The planned launches of future INTELSAT IV Spacecraft will augment the existing network, permit retirement of older limited-capacity spacecraft, and provide a full complement of in-orbit spares.

Table A V - 1

SUMMARY OF INTELSAT-SERIES SPACECRAFT CHARACTERISTICS

	INTELSAT I	INTELSAT II	INTELSAT III	INTELSAT IV
Year Placed in Service	1965	1967	1968	1971
In-Orbit Mass (kg)	37	81	127	700
Launch Vehicle	DELTA	Improved DELTA	Long-Tank DELTA	ATLAS-CENTAUR
Primary Power (watts)	40	75	120	400
Communications Repeaters	2	1	2	12
Bandwidth/Repeater (MHz)	25	130	225	36
Antenna Type	Omnisquinted	Omni	Mech. Despun	Mult. Mech. Duspun
Voice Circuits	240	240	1200	6000-9000
FM-TV Channels	1	1	4	12
Design Lifetime (years)	1.5	3	5	7

Table A V-2

NUMBER OF SATELLITES DEPLOYED IN OCEAN AREA SERVED

Intelsat Series Spececraft	Atlantic	Pacific	Indian
I	0	1	0
II	2	1	0
III	3	1	1
IV	1	0	0

Since the Early Bird satellite was placed in service in 1965, the INTELSAT ground network has grown from 5 earth stations to 79. While the majority of these stations are of a standard design utilizing a single 91-foot parabolic antenna, certain of the earlier stations still in service have less capacity, which is reflected in the grade of service and number of voice circuits they can handle.

Earth terminals having access to Atlantic-coverage satellites are located in the principal nations of Western Europe, a number of African countries, including Kenya, and Morocco, and several Middle-East nations, including Lebanon and Iran. In the Western Hemisphere, Atlantic satellite users include the United States, Canada, Mexico and a number of Central and South American nations, including Panama, Colombia, Venezuela, Brazil, Peru, Chile, and Argentina. United States access to the Atlantic system is primarily through the Andover, Maine, earth station and stations in Puerto Rico and the Canal Zone.

The Pacific-coverage satellites interconnect the continental United States earth terminals located in California and Alaska with Pacific-Basin and Asian sites including the Hawaiian Islands, Australia, Korea, Japan, Indonesia, Malaysia, Thailand, and the Republic of China. The Indian Ocean satellite serves primarily to connect India into European and Pacific elements of the INTELSAT Network.

(2) Domestic Satellite Applications

Nine applications are now before the FCC for authorization to implement Domestic Communication Satellite Systems and Services. The decision as to which application or applications will be authorizied is not expected before the early part of 1972. With implementation times ranging from two or three years, the system would be available in the 1974-1975 time frame.

The nine commercial organizations which have filed applications with the FCC for satellite systems and services are: MCI-Lockheed, Fairchild Industries, Comsat; AT&T/Comsat, Hughes, Western Union, GT&E/Hughes, Western Telecommunications and RCA.

Table A V-3 summarizes the communication capability and the public service offerings of each applicant. The proposed operational frequencies are shown in Table A V-4. The 4 and 6-GHz bands may be expected to be the work-horse

Table A V-3
SUMMARY OF DOMESTIC SATELLITE FILINGS

	AT&T/COMSAT	COMSAT	MCI-LOCKHEED	FAIRCHILD-HILLER
SYSTEM				
No. of Satellites	3 in Orbit 1 ground spare	3 in Orbit 1 ground spare	2 in Orbit 1 ground spare	2 in Orbit 1 ground spare
Orbit Locations [Longitudes]	94°, 104°, 119°W.	99°, 114°, 124°W.	114°, 119°W.	104°, 115°W.
SATELLITE				
Weight at Sync. Orbit	1600 lbs.	1600 lbs.	3900 lbs.	2905 lbs.
Spacecraft Size	110 inches in diameter 230 inches in height	110 inches in diameter 230 inches in height	8' x 5' x 6'[Stowed] x106'[unfurled]	9' in diameter[stowed] 25.3' in length
Stabilization	Spin	Spin	3-Axis [Momentum-wheels]	3-Axis [Momentum-wheels]
Station Keeping	Hydrazine Thrusters	Hydrazine Thrusters	Ion Propulsion Thrusters and Hydrazine Engines	Hydrazine Thrusters
Primary Power	~740 watts [solar cells on drum]	~740 watts [solar cells on drum]	4.4 kW [Solar Cell Array]	750 watts (solar cell cylinder)
Life Time	7 years	7 years	10 years	7 years
Launch Vehicle	Atlas Centaur	Atlas Centaur	Titan III D/Agena	Titan III C
COMMUNICATION SUB-SYSTEM				
Frequency Bands [Receive/Transmit]	5.925-6.425/3700-4.200GHz	5.925-6.425/3.7-4.2 GHz	5.925-6.425/3.7-4.2GHz 12.7-13.25/11.7-12.2GHz	5.925-6.425/3.7-4.2GHz 12.75-13.25/6.625-7.125GHz 2.5-2.69 Trans. Optional
Polarization	Linear	Linear	Linear	Linear
Number of Transponders	24	24	48 [24 for 6/4 GHz operation; 24 for 12 GHz operation]	120 [96 0.1w for narrow-beam point-to-point service; 24 for wide-area TV distr]
Usable Bandwidth per Transponder	34 MHz	34 MHz	36 MHz	34 MHz
Transponder Output Device	TWT	TWT	TWT	TWTs for Wide-area service; Solid State devices for narrow-beam point-to-point
E.I.R.P. per Transponder	33 dbW[beam-edge]	33 dbW[beam-edge]	34.5 at 4 GHz[beam-edge] 46 dbW at 12 GHz	36 dbW for narrow-beams 35.2 dbW for wide-area coverage at beam-center
EARTH STATIONS				
95-105' cooled T/R[G/T= 41.2 db/°K] 4/6GHz	5	2	--	6
42' cooled R/O[G/T= 35 db/°K] 4/6GHz	--	3	--	--
32' cooled T/R[G/T= 33 db/°K] 4/6GHz & 12GHz	--	--	20	--
32' cooled T/R [G/T= 31.5 db/°K] 4/6GHz	--	3	--	--
32' uncooled T/R[G/T= 29.0db/°K] 4/6GHz	--	25	--	--
32' uncooled R/O[G/T= 29.0db/°K] 4/6GHz	--	99	--	--
25' uncooled R/O	--	--	--	Exact No. N/A
PUBLIC SERVICE OFFERINGS	Willing to discuss with CPB the terms and conditions. Nothing Specific.	Willing to work out some sort of preferential service public broadcasting to meet the genuine requirements of the Corporation for Public Broadcasting[CPB]	Proposes to make available for experimentation in educational service, the equivalent of five TV channels without charge for a period of five years. Also plans to offer equal transmission capacityfor the remaining satellite life at a fraction of regularly established rates.	[1] Two fully non-interruptable satellite transponder channels, at no-cost, to the Public Broadcasting Service; shared use of narrow-beam channels for "off-shore" locations of Alaska, Hawaii, Puerto Rico and Panama Canal zone; [2] Part-time, free-use, of two satellite transponder channels for health-care delivery throughout U.S.; [3] Free service of one or two instructional television channels from the satellite directly to a low-cost terminal for school or community use on 2.550-2.690 GHz band; [4] Free use of the spacecraft segment for a communication system for Alaska.

Table A V-3 (cont)
SUMMARY OF DOMESTIC SATELLITE FILLINGS

	HUGHES AIRCRAFT COMPANY	RCA GLOBAL COMMUNICATIONS /RCA ALASKA COMMUNICATIONS	WESTERN UNION TELEGRAPH CO.	WESTERN* TELE-COMMUNICATIONS
SYSTEM				
No. of Satellites	2 in Orbit 1 ground spare	2 in Orbit + 1 at a later date 1 ground spare	3 in Orbit 1 ground spare	2 in Orbit + 1 at a later date 1 ground spare
Orbit Location [Longitudes]	100°, 103°W.	[114°], 121°, 125°W.	95°, 102°, 116°W.	113°, 116°, [119°]W.
SATELLITE				
Weight at Sync. Orbit	452.5 lbs.	638 lbs.	452.5 lbs.	....
Spacecraft Size	73 inches in diameter .. in length	....	73 inches in diameter .. inches in length	....
Stabilization	Spin	Spin/3-Axis [Not decided]	Spin	Spin
Station Keeping	Hydrazine Thrusters	Hydrazine Thrusters	Hydrazine Thrusters	....
Primary Power	220 watts [solar cells on the spinning drum]	∿305 watts[solar cells]	220 watts [solar cells on the spinning drum]	....
Life Time	7 years	7 years	7 years	....
Launch Vehicle	Thor-Delta M-6T	Thor-Delta 904/ Atlas/TE-364-4	Thor-Delta M-6T	....
COMMUNICATION SUB-SYSTEM				
Frequency Bands [Receive/Transmit]	5.925-6.425/3.7-4.2 GHz	5.925-6.425/3.7-4.2 GHz 12/13 GHz experimental	5.925-6.425/3.7-4.2 GHz	5.925-6.425/3.7-4.2 GHz 12.75-13.25/11.7-12.2GHz
Polarization	Linear	Linear	Linear	....
Number of Transponders	12	12 for 4/6 GHz operation 2 for 12/13 GHz	12	6 for 4/6GHz operation 6 for 12/13 GHz
Type of Transponder	Linear, Frequency Translation	Linear, Frequency Translation	Linear, Frequency Translation	....
Usable Bandwidth per Transponder	36 MHz	36-37 MHz	36 MHz	....
Transponder Output Device	TWT	TWT	TWT	TWT
E.I.R.P. per Transponder	33.1 dbW for Cont. U.S. 26 dbW for Alaska and Hawaii	35 dbW for cont. U.S. 26 dbW for Hawaii & Puerto Rico	33.1 dbW for cont. U.S. 24 dbW for Alaska and Hawaii	....
EARTH STATIONS				
98' cooled T/R[G/T= 36.7 db] 4/6GHz	2	1	....	....
45' ..... T/R[G/T= ....]4/6 GHz	....	....	7	....
35'uncooledR/O[G/T= 27.80 db] 4/6GHz	7	....	....	....
35'/32' cooled T/R [G/T=31.5 db] 4/6 GHz	....	13	....	....
33' uncooled R/O [G/T = 28.75 db]	....	....	6	....
PUBLIC SERVICE OFFERINGS	One channel on interruptible basis inclusive of transmit and receive earth terminals. Selection of ETV programs in the program package for the cable television industry.	Two transmit TV channels at reduced rates for ETV program distribution. Public Radio program distribution on "piggy back" basis on the channels assigned for ETV. Regular rate provision for Instructional television program distribution. "promotional" rates for experimental ITV services via standby satellite. Allocation of two ITV channels for Alaska.	Willing to offer one or more channels capable of transmitting TV signals if the FCC decides that it is in the public interest that non-commercial ETV networks should be provided satellite channels without charge. Satellite channels would be provided, if the Commission so decides, either by spreading the cost over other users of the satellite, or, from the spare satellite on an interruptible basis.	

*At the time this paper was written, authors did not have access to the detailed filing of Western Tele-Communications, Inc.

Table A V-4

PROPOSED USE OF FREQUENCY BANDS

Applicants	Frequency Bands (GHz) 1	2	3	4	5	6	7	8	9	10	11	12	13
MCI - Lockheed				▨		▨						▨	▨
Fairchild - Hiller		▨		▨		▨	▨						▨
Comsat				▨		▨							
AT & T/Comsat				▨		▨							
Hughes				▨		▨							
Western Union				▨		▨							
GT & E/Hughes				▨		▨							
Western Telecomm				▨		▨						▨	▨
RCA				▨		▨							

frequencies, while there will be very litte utilization of the 12 and 13 GHz frequencies. Operation of large aperture (greater than 30 feet) earth stations may be required and these will probably be located up to 80 miles from major metropolitan areas.

Fairchild Industries is the only applicant to propose use of the 7 GHz band for ETV-ITV distribution and for a thin-route demand-assignment multiple-access communication system to Alaska. The use of both of the 7 and 12 GHz bands for the respective services may afford some flexibility in the earth station design and siting and may result in lower cost.

b. <u>Experimental</u>

The Applications Technology Satellite (ATS) Program evolved from the early communications satellite programs, Echo, Telstar, Relay, and Syncom. Although these early spacecraft were utilized for experimental demonstrations, ATS-1 was the first synchronous orbit spacecraft that was intended to be a "bus" and to carry multi-disciplinary applications experiments selected from responses to an "Announcement of Flight Opportunities". ATS-1 and ATS-3 are both still alive and usable. They are shown on the following time chart along with the future available spacecraft facilities.

<u>MAJOR EXPERIMENTAL SPACE COMMUNICATIONS FACILITIES</u>

'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78
ATS-1						ATS-F		ATS-G		ATS-H		
	ATS-3						CTS				ATS-I	

A description of each of these experimental facilities follows.

(1) ATS 1 & 3

The ATS-1 and 3 experimental satellites are equipped with communications repeaters which have found extensive application in many areas relating to education, public broadcast, emergency disaster communications, search and rescue, and other applications relating to social needs. ATS-1 and 3 were successfully launched into synchronous equatorial orbit on December 7, 1966 and November, 1967, respectively. With the exception of a correctible recurrent malfunction of the ATS-3 mechanically despun microwave antenna, the communications subsystems of both satellites became operative in summer, 1971. A summary of the ATS-1 and 3 communications parameters is given in Table A V-5.

(2) ATS-F & G

The ATS-F & G design represents a major advance in the technology of advanced experimental satellites. For this generation of ATS, two flights, F and G, are programmed for launch in May, 1973, and May, 1975, respectively.

The technical objectives of ATS-F and -G are to :

(a) Develop the technology for space testing a thirty-foot diameter deployable antenna with a surface quality satisfactory for good performance at frequencies up to 6 GHz

(b) Provide a capability to point the antenna and spacecraft with an accuracy of 011 degree to any point on the Earth's visible disk from synchronous orbit

(c) Develop and space-test precision attitude measuring technology, and

(d) Provide a high gain steerable antenna and an oriented stable satellite at synchronous altitude for experimenting with advanced space applications concepts.

The large-aperture, space deployable antenna technology and associated radio-frequency feed technology have the capability to produce powerful, highly directional television signals which can be received by relatively small and inexpensive ground receivers. These technologies will therefore be applicable to satellites for improved mass instruction broadcasting in presently developing areas and for improved education in developed countries. They will also be applicable to tracking and communicating with lower-altitude satellites from synchronous satellites, for the first time making possible continuous contact between satellite and ground control center. The great directionality provided by the large antennas will also permit accurate measurements of the magnitude and location of surface sources of radio interference to satellite communications, providing data needed to establish criteria for improved sharing of the crowed frequency

Table A V-5

SUMMARY OF ATS 1 AND 3 COMMUNICATIONS PARAMETERS

Frequency of Operation	Number of Channels & Bandwidth	Channel Receive Frequency	Channel Transmit Frequency	Transmit Power (watts)		Antenna Type		EIRP Over Earth Coverage FOV		Earth Terminal Requirements for Type of Communications Service.
				ATS-1	ATS-3	ATS-1	ATS-3	ATS-1	ATS-3	
VHF	1 Channel, ~ 100 KH2 Bandwidth	149.22 MHz	135.6 MHz	8 Elements @5 Watts Ea. Nominal		Electrically Despun Phased Array		+ 22.5 dBW	+ 25 dBW	Duplex Voice Link Possible With YAGI Array Antenna 100 Watt Xmtr and Transistor Rcvr.
Microwave	2 Channels, ~ 25 MHz Bandwidth Each*	(a) 6212.1 MHz (b) 6301.0 MHz	(a) 4119.6 MHz (b) 4178.6 MHz	(a) 8 (b) 8	(a) 8 (b) 12	Electrically Despun Phased Array	Mechanically Despun Horn Antenna	(a) + 21.7 dBW (b) + 21.7 dBW	(a) + 26.0 dBW (b) + 26.0 dBW	EM-TV via ATS-3 Parabola, 5 KW Xmtr, and Paramp Rcvr (equivalent to intels at IV FM-TV minimum requirements)

*The microwave repeater characteristics summarized here are for the frequency translation mode of operation. In addition, a multiple-access mode was provided.

spectrum between terrestrial and satellite systems.

ATS-F and -G will both carry additional applications experiments in several disciplines which make use of an require the basic capability of technology of the spacecraft.

Experiments for ATS-F have been selected and are as follows:

(a) Educational Television (ETV) Experiment

The ATS-F spacecraft will be equipped with a pair of television transmitters operating in the 2.5 - 2.69 GHz band allocated for the satellite broadcast service at the 1971 meeting of the World Administrative Radio Conference in Geneva. It is planned to use these transmitters to beam experimental educational television programming to selected regions of Appalachia, the Rocky Mountain States, and Alaska. The program is sponsored jointly by the Corporation for Public Broadcasting, the Department of Health, Education, and Welfare, and the NASA. Special low cost satellite receiving terminals will be installed at participating schools, CPB stations, and DHEW Learning Centers for controlled experiments in multi-lingual educational television, computer-managed and computer-aided instruction, and inter-active instruction with limited student-teacher "talk-back".

(b) Tracking and Data Acquisition Experiment

This experiment will track and receive telemetry from, and transmit commands to the Nimbus E Meteorological Satellite using the full gain of the 30-foot antenna on ATS-F, thus providing a space test of technology for satellite tracking and data acquisition using a synchronous satellite.

(c) Aeronautical Communications and Traffic Control Experiment

This experiment will provide a transponder on ATS-F operating in the aeronautical L-band for multiple-channel communications and position-location tests with aircraft.

(d) Propagation Experiments

The spacecraft will carry radio equipment to perform propagation experiments in millimeter wave frequency bands designated for future use by the communication satellite service. Specific frequencies at which measurements will be made are 12, 18, 20, and 30 GHz. In addition, the spacecraft will carry beacon transmitters to obtain propagation data at frequencies between 40 and 400 MHz.

(e) Radio Frequency Interference (RFI) Experiment

The 30-foot antenna on ATS-F will be used to measure interfering signals originating in any selected 200- to 300-mile diameter section of the visible Earth in the frequency bands used for transmission to communications satellites and for terrestrial service.

(f) High Resolution Infrared Camera Experiment

This experiment will consist of a camera, operating in the infrared and visible regions of the spectrum, which will scan the Earth once every 24 minutes providing nighttime as well as daytime coverage of Earth weather.

(g) Scientific Experiment Package

ATS-F will carry an integrated package of seven scientific experiments to measure particle flux and direction and the behavior of Earth's magnetic field.

(h) Satellite Instructional Television Experiment (SITE)

In addition to the two-channel S-Band ETV experiment, ATS-F carries an 80-watt transmitter operating at 860 MHz. This transmitter will be used to beam instructional television programming to India in a cooperative experiment with the Indian Space Research Organization (ISRO). After launch, ATS-F will be maintained over the U.S. for about 12 months to permit full data acquisition from its other experiments. Then it will be moved to a position over 35 degrees E longitude for SITE operations over India and other participating nations in the Eastern Hemisphere. It will remain there for one year.

The experiment payload for ATS-G is currently being selected from approximately 67 experiment proposals in the disciplines of traffic management (Air Traffic Control and Maritime Services), Meterology, Science, Earth-Space Propagation characteristics, Radic Frequency Interference, and Advanced Spacecraft Technology. Present plans are to retain certain of the communications capabilities of the ATS-F Spacecraft and expand others to provide improved signal characteristics over larger areas of coverage. The two-channel ETV capability of ATS-F will be expanded to provide as many as ten television channels which can be broadcast to multiple regions within the United States and Alaska. The L-Band aeronautical communications capability will be modified to provide for programmable area coverage and new experiments in radio-location. The satellite-to-satellite relay experiment may be expanded to provide experimental support for both major observatory spacecraft such as NUMBUS and small scientific and applications satellites having limited data rates and antenna pointing capability. (See Table A V-6 for summaries of transmission capabilities).

(3) CTS

The communications Technology Satellite (CTS) is being developed as a cooperative effort between NASA and the Canadian Department of Communications. The purpose of this satellite is to demonstrate technology applicable to high-power communications from space in the 11.7-12 GHz frequency band. The satellite, which is scheduled to be launched in 1974, will contain a super-effiency 200-watt 12-GHz tube which will be used to amplify and beam signals through three-foot steerable antennas to a footprint on the ground about as large as a time zone. This high power space signal will be used to transmit FM television and other wide-band signals for reception in remote areas and to larger terminals in populated centers separated by great distances. The ability to steer the beams by moving the satellite will allow its use in the experiments at such widely separated locations as Hawaii, Alaska, Labrador and Northwest Canada. Since there will also be a lower power 12-GHz beam available, some interactive experiments using television will be possible with this satellite.

While the satellite will be maintained in an East-West position, it will be allowed to drift North and South, resulting in a daily "up and down" movement of the satellite of a few degrees. This will necessitate the use of "nodding" receiving antennas on the ground when narrow receiving beams are used. The satellite will weigh approximately 750 pounds and will be placed in orbit using the "low-cost" calendar year 1974 with a minimum design life-time of two years.

An outline of the communications capability of this satellite is given in Table A V-7. A conceptual drawing of the satellite is given in Figure A V-1.

Table A V-6
SUMMARY OF ATS -F & G FM-TV TRANSMISSION CAPABILITY

FREQUENCY OF OPERATION	ATS-F						ATS-G					
	NO. OF CHANNELS	CHANNEL FREQUENCIES	RF POWER AVAILABLE	EIRP & FOV	MINIMUM DIAMETER OF COVERAGE	EARTH TERMINAL RQTS. FOR FM-TV	NO. OF CHANNELS	CHANNEL FREQUENCIES	RF POWER AVAILABLE	EIRP & FOV	MINIMUM DIA OF COVERAGE	EARTH TERMINAL RQTS. FOR FM-TV
860 MHz	0.1	860 MHz	80 WATTS	+51 dBW ~3.0°	~1,500 MILES	10' - 15' ANTENNA TRANSISTOR RCVR.	NOT PLANNED FOR ATS-G					
2.5 GHz	2	(a) 2550 MHz (b) 2650 MHz	15 WATTS (per channel)	+54 dBW ~1.0° 12 Beams	~500 MILES EITHER BEAM	10'-15' ANTENNA, TRANSISTOR RCVR.	(To Be Determined)		200 Watts (TWT)	(To Be Determined)		(Same as ATS-F or Less)
4 GHz	3	(a) 3750 MHz (b) 3950 MHz (c) 4150 MHz	20 WATTS (total)	(1) +58 JBW 0.3° (2) +28 JBW ~1°*	(a) 150 MILES (b) EARTH'S DISC	(1) 5'-10' ANTENNA TRANSISTOR RCVR. (2) REQUIRES MINIMUM OF 30' ANTENNA	TO BE THE SAME AS ATS-F					
12 GHz	NOT PLANNED FOR ATS-F						1	~12 GHZ	5 Watts	+53 dBW ~0.6 **	~300 MILES	5'-20' ANTENNA, PARAMP RCVR. (Depends on local rain attenuation)
20/30 GHz	2	(a) 20.150 GHz (b) 30.150 GHz	(a) 2 WATTS (b) 2 WATTS	(a) +40, dBW, ~2.4 (b) +42, dBW, ~1.5°	(a) 1200 MI (b) 750 MI	15' - 60' ANTENNA, PARAMP RCVR. (Depends on local rain attenuation)	NOT PLANNED FOR ATS-G					

* PRODUCED BY SMALL EARTH VIEWING ANTENNA, NOT BY 30' REFLECTOR

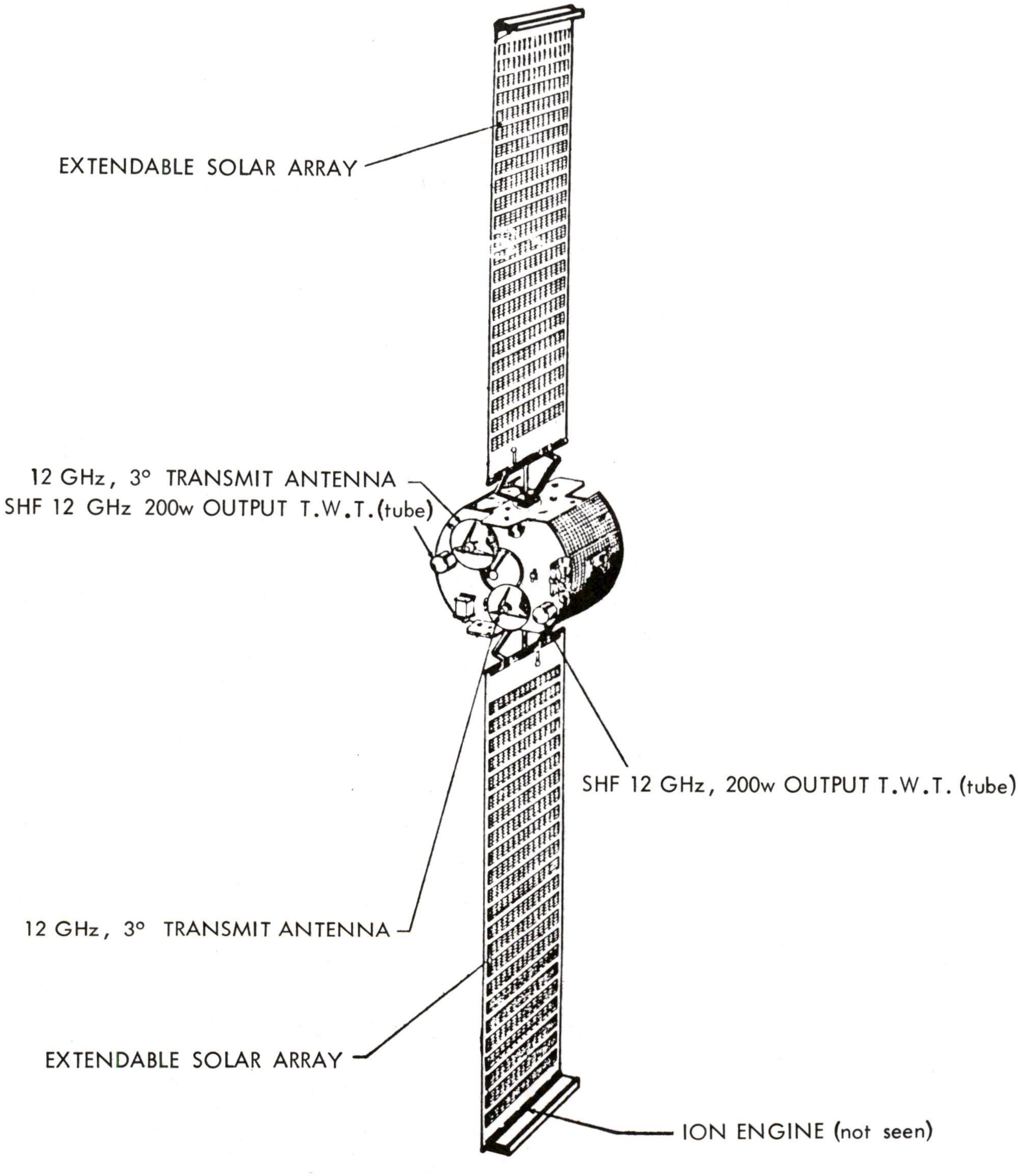
** PRODUCED BY PARTIAL ILLUMINATION OF 30' REFLECTOR

NOTE: ALL CHANNELS HAVE USEFUL BANDWIDTHS - 30 MHz; GROUND - SATELLITE LINKS FOR ALL CHANNELS AVAILABLE AT 2250 MHz, 5950 MHz, 6150 MHz, an AND 6350 MHz

Table A V-7

CTS COMMUNICATION CAPABILITY

Frequency of Operation	No. Channels	Channel Frequencies	RF Power Available	Field of View	Area Coverage	Earth Termin Requirements
12 GHz	1 High Power	Nominally 12 GHz	200 W	2.7°	500 mi.	6 - 10 Foot
	1 Low Power Video	Nominally 12 GHz	20 W Steerable	2.7°	500 mi.	20 Foot "Nodding"



CTS Satellite
Figure A V-1

(4) ATS H/I

ATS H and I are the next generation beyond ATS F and G of the multidisciplinary applications technology satellites. Among the applications areas in which the ATS H and I satellites have potential for advanced flight experiments are: meteorology, navigation, earth and ocean physics, and communications. The communications applications include earth-to-space, space-to-space, and space-to-earth linkages. As part of the capability, ATS H and I will flight test the satellite technology being developed for future space systems. Much of this technology under development, is applicable, directly or indirectly, to communication systems. The technology includes; multi-beam antennas, shaped bean antennas, high voltage power conditioning, liquid metal slip rings, ion thrusters, high power high efficiency tubes, high power waveguide components, high voltage solar arrays, heat rejection, accurate altitude control, and transmission to small terrestrial receivers. As presently envisioned the satellite will include among the experiments aboard the capability to transmit at 2.5 and 12 GHz at power levels in excess of 100 watts and 1000 watts respectively, using steerable beams. The use of highly efficient tubes in conjunction with the multiple beams will allow extensive and flexible experiments in such areas as information networking, frequency and orbit sharing, propagation, and user experiments in health and education.

The use of a 9 foot aperture for spot beam transmission will also allow for the reception of small signals from regional areas thus making interactive program experiments including duplex video, audio, and computer ties, possible with low powered ground terminals.

A preliminary concept of the ATS H and I spacecraft has been determined. The major identifying components of the satellite are: sun-pointing solar array wings,earth-pointing body containing most of the experiments and the communications hardware, and the earth-pointing multi-beam antenna system.

The ATS H and I program is at present in Phase A of the NASA Phased Procurement Plan. Launches are programmed for calendar years 1976 and 1978, respectively. The minimum design goal lifetime is two years.

B. PROGRAMMED STUDIES AND EXPERIMENTS

1. STUDIES

a. Terrestrial

The National Academy of Engineering Committee on Telecommunications has prepared a report, Communications Technology for Urban Improvement, for a consortium of Federal Departments including Housing and Urban Development, Transportation, Commerce, Justice, the Federal Communications Commission, and the U. S. Postal Service.

This report pointed out that city governments have requirements for closer communication with their citizens and readier response to citizens' needs, and that modern communication technology has a great potential for being instrumental in relieving many urban problems and upgrading the level of city life.

b. Electronic Mail Handling (EMH)

Completed and ongoing studies and experiments addressing the feasibility and development of an Electronic Mail Handling capability began in early 1970. A contracted preconcept effort under Postal Service direction began in January 1970 and addressed the capability of electronic technology to process and transmit mail throughout the United States. The study was exploratory in nature and designed to anticipate availability of future technologies. It did not attempt to solve problems of rising costs, outmoded facilities and increasing workloads. Near-term study objectives were:

(1) Evaluate the state-of-the-art of Electronic Communications

(2) Evaluate processing of mail and security needs

(3) Recommend methods for the electronic handling of mail

(4) Recommend laboratory design and specification

(5) Develop a technical data book on electronic communications equipment and technology

Progressing logically from this initial study, a major concept development effort began, under contract, in June, 1971.

The objectives of this on-going contract are:

(1) Develop a detailed EMH configuration which best meets Postal Service requirements and may be implemented in a sequence compatible with technological advances and economic justification.

(2) Establish the collection/distribution system and the equipment requirements whereby an EMH may be achieved.

(3) Define the national implementation plan for integrating an EMH into the operating postal system environment starting in 1977.

c. Space

The advent of communications systems using satellites has meant the addition of an entirely new dimension to communications problems and solutions. In order to assess these problems and to properly define the solutions, a number of analytical and experimental studies have been undertaken. These studies may be divided into three areas: general studies which identify users and/or assess technical and economic feasibility, specific studies in identifiable technological areas, and studies to optimize the use of the frequency spectrum and geostationary orbit.

The direction of the feasibility studies has in a sense followed the level of the technology. As each given level has been demonstrated by actual spacecraft, interest has gone toward the applications of still higher technological levels. During the last ten years there have been an increasing number of questions pertaining to the possibilities of high-power radio-frequency transmissions from space including the nature of problems involved. Governmental, educational, and private enterprise have attempted to answer these questions by supporting studies of the economic and technological feasibility of such systems, the identification of possible users, and the identification of experiments leading toward operation concepts.

The broad-brush feasibility and user studies have been followed by a number of studies concerned with specific user communities. These have included:

(1) Satellite systems to develop the communications in Alaska.

(2) Educational satellite experimental systems for the Rocky Mountain and Appalachian regions.

(3) Satellite systems to warn the public of possible natural disasters, and

(4) Biomedical information transfer satellite systems for the National Library of Medicine.

In order to fully assess the problems of frequency/orbit utilization and their solutions, NASA and OTP have supported analytical and experimental studies in the following areas:

(1) The subjective measurement of interference and an assessment of the pertinent parameters.

(2) The optimization of orbit utilization as a function of frequency, usage, and signal characteristics.

(3) The use of special transmitting and receiving antenna configurations that will minimize power spillage outside the coverage area or will minimize the effects of power radiated from an adjacent satellite.

(4) The measurement and analysis of propagation factors such as attenuation, scattering, noise and phase distortions.

(5) The analysis of the use of frequency interleaving and polarization to increase frequency usage.

2. EXPERIMENTS

a. ATS 1 and 3

The Applications Technology Satellites 1 and 3 are equipped with communications repeaters which can be used for experiments in the areas of education, public broadcast, emergency/disaster communications, search and rescue, and other social needs. These repeaters provide one VHF channel of about 100 kHz bandwidth and two microwave channels each of about 25 MHz bandwidth. The VHF channel can be used for voice. These facilities have been utilized in a large number of technological experiments and demonstrations involving various aspects and applications of space communications. These have included aircraft and maritime communication and navigation, emergency/disaster communications, transcontinental television transmission experiments, and transmission of digital data, weather maps (facsimile) and standard time information.

During the next two years education, health and law enforcement communities will be conducting a series of pilot experiments using the ATS-1 and 3 satellites. These projects, as part of the user experiment phase of the Applications Technology Satellite Program, provide the users the opportunity to verify their assumptions about their requirements for communication satellites and to demonstrate the feasibility of providing a required service within a prescribed cost budget. Several of these experiments, which include both on-going and planned projects, are described below.

(1) University of Hawaii Experiment

In March 1971, the University of Hawaii started the first phase of experiment in inter-university exchange of library resources and curriculum materials using the voice channel communications link on the ATS-1 satellite. In this phase of the experiment, students and faculty at the remote Hilo Campus on the Island of Hawaii were given access to the main library at the Monoa Campus in Honolulu. The objective of the experiment was to demonstrate the feasibility of using satellite and small, potentially low-cost, ground terminals connecting remotely located schools to share library facilities and to improve the timely availability of resource materials to those needing it for their studies. Preliminary results of the experiments show the feasibility of being able to consistently satisfy requests for reference materials within 24 hours using facsimile transmission via satellite between the campuses. This was a sighnificant reduction from the 7 to 10 days previously experienced by students and staff at the remote campus. The plan for the second phase of the experiment extends the service to include universities and schools located at other islands in the Pacific Basin.

(2) National Library of Medicine/Alaska Experiment

In March 1970, The National Library of Medicine and the State of Alaska initiated a series of health care experiments in which two remote Alaskan villages, Allakaket and Venetie, communicated with the Medical Center in Faribanks via the VHF voice channel of ATS-1. The purpose of this experiment was to compare the reliability and availability of a satellite link (including inexpensive terminal facilities operated by untrained personnel) with existing HF radio circuits currently used to link villages and cities in Alaska.

The experiment initially consisted of a scheduled one-hour-per-day "Doctor Call" from the two villages to Fairbanks. Several interesting results were achieved. The satellite circuit was found to be better than 97% reliable while the HF reliability was only 25%. At one time, the HF circuit was inoperable for a period of 8 days. The village aides were able to establish a conversational familiarity with the doctors at the Medical Center, thus facilitating the exchange of information.

In August, 1971, the experiment was expanded to include 18 additional villages. This expanded experiment provides remote health care diagnosis and treatment to each of the villages, and also evaluates the procedure of using the channel to provide medical programming for the villagers.

A further aspect of the on-going National Library of Medicine/Alaska Experiment involves the use of ATS-1 satellite channels to transport medical record data, diagnosis data, and research materials between the Medical Centers at Fairbanks and Anchorage and Native Health Service Hospitals in remote areas.

(3) Office of Education/Alaska Experiment

In November, 1971, the U. S. Office of Education will initiate an experimental educational service in remote villages in Alaska. The voice channel communications link of the ATS-1 satellite and the existing terminals and equipment will be utilized.

The experiment, which will run through one school semester, will evaluate the use of a voice channel for regularly scheduled professional interchanges between teachers in remote villages and those in the larger school system in Fairbanks.

The feasibility and desirability of voice channel dissemination of new instructional material specifically developed for native Alaskan children, who generally have a severe hearing disability, will also be determined.

(4) Stanford Computer-Aided Instruction Experiment.

In September, 1971, Stanford University will begin an experimental program in computer-aided instruction using the ATS-3 satellite to interconnect a number of rural school districts in the southeast Sierra counties with a centrally located computer system. Most rural school districts cannot afford to own and maintain a dedicated computer-aided instruction system. However, by cooperating with other communities with similar desires and using the commonly operated system, the cost per school for computer service should drop significantly. It is expected that using communication satellites to connect the widely dispersed schools to the central facilities can keep the cost for communication to the computer within the budgetary limitations of the rural school districts. In this experiment, which will be conducted throughout this coming school year, the rural schools will have the opportunity to evaluate the application of computer-aided and computer-managed instruction as an educational technique within their own environment. Of particular interest is the ability of the various school districts to obtain and use locally desirable programming inter-actively from a common centralized computer system.

(5) Department of Justice Experiment

An important public service communication experiment involving the law enforcement community will begin in the fall of 1971 using the ATS-3 satellite. Fingerprints taken in Sacramento, California, will be relayed by ATS-3 satellite to the Identification Bureau of the Florida State Police in Tallahassee using a standard police fingerprint facsimile transmitter. Police in Tallahassee will attempt to match the received prints with those in the files. The major objectives of this three-month experiment are to determine the performance requirements for the communication channel to satisfactorily transmit fingerprints at a high speed and to provide police officials with some experience in working with communication satellites in order to determine problems inherent in the introduction of such services into the routine of the law enforcement environment.

b. <u>ATS-F/G</u>

(1) Satellite Instructional Television Experiment (SITE)-India

The Indian Government plans an extension to a national level of a successful series of pilot programs in educational/

instructional television that have been conducted in the city of Delhi, India, and its environs during the past 10 years. The 860-MHz FM-TV transmission capability of ATS-F will be used primarily to support an experimental phase of an extension program during the period 1973-1974. FM-TV program material originating in either Delhi, Ahmedabad or Bombay (Figure AV-3) will be transmitted to ATS-F for re-transmission to television sets in about 3000 villages in some 7 key rural areas throughout India. The satellite will also serve schools, homes and villages in and near India's five principal cities. The satellite signal will be received by redistribution centers in the five major cities and directly by local receivers in each of the 3000 villages. The redistribution centers will receive the satellite signal on large antennas, reprocess it, and retransmit it to conventional VHF-TV sets located in local schools, homes, and villages. Using small antennas the direct-broadcast receivers in the 3000 villages, will amplify, process, and display the signal by means of a standard VHF unit equipped with an add-on modification to permit reception of satellite FM-TV signals.

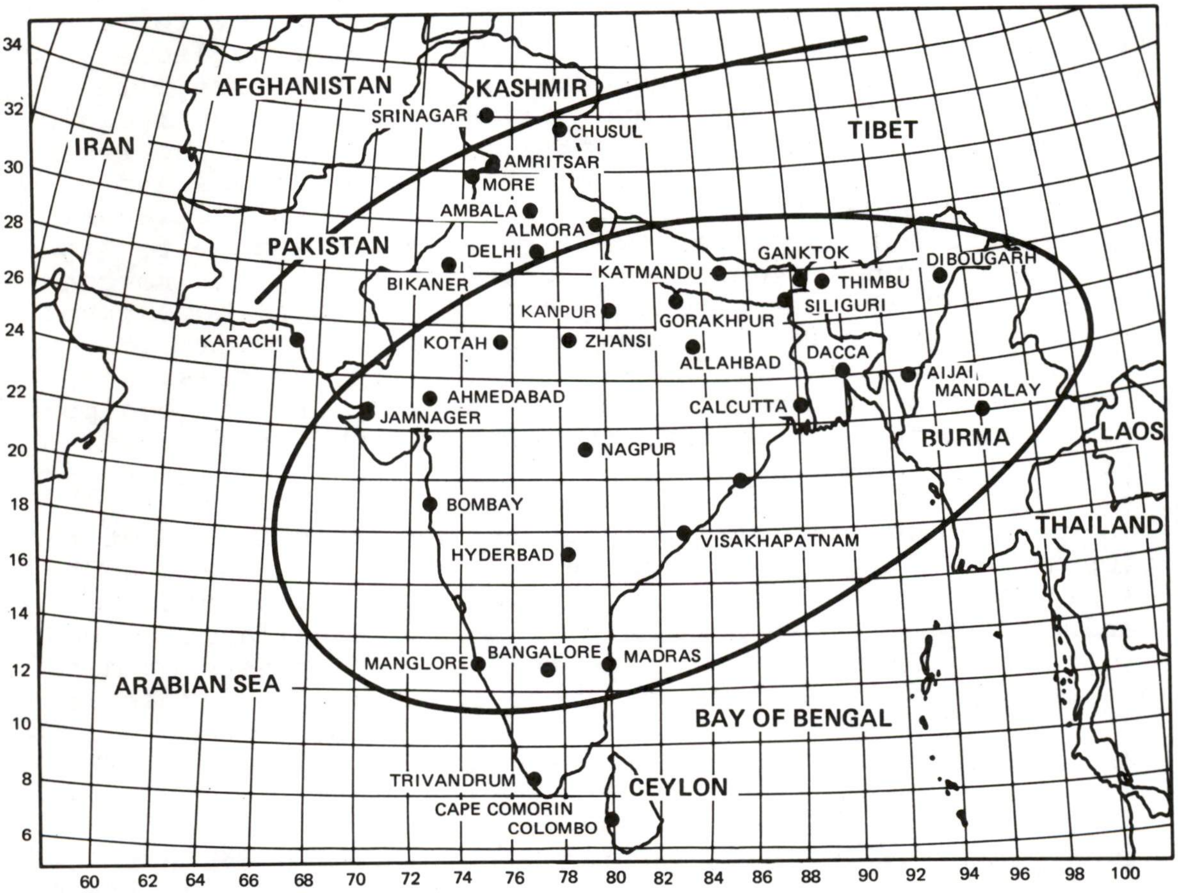
The experiment not only includes the hardware items but the production, distribution and evaluation of necessary software. The results of the experiment in both the areas of hardware and software, which will be made available to NASA, will aid in better determining the various aspects of mass communication from space to remote rural developing areas.

(2) Satellite Instructional Television Experiment (SITE) - South America

Discussions are underway concerning the possible use of the ATS-F satellite in a pilot test of satellite instructional television in remote areas of South America. This would require time-sharing of transmissions with periodic re-directing of the 30' antenna boresight to provide the desired area coverage. (Figure AV-3) This is considered practicable because of the substantial difference in local times between India and South America.

(3) Rural Regions Instructional TV Experiment with DHEW/CPB

A. 2.5-GHz, two-channel, FM-TV transmit capability is being provided in ATS-F to support an educational television experiment sponsored jointly by the Corporation for Public Broadcasting and the Department of Health, Education and Welfare. The subject of the experiment is distribution of educational and social development programming including



ATS-F @ 35° E. LONG.

BEAM CENTER: 79° E. LONG, 20° N. LAT.

-3db BW = 2.8°

-10db BW = 4.4°

Figure A V- 2

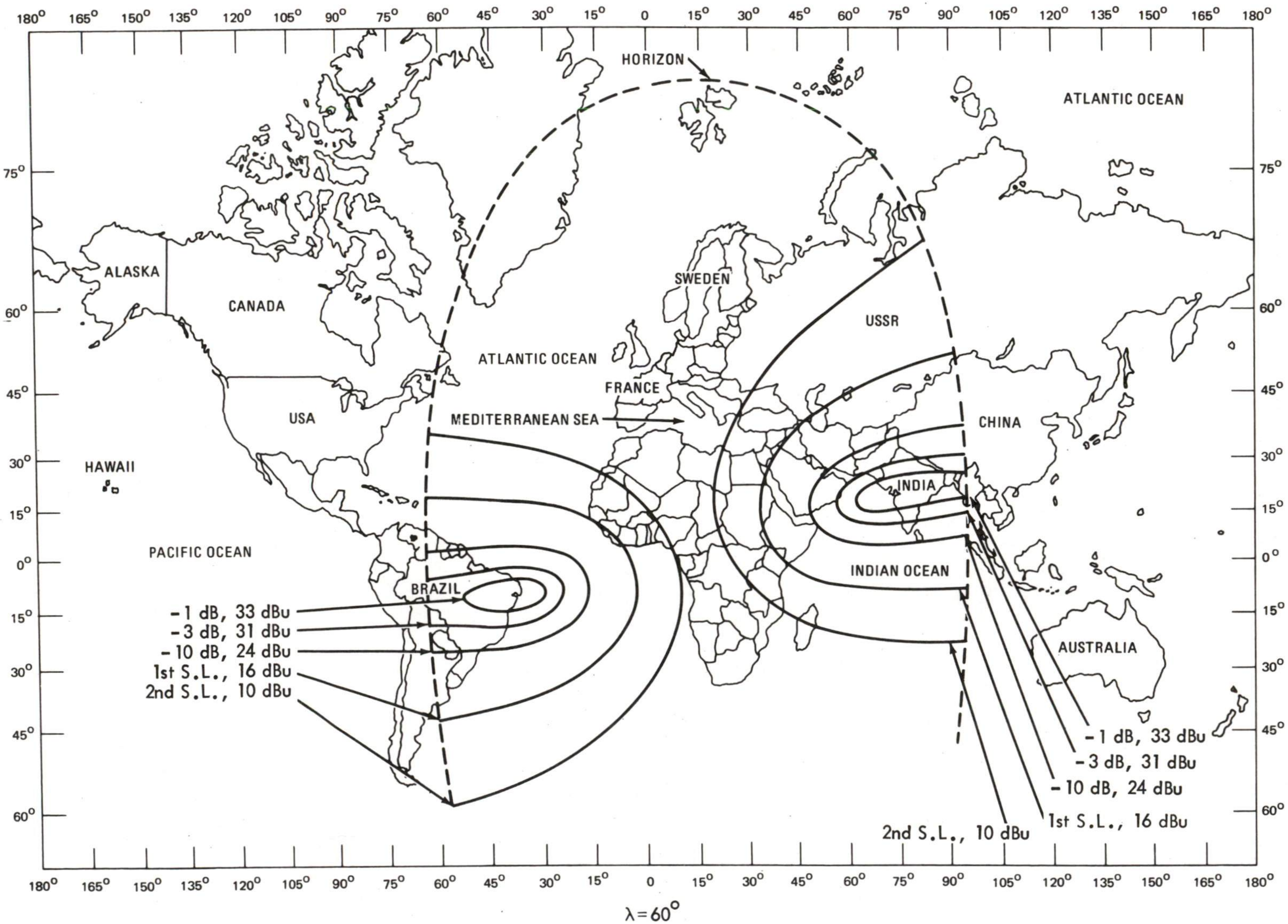

HORIZON
ATLANTIC OCEAN
ALASKA
CANADA
SWEDEN
USSR
ATLANTIC OCEAN
FRANCE
USA
MEDITERRANEAN SEA
CHINA
HAWAII
INDIA
PACIFIC OCEAN
INDIAN OCEAN
BRAZIL
AUSTRALIA
-1 dB, 33 dBu
-3 dB, 31 dBu
-10 dB, 24 dBu
1st S.L., 16 dBu
2nd S.L., 10 dBu
λ=60°

Figure A V- 3

computer-aided and computer-managed interactive instruction via satellite. The satellite will transmit to an area of about 350 by 500 miles, working with small low-cost ground receivers and modified cable TV head-ends for community reception. (See Figure A V-4).

Video programs originating at program development and software facilities located at a number of universities and CPB-affiliated educational television stations in the western United States will be transmitted to the Mojave and/or Rosman ATS ground stations via conventional land links for transmission to ATS-F and thence to selecting areas in the Rocky Mountain states and/or Alaska. Return-link data for interactive instruction is transmitted via satellite and conventional links to the program development center.

Programs for early child development, secondary school science center demonstrations, vocational training programs, higher educational and preventative health education are among the broad range of applications being considered. A formal pilot program in satellite ETV would be conducted over a period of several months with 4 to 5 hours of ETV programming per day, 5 days a week, divided into 1-hour or 1/2 hour segments. Control group techniques would be used for each of the distinct types of participating communities (primary and secondary school children, adult American Indians, for example) to evaluate the effectiveness of television instruction via satellite.

(4) ATS-G 2.5GHz Experiments

The ATS-G payload as presently conceived is pointed toward advanced FM-TV transmission experiments. The experiment program will be an expansion of the ATS-F two-channel 2.5-GHz ETV experiment to provide more channels at higher power levels. This will be accomplished by development of a 200-watt, broadband amplifier capable of covering the entire 2500-2690 GHz band allocated for satellite broadcasting.

(5) ATS-F 20/30-GHz Propagation Experiment

The primcipal objective is to obtain statistical data on rain attenuation at these frequencies. The experiment will be supported on the ground by dedicated NASA receiving terminals operated by cooperating experimenters. The terminals will be sized for reception of FM-TV from ATS-F during clear weather conditions. As received signal strengths at these frequencies will be strongly dependent on local atmosphere and rain absorption, it is to be expected that link outages will be experienced as a function of local weather. Observation of the statistics of such fades will be helpful in sizing future operational links at millimeter wave frequencies.

The spacecraft includes 2 watt RF transmitters at both 20 and 30-GHz and uses a 1.5' parabolic reflector to illuminate selected areas of the earth approximately 1,000 miles in diameter. The 20 and 30-GHz transmitters will be interconnected with the basic ATS-F transponder so that C-band signals received by ATS-F can be cross-strapped and transmitted to the earth at 20 or 30 GHz.

(6) Comsat Propagation Experiment

In order to obtain early data on propagation statistics in the 11-14 and 17-21 GHz bands a two-channel, up-link only, propagation experiment on ATS-F is being conducted. The experiment will measure the effects of rain, attenuation, scintillation fading, and other phenomena, and will provide data on siting requirements for space diversity reception. ATS-F will carry a special-purpose receiver having one narrow-band receive channel at approximately 13 GHz and a second receive channel at approximately 18 GHz.

Reception will be via a small earth-viewing reflector which provides coverage of an area approximately equal to the continental (48 states) United States. Multiple low-powered transmitters deployed at sites throughout the U.S. will transmit discrete unmodulated RF carriers at staggered frequencies in the 13-GHz and 18-GHz bands. The received signals will be frequency translated, processed, and retransmitted to a central ground site utilizing the available 4-GHz downlink.

(7) ATS-F 6-GHz RFI Experiment

The ATS-F experimental payload includes a broadband receiver for observations and measurement of radio frequency interference (RFI) in the 5.925/6.425-GHz band which has been allocated to communication satellite ground-space up-links on a shared basis with terrestrial common-carrier systems. This experiment will make detailed measurements of the signal levels developed in satellite receivers by existing terrestrial radio relay links and will provide additional data relative to ground-space frequency-sharing criteria and effective utilization of the synchronous orbit. These data will be available for the establishment of regulations and standards for intra-system and inter-system compatibility of proposed communications satellite systems. The narrow antenna beam of the ATS-F parabolic reflector will permit observation and measurement of terrestrial system emissions of the order of watts and will permit the conduct of controlled experiments in satellite signal interference to ground-based microwave radio relay systems.

c. CTS

Communications experiments with the CTS satellite will be conducted using the 12-GHZ high-power transmission and the steerable-beam capability of the spacecraft. These communication experiments will include single-channel vido, one-way data and voice communications and a limited amount of interactive communications using a combination of small and large terminals. Propagation experiments will also be made using the 12-GHZ down-link capability. NASA will conduct applications experiments, sharing the use of the satellite with Canada, as part of a program of studies in cooperation with other governmental and educational institutions in the areas of education and health care.

d. ATS H/I

The Corporation for Public Broadcasting (CPB) has identified a need for experiments and services involving public instructional broadcasting to school systems in rural areas and providing services to migrant workers (See section C-3 of this Appendix). Since multiple-channel coverage for specific geographical regions will be shaped to conform rather precisely to subsatellite areas of concern. Space segment transmitter power should begin to approach the level of a kilowatt or more at frequencies of interest, 2500 MHZ and 12 GHZ.

In addition, technological experiments with ATS-H and I will be conducted using the multiple shaped-beam high-radio frequency power capabilities of the spacecraft. These communications experiments will include multi-channel video and two-way data and voice communications using small ground terminals. Video interactive experiments will also be performed using moderate and small size terminal up-links. NASA will conduct applications experiments with ATS-H and I as part of a program of definitive studies in cooperation with other Government and educational institutions in the areas of education, health care and law enforcement.

Experiments will also be used to verify analytical solutions to frequency and orbital utilization.

e. Two-way Broadband Communications

A series of experiments utilizing two-way broadband capability are being carried out in the private sector. The actual equipment being used is not satisfactory for mass production and use, but key problems are being identified, and interim technological solutions are being attempted.

As an example, one experiment which the Department of Housing and Urban Development will soon have underway consists of two interactive home terminals that are being installed together with basic head-end equipment to serve the terminals in the new community of Jonathan, Minnesota. Visitors to the community will be invited to use the terminals in order to answer their questions about the community. Answers to potential questions concerning types of housing available, planned community facilities and schools, transportation, and future commerce and industry in the new community will be available on single-frame video from the terminals. In addition, sample interactive education programming, limited shopping and other services that will demonstrate system capability will be provided.

Visitor (user) reaction to the experimental system will then be solicited for the purpose of providing data on potential subscriber reaction to a two-way service. Data such as this will furnish a foundation on which to base estimates of future demand for types of service and amounts which potential subscribers would be willing to pay for such services.

f. EMH Equipment

Work related to the studies described in Appendix A V-B. 1.b has been conducted in equipment design of an advanced optical character reader (AOCR) which is to assist in input conversion at EMH centers. The task objectives of this work include design, development, and installation of an engineering model to be used in testing and refinement of equipment design.

Engineering model performance design requirements specify a capability for reading over 200 different fonts, encompassing any typewriter, addressograph, on-line printer font and a number of others. Both template and feature reading techniques will be utilized to achieve a message accept rate not lower than 0.85. Machine reliability is to be at the 0.96 level with mean-time-between-failures of 26 hours and mean-time-to-repair of one hour. Error rates, feed speed, and other performance values are anticipated to be well within the limits required for successful EMH operation.

C. NEW FEDERAL PROGRAMS AND INITIATIVES

1. PROGRAM INITIATIVES FOR EDUCATION.

This material, taken from a preliminary draft of the last chapter of the OE Educational/Cultural Report, was provided at the close of business on 16 August 1971. It is reproduced here as received.

If powerful new communication technologies are ever going to provide the kind of broad public benefits desired it will be necessary to lay out a specific and bold program of experimentation, demonstration and implementation that will elicit participation from both public and private sectors at national, state and local levels. The following suggested initiatives are indicative of the kind of leadership role that the Federal Government might play in bringing the full power of modern communication technology to bear on significant social problems. These initiatives were selected as follows: they deal with areas of recognized national concern; they either offer services to segments of the population who at present receive little or no services of this type proposed or they provide an existing service at far lower cost; while calling for certain technological innovation and development, they are based solidly on established techology and are designed to take full advantage of existing capabilities. The Federal role is conceived of as one of fostering innovation and encouraging use by example. Three principal action elements make up this initiative. They are: a commitment to develop certain kinds of programming directed at specific problems and target population; a program of technology implementation to insure that the necessary communications systems will be in place to deliver the programmed educational materials to the intended audience and finally, a program of Research, Development and Evaluation supported by appropriate legislation to enable states and localities to implement and extend the Federally demonstrated successes.

Program Initiative: High School Equivalency

Goal/Purpose:

At the present time approximately 40% of urban American students do not complete high school and nationwide approximately 25% of high school students do not finish high school.

This means that 1,500,000 young people each year are entering the job market without the necessary skills for employment. Many of them will be additions to the present group of 18,000,000 people who cannot now read and write well enough to perform such basic functions as filling out bank, social security and tax forms.

The goal we have set is to increase the number of people who achieve a high school equivalency degree by one million by 1975 and by at least three million more by 1976, the nation's bicentennial.

The Program

To do this will require a major investment in the human resources of our country. The Department of HEW, Office of Education, the Department of Labor and the Corporation for Public Broadcasting would fund the necessary research and development effort to begin to develop telecommunications based programs which will provide the educational materials enabling individuals to acquire the necessary skills to attain a high school equivalency diploma.

These materials will be distributed through existing broadcast facilities -- public television, cable systems -- and through other new telecommunications and broadcast facilities as they become operational. Special attention will be given to the disadvantaged living in inner cities, migrant farm workers unserved by existing systems and those whose geographical isolation denies them a quality high school education.

The specific target population for this initiative is the age group from 16 up.

The Budget

FY 1972 Supplement - $200,000

... for Preliminary planning and research

FY 1973 - $8,000,000

... for program development and pilot testing

FY 1974 - $8,000,000

... for final testing, production, and dissemination

Program Initiative: Dissemination of Day Care Models

Goal/Purposes

As indicated earlier, many forces are converging to accelerate the need for day care services in this country; among them female employment, national mobilization to fight poverty, welfare reform. Estimates indicate that by 1980 over one-half of American women will be employed outside the home. These women are currently caring for approximately 12 million children under 6 years of age. Thus, there is a vital need to provide day care services to children of currently working mothers and mothers enrolled in manpower training programs. It is therefore essential to begin training professionals and para-professionals to staff the large number of day care facilities which will be necessary in the near future.

We propose to develop a telecommunications-based program primarily intended to disseminate information about models of early childhood education but also providing additional preschool programming in areas of intellectual development not included in existing Sesame Street's preacademic focus.

The goals we have set are: 1) to train 5,000 personnel in early childhood education by 1974 and an additional 20,000 by 1976, and 2) to significantly increase the problem-solving ability of children in day care centers through the use of interactive telecommunications.

The Program

This program will experiment in alternative approaches to early childhood education currently part of the Head Start and Follow-through Planned Variation program. The two experiments have in common eight distinct models of early education sponsored by universities, private corporations and other institutions.

This initiative will seek to involve the sponsors of the eight models to develop staff training programs suitable for widespread use via telecommunications. Training courses for professionals and para-professionals will be established relying largely on media instruction accomplished by on-site instruction at Federally sponsored demonstrations. The demonstrations will be developed by building on Head Start Centers which have been sponsored by the Office of Child Development from 1968 to 1971 as part of the Planned Variation experiment.

The programming developed by each of the eight models will include 10 hours of materials for children to illustrate the model's orientation and 5 hours of staff training materials. The impact of the materials for children will be assessed through studies of children in day care centers who watch these programs. The training materials will be evaluated through measurements of increases in skill among already trained personnel and effectiveness in training new personnel.

The goal will be to develop materials compatible not only with current broadcast facilities but also with the interactive telecommunications networks projected for implementation during the next 10 years.

Budget

FY 1972	$ 500,000	Planning grants for developers of alternative model packages
FY 1973	7,000,000	Development of first-year staff and children's materials
FY 1974	7,000,000	Development of second-year staff and children's materials
FY 1975	500,000	Evaluation of efficiency and effectiveness
TOTAL 4-year cost		$ 15,000,000

Goal/Purpose

At the present time there are severe shortages of qualified people in the allied health fields: X-ray technicians, dental technicians, nurses, and physicians' assistants. In addition the vocational fields related to mechanics and a number of skilled craft areas such as sheet metal workers and tool and die makers are priority areas.

Only 38 percent of the demand for health professionals and only 35 percent of the demand in the above mentioned technical fields will be filled this year. Because of the particularly critical need for personnel in the allied health fields we propose a major initiative of providing telecommunications assisted instruction in these allied health fields.

The goal of this program will be to train 10,000 specialized health personnel by 1976. Toward that goal we propose to initiate immediately a program to meet those goals.

The Program

This program would be initiated by the DHEW. The allied health fields manpower training program will begin by collecting, evaluating and cataloging currently existing health training materials in the form of articles, tests, slides and films. It will develop a program for creating from these packets for particular health occupations a packet which can be accessed by individuals on demand in self-paced time frame. The focus of the software packages will be determined by projected medical care needs of the next decade.

The Budget

FY 1972	$ 400,000	Planning grants to two potential contractors
FY 1973	3,000,000	Pilot project
FY 1974	5,000,000	First year production and implementation
FY 1975	5,000,000	Second year implementation
FY 1976	750,000	Evaluation
	14,150,000	

Consideration will be given to developing bilingual sessions of the program material to serve the needs of Spanish speaking Americans.

The specific target population for this initiative is the age group from 16 up.

PROGRAM INITIATIVE -- OPEN UNIVERSITY

Goal/Purpose

Only 10 percent of Americans over 24 attend college. In addition, many people leaving secondary school are not given the opportunity to enjoy the benefits and privileges of post secondary education which they feel should be theirs. With the appropriate use of communication technology it is fairly certain that scarcity of opportunity could be reduced or eliminated as a barrier to post-secondary education.

The goal of this initiative would be to assemble the program resources for an "open university" and to develop at least one model of a delivery and accreditation system.

The Program

A number of institutions of higher education would be funded to gather the best audio and video course material and to develop or contract for additional programs, especially individualized interactive programs, so that full degree curricula could be offered to the general public without residence requirements. The opportunity to have access to such materials would be extended to include a large number of businesses as well as individual homes. Limited two-way interactive communications plus conventional TV to a large number of industrial firms as well as to homes will be required to make this program effective.

The Budget

FY 1972 -	$ 300,000	- Start up
FY 1973 -	4,000,000	- Research, Design, Pilot
FY 1974 -	4,000,000	- Test, produce, use
FY 1975 -	500,000	- Evaluate
	$ 8,800,000	
FY 1975	500,000	- Broadcasting of programs to start January 1, 1974
		- Evaluation of efficiency and effectiveness.

PROGRAM INITIATIVE--FUNDAMENTALS OF MATHEMATICS

Goal/Purpose

As many as 20 percent of school children are estimated to have difficulty with fundamental quantitative concepts at the early elementary level of schools. For these children there is rarely the opportunity to review and/or reinforce these important skills as they are being developed. A program to address the related needs of young children in the field of reading ("The Electric Company ") is being developed by the nationally known Children's Television Workshop, but a similar initiative has not yet been developed in the field of mathematics.

The goal of this program initiative is to begin the necessary research to implement a national program to improve every child's opportunity to master the basic quantitative skills so necessary to his future academic and career needs.

The Program

The program to be initiated by HEW through the Office of Education is to undertake the necessary research and development effort to provide video programs for the teaching of basic mathematical concepts of young children. This program will require the technological capability to transmit video signals to homes and schools across the United States either through existing broadcast capabilities or interactive telecommunications capabilities operational by 1975. Teachers and school officials would participate in the development of these materials and would be encouraged to use the materials in connection with their regular curriculum. Special provision would be made for interactive capability in both schools and homes in demonstration areas.

The program would be initiated jointly by DHEW, Office of Education, the Corporation for Public Broadcasting and the National Science Foundation.

The Budget

FY 1972	$ 200,000	-	Survey and Start-Up
FY 1973	2,000,000	-	Initial assembly of Program
FY 1974	5,000,000	-	Operation plus new Program Development
FY 1975	5,000,000	-	Continuing Operation plus Evaluation

Total 4-year cost $12,200,000

Some additional smaller efforts based on existing programs or special opportunities might also be supported. A bilingual version of the Sesame Street reading program could be encouraged and given wider distribution.

The special opportunities afforded by the NASA Skylab could make possible an exciting secondary school science series that could include direct participation of a large number of students in planning experiments and discussing results with the scientists-astronauts in space.

a. Operational Systems for Education

(1) Program of Experimentation

In section V-C a number of software program initiatives to address significant problem areas were identified. It is intended that this material be delivered over advanced communication systems. Since these initiatives concern educational problem areas that involve a large and diverse population, there are important questions with regard to the format of the educational program material and the structure of the communications system for delivery which must be resolved during the period of time when both of these elements of the total system are being developed. These include questions about significant differences in the way that different target audiences can relate to the educational program material. In addition, since no television program, however good, can constitute a total approach to an educational problem, there are questions concerning the need and form of support activities. Such considerations will reflect themselves in the configuration of the actual delivery system. The number and complexity of intermediate modes in the communication complex will determine which individuals and groups will be able to intervene in the communication process, either in terms of selecting materials, and interacting with the learners, or providing other support functions. For these and other reasons it is clear that a carefully developed program of experimentation needs to be undertaken.

To obtain a complete sampling of the various target groups which might benefit from the educational software programs, it is necessary to have communication facilities that can reach into remote locations as well as urban communities. The opportunity to use NASA experimental satellites to reach these isolated populations provides an attractive and cost-effective method of conducting the needed sampling of different target populations during the process of developing software program material. Critical questions about the appropriate size of audience that can be served by a single variation of a program affect the per capita cost and must be answered early in the software development program. In addition different arrangements of the communications facilities will have to be provided in order that different approaches to a total delivery system, which includes support services, can be evaluated.

Therefore, early in the development of each educational software program, certain technical communication facilities will be required to test and evaluate material with a wide range of target populations. One-way transmission of experimental television program material can be begun immediately utilizing the facilities of the Public Broadcast System and cooperating cable TV systems. The availability of the ATS-F experimental satellite in mid-1973 affords the first opportunity to test material with certain remote populations. It also can provide two-way communication capability to test interactive program material and to enable field test teams to communicate evaluation data to the production center. Similiar two-way capability will be available on selected cable systems in late 1972 and early 1973.

(2) Communications Services Required

Program development and experimentation will require availability of certain communication facilities. Communications requirements will vary from one software development program to another, but the general dimensions of the requirements are sufficiently common that for the most part they can be stated as a single requirement.

First we must have the capacity to reach target populations with experimental program material and to permit selected elements within these target populations to respond to primary and secondary program development centers.

These target populations are found in different parts of the country and will have to be reached in a variety of different viewing environments. Conventional broadcast and cablecast facilities will be sufficient to reach an adequate sample of the urban target populations. The specific structure of the required urban communication capability will be discussed in the following section. The various rural and isolated populations can be most effectively reached by satellite. The sort of geographic coverage that would adequately sample the target populations during the time period 1973-74 includes the Rocky Mountain region, Alaska and Appalachia. The communication service into these regions can be on a time-shared basis and would consist of a single TV program distribution channel with limited audio and data feedback channels.

As estimated 500 terminals throughout the areas mentioned feeding broadcast facilities, cable front-ends and individual institution closed-circuit systems would permit a valid experimental sample to be gathered.

(3) Experimental Cable Capacity

In densely populated urban areas broadband cable systems offer the best prospects of an early experimental capability. Many questions involving the involvement of various intermediaries in the educational process cannot be resolved without some opportunity to experiment with different system configurations.

A number of cities (perhaps 10 to 20 cities drawn from those selected by the President for increased Federal assistance) might be selected as test sites for a comprehensive cable communications experiment. Locations should be selected on the basis of: composition and specialized needs of their populations, community interest and resources, the sufficiently advanced cable system to permit a wide range of experimentation with minimal add-on costs.

All of the various cable wiring configurations in the test cities would eventually provide access to approximately 90% of the target populations either in their homes or in some kind of community center, four or five channels to be available for education and other public service uses.

Questions surrounding the use of telecommunications for education involve organization support services and locales where organizations can gain access either as users or as manipulators of the information flow. For this reason several quite distinctly different schemes for wiring of an urban area incorporated are indicated.

One of the simplest configurations is the method of wiring commonly used in present CATV systems. There is essentially a single point of access at the cable head-end and materials can be sent directly from there to all the subscribers. The only way to separate one group of subscribers from another is through such techniques as time division multiplex at the head-end which requires special equipment in each subscriber's home. Such a system is most attractive for those materials that are intended for direct distribution to the end user. A single complex of rather substantial facilities probably including the public television station, the library and a university would feed the system. It would essentially offer services that were alternatives to those available through the established educational institutions. Program material might be transmitted direct from a national programming source (e.g., Children's Television Workshop) to the end user. Intervirtually all users homes and thus would be restricted to fairly simple and reliable devices.

A second and more complex configuration requires the introduction of a number of facilities designated elsewhere in this report as community learning centers scattered throughout the city. These would be either at or closely associated with established centers of community activity (e.g., junior high schools). Consoles at the community learning centers and the major sources called a district learning center would have considerably greater channel capacity.

This scheme would call for the setting up of a system of trunks with networks to individual homes branching out from the community learning centers. Such a configuration requires a much greater participation on the part of the communities own institutions in the operation and in fact represents an extension of the power and reach of those institutions. Information is organized and managed by one additional element in the communications net before the end users have access. Such a system could, of course, be operated in such a mode as to make it equivalent to the first system.

The third and most complex system considered here is a fully switched two-way voice and video system and is essentially the broadband equivalent of the telephone system. Such a system gives users, either individually or collectively, access to each other or to specialized source stations. There are various gradations in the complexity of these switched systems and more study is needed before specific recommendations regarding educational and public service requirements can be produced for such a system.

(4) Schedule of Implementation

The schedule of development for the software programs mentioned in Vol. I, section IV-C, is such that the first test versions would be ready for testing on select audiences in mid-1972 in those areas where cable facilities are in place. Some tentative interactive program material may be ready for testing on more advanced cable systems in late 1972. Such testing would be a necessity largely to urban populations although a few rural CATV systems might be connected to the program centers. By mid-1973 the availability of the NASA ATS-F experimental satellite will make it possible to extend the tests to target populations in

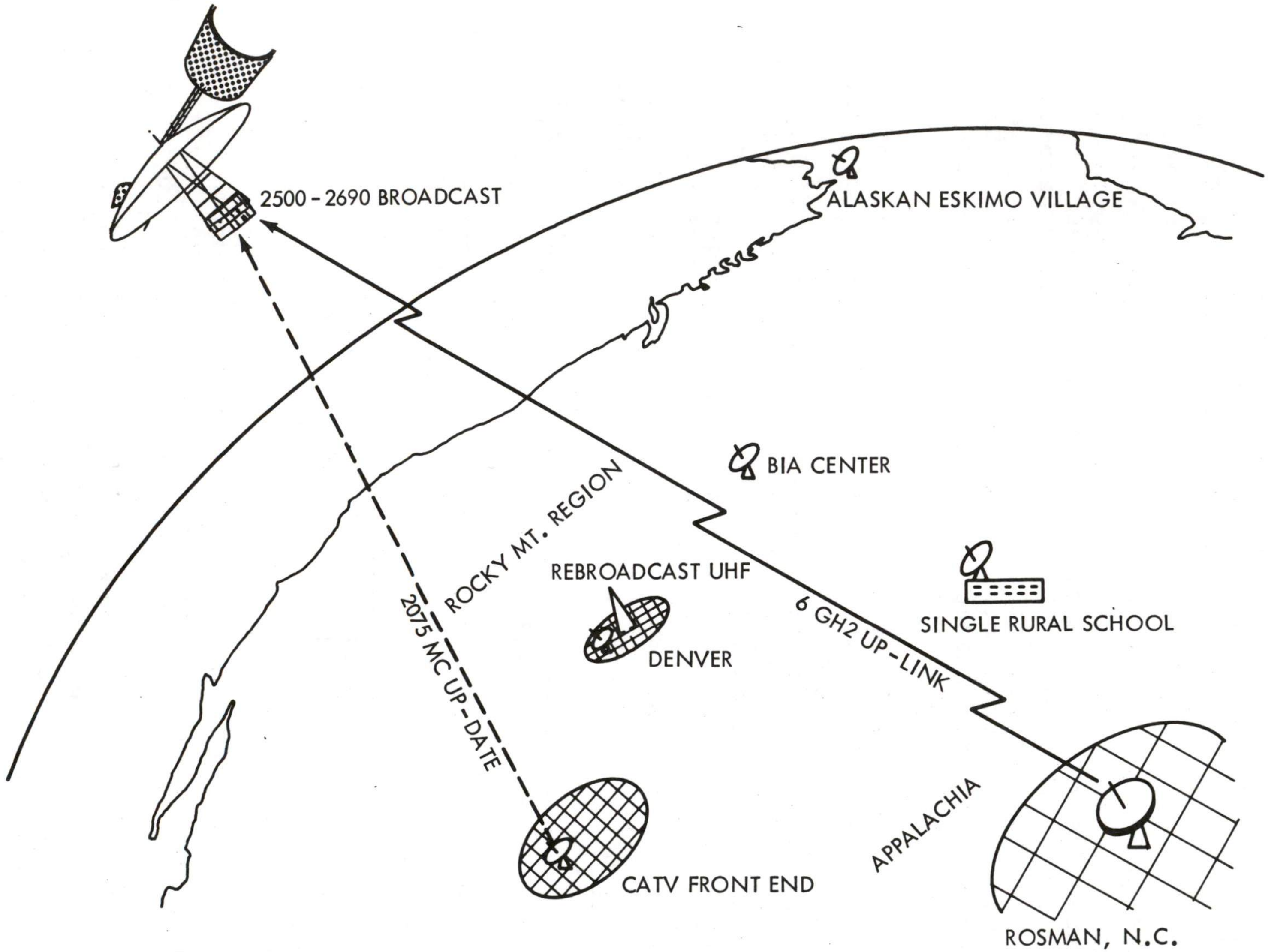


Figure A V· 4 System Concept For 1973 - 1974 ATS - F EXPERIMENT remote and isolated locations. However, the number of hours and areas covered will be quite restricted. By mid-1974 a phase of evaluation and software modification will be begun with the objective of producing by 1975 a fully validated and effective set of software materials in each of the five subject areas including all necessary variations to meet the needs of specialized user communities. (Reference Figue A V-5).

Additional experimental satellite and cable facilities are expected to become available at approximately this time so that a major demonstration and dissemination program could be undertaken in conjunction with the nation's bicentennial celebration in 1976.

(5) Research, Evaluation, and Dissemination

To achieve the sort of vision of the future described in V-C a substantial long-term program of research, evaluation and dissemination will be required. The proposed initiatives will provide convincing demonstrations of what could be possible but present resources and legislative authorities of the user community do not permit the sort of on-going substantive involvement in their development of communications capabilities that is required if major improvements are to be realized. It would, therefore, seem reasonable that one overall initiative would be the development of comprehensive telecommunications legislation for DHEW which together with the necessary long-term budget proposals would provide the basis for continuing support to the states and communities as they move to implement the more successful aspects of the near-term demonstration experiments.

2. PROGRAM INITIATIVES FOR HEALTH SERVICES

a. Experiments

(1) Purpose of Experiments

Experimental systems are to be set up, operated for a test period, and continuously evaluated for the purpose of determining their effectiveness in improving health services in four problem areas. In the area of public education the goal will be to evaluate the effectiveness of TV programming and a "dial-advice" telephone service in making the public aware of health services available, where and how to utilize them. An existing system will be used as a basis for studies to determine how improved distribution and retrieval of patient health records and the standardization of forms for collecting this information will aid hospital personnel administrators and private physicians not only in providing care to patients, but also in identifying health problems in a region, predicting the onset of epidemics, scheduling capital equipment and making proper diagnosis quickly. Evaluations of new 2-way audio and video systems connecting professionals both regionally and nationally will be concerned with increases in patient-physician consultations, and professional conferencing and instruction. The basic experiment is to determine to what extent full and complete transmissions of information can substitute for physical movement of patients, consultants and materials.

Finally the two-way voice and video systems set up in neighborhood health centers to interview, diagnose, and refer patients more conveniently will be evaluated to determine how effectively medical services have been made more available to the isolated and disadvantaged.

(2) Experimental Description

(a) Education of the Public

Short messages and educational programs will be broadcast over TV, radio, and CATV in an attempt to reach disadvantaged people and offer them health care information and advice regarding services available to them in their area.

A "dial-advice" system is also planned for metropolitan areas. A telephone number will be widely advertised. A staff member will be on duty 24 hours a day, and he will be ready to respond to calls in one of three ways:

1) answer a simple question directly, 2) play one of a number of recorded 3-minute messages, or 3) switch the call to an emergency medical duty officer.

(b) Computerization of Health Record and Biomedical Information

The experimental population is in a region of approximately one million people. Each acute and chronic in-patient care facility, clinic and a number of physician's offices will be equipped with a teletype terminal for accessing a computer in which the medical records of the trial population are contained. When a patient enters, a request for his record is typed onto the terminal and within 5 minutes his record appears as hard copy. The record will be in a standard format not to exceed 300 words and such that all pertinent information is presented in a categorized fashion. As the patient passes from service unit to service unit the record can be accessed at each point and each attending health professional is immediately made aware of vital information regarding his case. When the diagnosis and therapy have been completed for this episode all entries by attending practitioners are processed and returned to computer storage to update the record. This information is now available anywhere for use by other health personnel or for hospitals' administrative purposes; e.g., billing. One of the most important features is that the information is available for analysis and resource management. Confidentiality will be maintained throughout.

(c) Communication Among Professionls

Two trial applications are planned. The first will link four major health centers in Salt Lake City, Denver, Tucson, and Albuquerque with 40 health settings in the four state areas. Each major health center will be connected via satellite with ten settings within the state chosen. The major health centers will also be interconnected via satellite (ATS-F).

The interconnection between major health center and health settings and between major health centers will be two-way color TV. Consultations between the patient, his physician, and a consultant as well as diagnostic material will be communicated between health settings and health centers. Learning experiences, research information, and diagnostic consultations will be shared between medical centers. This connection may be via microwave or satellite.

The present national system for bibliographic search and retrieval (AIM-TWX) will be expanded to include computer-assisted instructional programs presently in operation at four academic health science centers and make them available to a wider user audience. Expansion, and eventually encompass medicine, dentistry, nursing, and the allied health professions. The network consists of a TWX-grade line with entry at 13 locations throughout the country. The user will use his own telephone to dial one of the 13 entry points. His request will be combined with others and transmitted transcontinentally on the existing network. The services to be available will initially include the bibliographic search, the simulated therapeutic regimens and information relative to adverse effects of drugs.

(d) Availability of Health Care

Initial trials of a new neighborhood health care program will be conducted using existing health centers (hospitals, medical centers) and neighborhood stations within walking distance of people needing the services. Neighborhood stations will be conveniently located in places such as elementary schools or churches. Twenty neighborhood health care stations will be established in five cities. One health center (hospital, medical center) in each city will be linked to 4 neighborhood health-care stations in that city by two-way black and white TV or picture phone. The central point of consultation (hospital or medical center) will be manned 7 days a week from noon to 10 p.m. by a physician, or a specially trained nurse clinician. They will serve on a rotating basis to minimize staffing problems. A person, preferably recruited from the neighborhood, and bilingual if the setting demands, will have intensive training of approximately 1 month to prepare him to conduct an interview, schedule patients, facilitate consultation with the center and operate the transmission equipment. Three people will be required to man each neighborhood station. Results of consultations will be returned to the neighborhood health station. Consultations will be on a scheduled basis to conserve the time of both the professional personnel and the patients, although some service can be provided on demand.

(3) Key Milestones

The projected starting date for each of the new programs is July 1972. Messages and programs for broadcasts to educate the public should be prepared, and the system should be ready for operation in 9 months. The dial-advice program will be set up in two stages, the first 10 offices equipped and staffed within 6 months and the last 10 within a year. The same 2-stage, 12-month schedule is planned for establishing the twenty neighborhood health centers as well. The AIM-TWX system is already in operation, but the program will be expanded to a 4 medical center program by mid-1973. Computerization of health records is also expected to be operational within 12 months, or by mid- 1973.

(4) Costs

(a) Education of the Public

Health CATV - It is assumed that the Health CATV system will use a dedicated channel in an existing urban CATV system, 12 hours a day, 6 days a week to reach 1000 color television receivers located in doctors' waiting rooms and clinics. The programs would be repeated on a one-hour cycle, with programs changed every two months. The cost of the initial pilot system includes the cost of programming. Expansion to other major urban areas would require only hardware and operating costs: programs would be supplied by snydication at a small incremental cost.

The Health CATV system is best suited for urban areas where there are at least one thousand doctors and clinics that would cooperate with the program. In less densely populated areas with a small number of potential outlets, the system does not appear cost-effective.

INVESTMENT COST

The investment in hardware to provide an initial pilot health CATV system for an urban area containing one thousand cooperating doctors and clinics during the first year is estimated to be $600 thousand.

Investment cost for one urban system:

Video tape recorders (2)	$200 K
Color television receivers (1000)	400 K
	$600 K

ANNUAL OPERATIONS

First-year operating costs are estimated to be $605 thousand, including an estimated $370 thousand for the production of 6 hours of programming and short weekly inserts. Subsequent annual operating costs are estimated to be $590 thousand, also including $370 thousand for new programming.

Uniform annual costs for one urban system:

	First Year	Subsequent Years
Programming, 6 hours @ $60K/hour	$360 K	$369 K
Weekly program changes	10 K	10 K

Receiver installation/ maintenance	40 K	50 K
CATV connection charge, 1000 x $25	25 K	---
CATV subscriber charge, 1000 x $60	60 K	60 K
CATV channel lease @ $5/hour	20 K	20 K
Video Operator Technician (3)	50 K	50 K
Health CATV Program Management	40 K	40 K
	$605 K	$590 K

BUDGETING

To accomplish the objectives of the Health CATV System, the following annual funding would be required:

	FY 73	FY 74
Investment	$600 K	
Annual operations and maintenance	$605 K	$590 K
	$1,205 K	$590 K

ULTIMATE PER CAPITA COSTS

When the 100 largest metropolitan areas are wired for cable television, the health CATV system could be expanded to reach an estimated potential audience of 100 million. Program production cost would then be spread over the 100 local systems, and annual operating cost per system would decrease to about $360 thousand. Total annual operating costs for 100 urban systems would be approximately $36 million. On the assumption that approximately one million persons would be able to view the program at one of the one thousand receivers in each of the cities at least once a year, the per capita cost per year would be less than 40 cents.

"DIAL ADVICE"

The target population in the greater Cincinnati area is one million people. The service time is 24 hours per day, seven days per week. One line per 10 thousand population allows a user one call every five weeks if the average service time is less than 5 minutes and the demand rate is constant. If incoming calls are queued the average rate could be serviced adequately with the ratio of one line per 10 thousand population. If lines are queued and demand rate rises to 3 times the average, the mean waiting time would be about four minutes.

Based on the previous assumptions, 100 telephone lines would be required to service the Cincinnati area. Twelve operators, one administrator and one M.D. would be required per shift.

<u>INVESTMENT</u>

Equipment	
125 Cassette players (includes 25 for backup)	$ 35.5 K
15 Operator station ($100 each)	1.5 K
Office Furnishings	5.0 K
Content Material	
Social and Health Services Directory	5.0 K
Medical Advice Tapes	40.0 K
Medical News Reports (Weekly Update)	5.0 K
Common materials duplicated for each station	1.5 K
Training	100.0 K
	$193.5 K

<u>ANNUAL OPERATION</u>

Staffing	
Operators, 12/shift x 5 shifts/week x $9 K	$540.0 K
Administrators, 1 + 1/shift x 5 shifts/week x $15 K	90.0 K
Physicians, 1 + 1/shift x 5 shifts/week x $20 K	120.0 K
Custodian	10.0 K

Maintenance (10% of investment)		4.2 K
Rental of Space		
12 on-duty operators	1000 sq. ft.	
Staff Space	500 sq. ft.	
Front Office Storage	1000 sq. ft.	
$5/Sq. ft. rental x	2500 sq. ft.	12.5 K
Telephones		
100 lines @ $180/yr/line		18.0 K
		$794.7 K

BUDGET

	FY 73	FY 74
Investment	$194 K	-
Annual Operations and Maintenance	795 K	$795 K
	$989 K	$795 K

(b) Regional Medical Information System

The target population for the experiment is an areas of about 1 million people: Thus, immediate access and retrieval storage is required for 1 million records. There will also be requirements for an operating system, the queuing program, request processors and other user and system routines. It is estimated that 400 million characters of storage will be required. To provide backup, a direct-coupled system with 65K core with each CPU will be required for the anticipated loads.

Fifteen hospitals (250 beds each) will be linked to the computer systems by way of CRT terminals with hard copy capability. Each hospital will have 10 terminal units. In addition, 250 terminals will be linked to the system for use by physicians and others. It is anticipated that one-half of the direct-coupled system will be installed during the first year of development with 10 terminals linked in.

INVESTMENT

Direct-Coupled Computer System	$3.0 M

RAM/Archival Storage	$1.0 M
450 CRT/Hard Copy Terminals	$3.2 M
Communications InterFace	$1.0 M
	$8.2 M

ANNUAL OPERATIONS

Staffing	
2 operators x 5 shifts/week	$150 K
System Administrator	30 K
3 System analysts/programmers	60 K
Custodial	10 K
Equipment maintenance, 3 technicians	60 K
Building Rental	25 K
Maintenance (10% of investment)	800 K
	$1.135 M

BUDGET

	FY 73	74	75
Investment	$2.6 M	$5.6 M	-
Annual Operations and Maintenance	.25	.90	$1.14
	$2.85M	$6.5 M	$1.14

(c) Communication Among Professionals

Two-way color TV - A 9-month experiment will provide two-way color TV communication in a four-state area (Arizona, New Mexico, Colorado, and Utah) through ATS-F satellite communication. Estimates of costs are as follows:

INVESTMENT

44 TV cameras @ 40K	$1.76 M

44 Satellite TV, two links @ $23 K	1.01 M
50 Color monitors @ $3 K	.15 M
	$2.92 M

ANNUAL OPERATIONS

44 technicians @ $20K/year	$ .88 M
Administration, monitoring, and evaluation 5 @ $40K	$ .20 M
Maintenance (10% of investment)	$ .29 M
	$1.37 M

BUDGET

For this experiment the amount budgeted is $4.29M in FY 1973.

(d) Computer Assisted Instruction and AIM-TWX

The Computer-Assisted Instruction experiment is scheduled for completion in 3 years and gradual build-up of an operational system could be accomplished in eight years. Acquisition of the terminals is started with 40 terminals in the first year, 120 in the second year and 240 terminals in the third year.

INVESTMENT FOR OPERATIONAL SYSTEM

The investment involved in Computer-Assisted Instruction is for terminals and audiovisual equipment. The terminals are a commercially marketed item (IBM 2741 or equal) which costs approximately $3000. It is assumed that this price will decrease to $2500 each on a large buy of 7200 units. For a fully implemented national system the investment cost is 7200 terminals @ $2500 = $18M. Audiovisual Investment (needed for each terminal) is:

Projector	$ 160
Cassette	$ 100
Rear View Screen	$ 15
7200 terminals x	$ 275 = $2.0 M

Total investment is, therefore	$ 18 M + $2.0 M = $ 20 M

INVESTMENT FOR THE CAI EXPERIMENT

Audio-Visual Equipment	$ 110 K
Terminals	1200 K
	$1310 K

There is no investment required for AIM-TWX

ANNUAL OPERATIONS

Development of Material

Medical school and practitioners (graduates and continuing)	$125 K	
Supporting Personnel	$125 K	
4 regions x	$250 K	$1,000 K
Nursing, $15K x 4 people	$ 60 K	
Supporting personnel 1 ea.	$ 15 K	
4 regions x	$ 75 K	$ 300 K
Allied Health, 15 people x $15K x 4 schools (various specialities)		$ 900 K
CORE (Commonality Courses) Coordinators, 2 people x $15K x 4 schools		$ 120 K

Computer Time

Telepacks/line rental ($1K each for 1st 5 terminals. $360 each from 6 to 120 terminals. $300 each thereafter)	$ 130.4 K
Computer Time ($40K/month. Assumed 1 computer per 120 terminals with minimum equivalent of 1 computer)	$1,920 K

Computer Personnel

4 program/writer coordinator @ $16K	$ 64 K

16 programmers @ $12 K	$ 192 K
4 systems engineers @ $16K	$ 64 K
Evaluation costs	
1 evaluator @$25K plus $20K support x 4	$ 180 K
5 Audio-Visual personnel $15K	$ 75 K
Supplies, artwork, photography	$ 40 K
AIM-TWX (stated at maximum)	$ 225 K
	$5,210 K

BUDGET

	FY 73	74	75
Investment	131	393	786
Annual Operations and Maintenance	3420	4020	5210
	$3550 K	$4410 K	$6000 K

(3) Avialiability of Health Care

This experiment is costed over a three-year period. Table AV-8 details the total investment required to start the experiment. Table AV-9 details the operating costs per year necessary to run the experiment.

Twenty neighborhood health care stations are to be established with another 20 stations established in 5 health centers (hospitals or medical centers). Four stations are to be in each health center.

For the operational system in the future, $600M total investment is anticipated (cost per person of $15 for 50M people). The annual operating cost per person is estimated to be $20. Thus total urban operating costs are $4000M and rural operating costs are $400M (both per year) for the projected operating system.

BUDGET

	FY 73	74	75
Investment	$.60M	$.52M	-
Annual Operations and Maintenance	.25M	1.00M	$1.89M
	.85M	$1.52M	$1.89M

Each of the health service experiments mentioned can be implemented using presently existing communications systems, telephone, teletype, computer, black and white TV or picture phone, and two-way color TV. When experimental satellites are available it may be more cost effective to transmit color TV signals via satellite, however, no program depending on satellite transmission is proposed.

c. Operational Systems

(1) Description of System

Providing the trial system experiments in 2 a. (2) are successful, the operational health service programs will be identical to these experimental programs.

(2) Supporting experiments required

No supporting experiments are deemed necessary

(3) Introduction schedule

As the experimental and operational systems are identical there will be no break or introduction of new services, but merely a confirmation of these health services discussed in Section 2a.

(4) Milestones and cost:

Operational costs should be projected on the same basis as the experimental costs given in 2 a. (4).

TABLE A V-8

INVESTMENT

Health Care Stations, 20 in neighborhood plus 4 stations in each of 5 health centers (hospitals or medical centers: 40 total.

Cameras and monitors, B&W TV	40 @ $3,375	135K
Renovation and equipment	40 @ $ 2K	80K
Cable Connections, neighborhood stations to health centers		500K
Start-up Costs, development of agreements, staffing patterns, schedules, etc.		120K
Course development for personnel training		100K
Recruitment and training costs		40K
Stipends and benefits for trainees (60 for one month)		20K
Equipment and supplies for training		10K
Final Evaluation, post experiment (3 months)		50K
Development and systems engineering, physical equipment 10% of investment		60K
TOTAL INVESTMENT		$1.12M

TABLE A V-9

OPERATIONS COST PER YEAR

Wages, salaries, and benefits for neighborhood Health Stations	$500K
Professional and staff costs at centers	$1200K
Heat, light, services and supplies	40K
Evaluation costs	60K
Maintenance (10% of investment)	
Cameras and Monitors	2K
Renovation and Equipment	8K
Cable Connections (1%)	50K
Start Up Costs	29K
TOTAL OPERATIONS COST PER YEAR	$1.89M

3. PROGRAM INITIATIVES FOR CPB/PBS

a. Experiments

The Public Broadcasting Act of 1967 called upon CPB to guide and develop non-commerical educational television until a minimum program service could be provided to every citizen. It further called upon CPB to study and make use of the new technologies to provide increased cultural and educational opportunities to the public through the radio and television media. CPB contemplates a continually evolving series of user experiments on satellites to up-grade continually its ability to provide high-quality, diverse programs to increasing numbers of people. On June 14, 1971, a joint announcement was made by CPB; the Department of Health, Education and Welfare and NASA of plans for experiments to test various educational and health applications of communications satellites.

(1) Purpose of Experiments

The first experiments would use the Applications Technology Satellite (ATS)-F to explore technical, economic, and educational practicality of regular television transmissions to low-cost ground receivers in remote regions of the United States. The results would help determine specifications for large-scale, wide-band distribution services for public broadcasting.

(2) Experiment Description

Ground transmission and receiving facilities provided by CPB and DHEW will be utilized with the ATS-F satellite for broadcast transmission and reception in the ITFS band at 2500 MHz. The transmissions will be made to selected classrooms, community centers and public broadcast stations in the Rocky Mountain region and in Alaska, and to cable head ends in these areas. Transmission of program materails will be varied to assess technical quality of reception in the band, to assess the effectiveness of interaction between viewers and program materials, and to compare effectiveness of one-way video with and without computer-assisted instructions.

The next step in the experiment program would propose utilization of the Communication Technology Satellite (CTS) currently under joint development by the United States and Canada to carry out similar experiments in the newly allocated 12 GHz band. Beyond this, plans for experiments at 2500 MHz using ATS-G are expected to lead to understanding of operating procedures appropriate to multiple-channel, and perhaps multiple beam operation. Extending this series of experiments to the technologies of high power and multiple, contoured, cross-section beams anticipated for ATS-H would lead to a definition of prototype designs for operational systems. CPB's letter supporting this preparation for its multichannel and regional needs of the future is attached with permission.

Since the chief tasks of public broadcasting are educational and cutural in the broadest sense, the program material to be used in these technical experiments will also be innovative and experimental. Thus a series of experiments in programming methods, techniques, and applications will accompany the series of technical experiments.

(3) Key Milestones

Figure A V-4 shows planned launch and orbit cycles for NASA's projects experimental satellite program through 1980. The launch dates for ATS-F and G are May of 1973 and 1975, respectively, that for the CTS, December 1974 or January 1975. ATS-H and I are anticipated approximately as shown.

(4) Cost and Schedule

The primary experiment on the ATS-F satellite is a joint program by CPB and HEW. Costs will be shared between them, with the total ground equipment complex comprising about 500 receiving sites. CPB plans to provide suitable receiving environments for up to 100 sites at costs estimated to be $500/site. Video taped programming will be delivered to the earth station for regular transmission to the satellite.

The costs of this program are already absorbed in various other CPB grants for which the material was originally developed.

Neither CPB nor HEW have agreed on the details of the interactive experiments and as such, the cost and schedule details of this aspect are not defined. A gross estimate of overall experimental costs without regard to apportionment is approximately $6 million for the years 1973-74.

With regard to cost and scheduling of the experiments in (b) (2) below, support for suitable ground environments is contemplated in conjunction with HEW, CPB will supervise the delivery of programming to the proper transmitting site. Since details of the CTS and ATS-H/I satellites have not been available, costs and schedules are not included here, except as to ensure our commitment to the experiment goals.

(5) Required Communication Support Service

These are as noted above.

(b) Operational Systems

(1) Description of System

The operational system for public broadcasting services is based on a projected need for between 10 and 15 television channels simultaneously available in each time zone by 1980. As detailed in Appendix I, this enables CPB to fulfill its basic obligation of one noncommercial public broadcast channel available to the entire population in all 50 states and to support educational requirements for high-school equivalency, University of the Air, and children's channels for high-quality educational and cultural programs. This capacity may be more than the planned expansion of terrestrial facilities can accommodate. CPB foresees an operational system which makes use of a combination of cable systems, wired communities, terrestrial broadcast stations, and multiple beam satellites with contoured cross-section beams. The precise makeup of the system will depend upon the success of other experiments such as those of wired communities and the pace at which the cable systems proliferate. One system model is based on four ten-channel, multiple beam satellites interconnected with a ground complex.

(2) Supporting Experiments

As discussed in (3) (a) above, the ATS-G, CTS, and ATS-H experiments will support definition of the operating system. These results will contribute to the definition of the operating systems, regardless of the mix between satellite and terrestrial facilities in an operational system. As CPB feels its service will be operational by 1980, the ATS-H experiment is an essential step toward the definition of an operational prototype.

(3) Introduction Schedule

This will depend upon the growth of wired cities and the actual CPB requirements. To go from a single national channel in 1975 to as many as 10 by 1980 would require a rapid introduction of satellite interconnection capability to supplement the wired community complex and provide adequate networking. If ATS-H is authorized as a new start in fiscal year 1973, the introduction of an operational prototype could occur in time to meet the 1980 needs.

(4) Milestones and Costs

(a) Costing Limitations and Problems

The number of broadcast television stations used in both the terrestrial and satellite systems (365) is not a CPB goal, but rather an estimate made by the Carnegie Foundation in Public Television: a Program for Action. Terrestrial system costs are consistent with the Carnegie Foundation study. The AT and T charges for 110 points connecting 209 stations be $49M by 1975. If any more stations are added, the charges will increase to the commercial rate of $15M for the original 209 stations. The FCC required the $4.9M rate only as long as the number of stations does not increase. A proportional charge will be made for additional stations. Also, the commercial rate charges would be increased by a factor of 10 because CPB wants 15 channels. (Ten channels using buffer storage will give CPB 15 equivalent channels.) This is a lower bound because the terrestrial system is not capable of handling the 15-channel CPB load. New capability would have to be added. At a commercial rate of $15M per channel for 209 stations, AT and T may not be willing to add the capability. Costs will be given for the terrestrial and satellite systems and a comparison will be made. After the first hardware system lifetime, it is assumed that the annual budget is equal to the uniform annual cost (TABLE A V-12).

(b) Investment

The investment required to add the 156 new stations to the terrestrial system is $109 million. This does not include AT and T investment in the terrestrial transmission system. This cost enters as an operating cost per year. (See TABLE A V-12).

The investment required to add the 156 new stations and the satellite equipment at all stations for a complete satellite system is $261 million. All terrestrial links between

Table A V-10
TERRESTRIAL COSTS
(includes no programming costs)

HARDWARE		
156 Additional Stations (non-production) @ $700 K Each		$ 109. M
ANNUAL OPERATIONS		
8 Production Stations (staffing & maintenance) @ $1 M Each		8. M
357 Non-production Stations (staffing & maintenance) @ $150 K Each		53.6 M
AT&T CHARGES		
Original 110 Points	$15 M	
Added 78 Points	10.6 M	
	$25.6 M	
$25.6 M x 10 Channels		256. M
TOTAL ANNUAL OPERATIONS		$ 318. M
CAPITAL RECOVERY		
Production Stations		
8 x 0.14903 x $1 M (8%, 10-year life)		1.2 M
Non-Production Stations		
357 x 0.14903 x $.7 M (8%, 10-year life)		37.2 M
TOTAL CAPITAL RECOVERY		$ 38.4 M

MILLIONS OF DOLLARS

Year of Operation	Discount Factor 8%	Budget Annual Cost of Terrestrial System	Present Value	Budget Annual Cost of Terrestrial System	Present Value
1	.9259	$ 48 M	$ 44 M	$30 M	$ 28 M
2	.8573	95	81	43	37
3	.7938	139	110	54	43
4	.7350	179	132	46	34
5	.6806	219	149	51	35
6	.6302	251	158	66	42
7	.5835	287	167	75	44
8	.5403	323	175	67	36
9	.5002	318	159	67	34
10	.4632	318	147	67	31
			$1322 M		$364 M

The present value cost of the satellite system is $364 M. The terrestrial system present value cost is $1.7 billion. With equal benefits, the satellite system should be selected over the terrestrial system.

Table A V-11

SATELLITE SYSTEM COSTS (includes no programming costs)

HARDWARE INVESTMENTS	
156 Additional Stations (non-production) @ $700 K Each	$109. M
365 Ground Stations (10-channel receivers) @ $20 K Each	7.3 M
UPLINKS	
Transmitters at 8 Productions Stations @ $2 M Each	16. M
Transmitters at 6 Mobile Stations @ $.25 M Each	1.5 M
2 Launch Vehicles @ $13 M Each	26. M
Development & Systems Engineering (not satellite) @ $10% of Investment	16. M
2 Satellites @ $25 M	50. M
Satellite Development (no prototypes)	35. M
TOTAL INVESTMENT COSTS	$260.8 M
ANNUAL OPERATIONS	
8 Production Stations (staffing & maintenance) @ $1 M Each	8. M
357 Non-Production Stations (staffing & maintenance) @ $150 K Each	53.6 M
Staffing Uplink Ground Stations:	
1 Engineer x 5 Shifts x $40 K = $200 K	
2 Technicians x 5 Shifts x $20 = $200 K	
$400 K	
8 Uplink Ground Stations @ $400 K Each	3.2 M
Equipment Maintenance for:	
365 Ground Stations (10% of investment of $7.3 M)	.73M
8 Uplink Ground Stations and 6 Mobile Stations (10% of $17.5 M)	1.75M
TOTAL ANNUAL OPERATIONS	$ 67.28M
CAPITAL RECOVERY	
Production Stations 8 x 0.14903 x 31 M (8%, 10-year life)	1.2 M
Non-Production Stations 357 x 0.14903 x $.7 M (8%, 10-year life)	37.2 M
Receiving Ground Stations 365 x 0.14903 x $20 K (8%, 10-year life)	1.09M
Uplink Ground Stations	
8 Ground Stations 8 x 0.14903 x $2 M	2.4 M
6 Mobile Stations 6 x 0.14903 x $.25 M	.22M
Launch Vehicles 2 x 0.25046 x $13 M (8%, 5-year life)	6.51M
Systems Engineering (not satellite) 0.14903 x $16 M (8%, 10 years)	2.38M
Satellites 2 x 0.25046 x $25 M	12.5 M
Satellite Development 0.25046 x 35 M	8.77M
TOTAL CAPITAL RECOVERY	$ 72.27M

Table A V-12

CPB/PBS SATELLITE SYSTEM (operational) (in millions)

Fiscal Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Annual Recur-ring	Total
1st SYSTEM LIFE															
1. Investment															
R & D															
Hardware		30	43	54	46	37	24	19	8						
INVESTMENT TOTAL		30	43	54	46	37	24	19	8						261
2. Annual Operations & Maintenance							27	47	67	67	67	67	67	67	
3. Capital Recovery		8	20	36	48	59	66	71	73	73	73	73	73	73	
Budget (actual annual costs) (1 + 2)		30	43	54	46	37	51	66	75	67	67				
Uniform Annual Costs (2 + 3)		8	20	36	48	59	93	118	140	140	140	140	140	140	

Table A V-13

CPB TERRESTRIAL SYSTEM (in millions)

Fiscal Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Annual Recur-ring	Total
1st SYSTEM LIFE															
1. Investment															
R & D															
Hardware		8	15	20	20	20	12	9	5						
INVESTMENT TOTAL		8	15	20	20	20	12	9	5						109
2. Annual Operations & Maintenance		15	77	139	201	263	325	387	446	446	446	446	446	446	
3. Capital Recovery		3	8	15	22	29	33	36	38	38	38	38	38	38	
Budget (actual annual costs) (1 + 2)		23	92	159	221	283	337	396	451	446	446				
Uniform Annual Costs (2 + 3)		18	85	154	223	312	370	432	484	484	484	484	484	484	

the 365 stations are completely eliminated. (See TABLE A V-11).

(c) Operations

The operations and maintenance cost per year for this terrestrial system is estimated to be a minimum of $318 million. The satellite system operations and maintenance cost per year is estimated to be $67 million. No terrestrial link will be required. The satellite broadcasts directly to the station which broadcasts to the home.

(d) Trade-Off and Budget

Fifteen channel capability for either system can be done for the cost of 10 channels if buffer storage is used. See Section III B.1.c.(2) for an explanation of how this was done for the National Communication System Including Satellites. This was also done in Section III A.3.b. for the Terrestrial National Communication System.

In order to make a comparison between the two systems, the budget annual costs must be used. Since these benefits are identical for both systems it is not necessary to use incremental benefit-cost ratios for the CPB/PBS comparison, but rather to select this system with lowest total present value cost. The discount factor used is 8%. The budget annual costs are taken from Table A V-12 and Table A V-13. The analysis is made in Table A V-10. The result is 364M. for satellite system and 1322M for terrestrial system.

Note

Programming Costs for CPB/PBS

An estimate of programming costs was obtained from CPB. For FY 72, $400K has been budgeted for the High School Equivalency programming. $1.5 million will be the minimum programming budget for FY 73.

The University of the Air will broadcast live classes from universities participating in the program. Thus there will be no programming costs for University of the Air.

CPB is in the preliminary research phase of Adult Learning. They are attempting to determine materials, content and program length. There will be one project ready to offer to the public over PBS in September of 1973, called Reading

Corporation for Public Broadcasting

888 16th Street, N.W., Washington, D.C. 20006, Phone: 202-293-6160

July 12, 1971

Dr. Richard B. Marsten
Director, Communications Programs
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Dr. Marsten:

The Corporation for Public Broadcasting is now preparing in conjunction with the Department of Health, Education and Welfare detailed experiment plans for the ATS-F experiment at 2500 MHz.

At earlier meetings in your office I mentioned the Corporation's interest in pursuing the use of communication satellites beyond the ATS-F experiment stage. Our hope is, one day, to be able to deliver many different television services to numerous separate and distinct areas of the United States. One such service is public instructional broadcasting to school systems in rural areas; another is specialized services to migrant workers.

In order to accomplish these objectives, we would require satellites which are considerably advanced from a technology standpoint beyond the ATS-F configuration, especially since multiple-channel coverage for specific geographical regions will be needed. In particular, CPB envisions spacecraft with multiple high-gain beams, each of which can be shaped to conform rather precisely to sub-satellite areas of concern. In addition, space segment transmitter power should begin to approach the levels of a kilowatt or more at our present frequencies of interest, 2500 MHz and 12 GHz.

In your planning for the advanced ATS series, we would hope NASA would give consideration to these interests of CPB.

Rec'd Communications Programs
Date 7/13/71
Time 4:00
Distr
Suspense 7/28/71

Sincerely,

Philip A. Rubin

Philip A. Rubin
Director, Engineering,
Research and Development

1345 Avenue of the Americas, New York, New York 10019, Phone: 212-582-2020

Mathematics in a Contemporary Context. The program will be broadcast three (3) times per week for 13 to 20 weeks. The costs for programming are 15 to 20 thousand dollars per unit. The unit is not fixed but may vary in length from 20 minutes to an hours.

4. PROGRAM INITIATIVES FOR LAW ENFORCEMENT

a. Experiments

The forwarding of fingerprints to the FBI and the exchange of criminal information between the National Crime Information Center in Washington and remotely located FBI centers and law-enforcement agencies is an existing capability and does not require experimentation.

b. Operational Systems

System for Exchange of Information on Criminal Events

(1) Description of System

Two types of requests for information are received and answered by the FBI in Washington, D.C.: (1) Fingerprints received for file and identification. The FBI response indicates that the individual either has no criminal record on file or the criminal record is forwarded via the NCIC dedicated lines. (2) Data is passed via dedicated communication lines between the National Crime Information Center computer and remote terminals located in 50 states and Ottawa, Canada. It consists of queries concerning wanted persons, stolen property, and criminal events from the states, and answers from NCIC drawn from the data file. Users may also update file items which they have entered into the file.

It is expected that in the future state law-enforcement centers will begin participation in the computerized offenders' criminal records program which will relieve the FBI of some of the fingerprint identification and record keeping burden.

Fingerprints are received daily, largely by mail. About 35 per month are received via a facsimile system. Fingerprints would continue to be forwarded to NCIC via U.S. mail by using the new Electronic Mail Handling Service described in Section V of this appendix.

A high-priority option would be used to ensure immediate forwarding. Within minutes the data arrives in Washington, and is converted on U.S. Post Office machines. These are located at the FBI building because of the high volume. About 10,000 prints per day related to criminal activity are expected after the state centers take some of the burden. These prints require identification and are processed. Responses are transmitted to the requestor via the NCIC data channel.

When crime data is requested by an FBI regional office or state law-enforcement center, it will be forwarded and answered over a dedicated channel due to the confidential nature of the data. The request is made on teletype terminals from approximately 75 locations. For realibility, at least two channels are available from each location. The juxtaposition of the FBI centers and the State centers results in a requirement for one hundred thirty-five 2400-baud (bits per second) lines, and sixty 150-baud lines.

The NCIC data request, if originating on a 2400-baud terminal, passes over lines to the nearest post office, where it is transmitted to the communications system using a time or frequency division multiplexed channel located adjacent to that of the post office. The FBI channels will fit within the postal system requirement. Sharing of the spacecraft interface with the post office avoids duplicate costs for the ground station of $200,000 each. The 150-baud lines are assumed to be terrestrial, although a more detailed study may show cost savings via satellite.

NCIC data requests from many law-enforcement centers may be delivered simultaneously to the FBI building and the NCIC computer via the post office ground station at Washington, D.C. to the FBI building via a communication line of 240 KHz band-width.

Replies from the NCIC are available in about 10 seconds and are returned via the same telecommunications link.

(2) Supporting Experiments required - none.

(3) Introduction Schedule - The schedule will coincide with and be determined by the EMH introduction schedule.

(4) Milestones and Cost

(a) Introduction

The cost estimates of the improved communications system for Law Enforcement functions included those for new investment and operations of the system with principle regard to acceleration of the FBI's fingerprint identification service.

(b) Investment Cost

Enhancement of the capability of law enforcement communications is based upon use of the Electronic Mail Handling (EMH) System proposed for the Postal Service. The EMH and the law enforcement communications network will come together in 75 major cities. Interconnection at these 75 common points will consist of 2400 bit per second terrestrial links, resulting in replacement of 150 terrestrial links for the law enforcement communications network. The above duplication of the links is planned to increase the reliability of the service. Provisions of the necessary RF modulation and demodulation equipment is estimated to cost 1.9 million dollars. No other investment is anticipated.

(c) Operations Cost

Since the proposed communications network for law enforcement consists of both new and old sections, the estimates of operations total costs must cover both segments. The esti mates of annual costs are displayed in the following sections. Additional staff is not required.

LAW ENCORCEMENT COMMUNICATIONS NETWORK COSTS

Hardware

Replacement of 150 terrestrial links	$ 1900K

Annual Operations (no change in manpower from present system)

Rental by FBI	
Existing terrestrial links	
60 150-BPS lines	290K
Existing terrestrial link modems	
60 150-BPS units	70K
Replacement terrestrial links*	
150 2400-BPS lines	10K
Replacement terrestrial link modems*	
150 2400-BPS units	540K

*These coupled with satellite links, would replace 150 existing terrestrial duplex links.

Rental from Post Office

New Satellite link connection	10K
Maintenance of RF modulation/demodulation	190K
TOTAL ANNUAL OPERATIONS	$1110K

Capital Recovery

RF modulation/demodulation equipment 8%, 10 year of life)	$ 283K

Budgeting

To accomplish the objectives of the proposed system that would replace the existing operating law enforcement communications network, the schedule of expenditures is given below. The projected annual cost of the old system must be bourne until the new system is operational.

LAW ENFORCEMENT COMMUNICATIONS NETWORK
(in thousands)

Fiscal Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1982	1983	1983	1984	Annual Total Recurring
1. Investment														
R&D														
Hardware			144	270	348	355	352	205	158	68				
INVESTMENT TOTAL			144	270	348	355	352	205	158	68				
2. Annual Operations and Maintenance														
Old Network	1455	1650	1650	1650	1650	1650	1435	957	479					
New Network							133	455	777	1110	1110	1110	1110	
TOTAL	1455	1650	1650	1650	1650	1650	1568	1412	1256	1110	1110	1110	1110	
3. Capital Recovery				21	62	113	166	219	249	273	283	283	283	283
Actual Annual Costs (1 + 2)	1455	1650	1794	1920	1998	2005	1920	1617	1414	1178	1110	1110	1110	1110
Uniform Annual Costs (2 + 3)	1455	1650	1671	1712	1763	1816	1787	1661	1529	1393	1393	1393	1393	1393

Trade-Off Present System vs. Proposed System

The trade-off is a comparison between continued use of the old system and implementation of the propceed system. In the long-run the annual operating cost of this old system is estimated to be $1650K, whereas the new system's operations costs are estimated to be $1110K annually. Since the investment for the old system is not known, it is impossible to use conventional methods of comparison. The technique used here will be to ignore the capital recovery cost for the old system and simply compare the operations cost of the old system with the operations cost plus capital recovery cost for the proposed new system. In effect, it is assumed that the $1650K annual cost of the old system includes capital recovery. The present value of the costs from FY 1972 to 1984 is presented below.

1 Year of Operation	2 Discount Factor 8%	3 Uniform Annual Cost (old)	4 Present Value	5 Uniform Annual Cost (new)	6 Present Value	6-4 Combination Value
1972	.9259	1455	1347	1455	1347	0
1973	.8573	1650	1415	1650	1415	0
1974	.7938	1650	1310	1671	1326	16
1975	.7350	1650	1213	1712	1258	45
1976	.6806	1650	1123	1763	1200	77
1977	.6302	1650	1040	1816	1144	177
1978	.5835	1650	963	1787	1043	80
1979	.5403	1650	891	1661	897	6
1980	.5002	1650	825	1529	765	-60
1981	.4632	1650	764	1393	645	-119

From this data it is apparent that the new system is more costly from FY 1974 until FY 1980 at which time the new system becomes the most economically advantageous and remains so thereafter.

The system is a pair of color TV channels origination in Washington, D.C., and distributed nationwide. Anticipated utilization is insufficient to justify building a system solely for this use. Therefore, the service will make use of systems designed for public broadcast service.

5. PROGRAM INITIATIVES FOR POSTAL SERVICE

a. Experiments

(1) Purpose of Experiment

The purpose of the Electronic Mail Handling (EMH) experiment program is to evaluate subsystems concepts, gain operational experience, and provide a performance information bank from which the operational equipment design specifications can be formulated.

(2) Experiment Description

An experimental EMH station will be established to open an evaluation program. After the EMH system becomes a reality, state-of-the-art equipment technology will be evaluated to enhance the efficiency of the operational system. The station will be divided into four major subsystem areas:

- ° Input conversion
- ° Data processing and storage
- ° Data transmission
- ° Output conversion

Initial testing will be directed to each major subsystem and will be effected through simulation modeling, actual equipment interfacing. Overall system tests will be conducted when feasible and early point-to-point demonstration will be performed to gather data on loading factors, based on user acceptance and the progress of system development. The various series of tests that will be performed are outlined below:

(a) Input Conversion Subsystem

- ° Scanning rates
- ° Paper handling problems
- ° Rejection and thru-put data rates
- ° Resolution and data compression performance
- ° Multifont reading capability

(b) Data Processing and Storage Subsystem

- ° Input and output conversion control and monitor functions
- ° Storage and sorting stage techniques
- ° Error and reject rates

(c) Data Transmission Subsystem

- ° Determination of acceptable transmission links error per rates
- ° Refinement of station-to-station transmission requirements

(d) Output Conversion Subsystem

- ° Acceptable thru-put rates
- ° Paper-handling techniques
- ° Sorting, storage and delivery techniques
- ° Output device noise levels

(e) System Tests

- ° System loading factors
- ° Multiple store-to-store transfers
- ° Overall system capacities
- ° Overall error and reject rates

(f) Module-to-Module Test

A point-to-point demonstration test over a combination of land lines plus satellites will be conducted between two EMH modules to determine the degree of user acceptance and measure progress within the evolving system. The data gathered will be used to refine the operational system loading design specifications and determine system weaknesses and requirements for further testing.

(3) Key Milestones

The key milestones are contained in (4) Cost and Schedule. The point-to-point demonstration can take place 30 weeks after program initiation.

(4) Cost and Schedule

Leased equipment will be used wherever possible to reduce initial capital outlay and improve delivery schedules.

Subsystem	$K/Month Lease Cost	Cost ($K) Total
Test Equipment		100.0
Input Conversion	2	43.2
Data Processing	15	324.0
Transmission	1.4	30.2
Output Conversion	3	64.9
EMH Module	5	10.0

The projected schedule is as follows:

	Equipment Delivery	(at start)
PHASE I	Integration & Checkout	(start - 15 weeks)
PHASE II	Point-to-Point Test	(15 - 41 weeks)
PHASE III	(41 - 93 weeks)	

(5) Required Communications Services Support

All tests, except the point-to-point demonstration tests, are conducted in the EMH experimental station and require no external communications support. However, the point-to-point demonstration test will require communication support. A cross-country loading data base would be useful and would be obtained with a communications hook-up between the East and West Coast EMH modules. One effective low-cost method would be to interface the East Coast module into the Goddard Space Flight Center by land communications, then via the ATS satellite to the Mojave Tracking Station (California), and from Mojave to the West Coast module by land communications.

Facility costs are not considered in that the experimental equipment would be placed in available space in existing postal facilities. Manning requirements are listed below:

SUBSYSTEM	NO. of MO.	NO. of PERSONNEL	GS GRADE
Test Equipment	22	2	9,11
Input Conversion	22	2	7,9
Data Processing	22	1	9
Transmission	22	1	11
Output	22	2	7,9
EMH Module	2	2	9,12
Test Director	22	1	13

Average Yearly Salary Cost	109.7 K
Multiplier of 1.6 to Represent Cost	175 K
Installation Cost and Debugging	100 K
Capital Cost Recovery	14.9 K
Yearly Lease Cost	257.6 K
Total Annual Operating Costs	497.5 K

b. Operational Systems

(1) Description of System

A systems concept which will provide the services required for the postal system is discussed in this section. The approach to technical studies has been highly conservative. Since all of the technology required for the described system presently exists in operational or demonstrable prototype form, no major technological breakthroughs are required for this system to be feasible. Cost data are conservative; in each case the price used reflects a cost at which the item is presently available in small lots. The types of equipment required for this system are in a field where new developments are presently increasing the ability and decreasing the cost of the individual components very rapidly. No allowance has been made for either technological improvements or cost reductions.

The system described is capable of processing one hundred million letters a day. This adds up to a volume of thirty billion pieces a year assuming full usage for three hundred days each year. Letters in computer-generated form on magnetic tapes will be accepted, and all physical handling of input letters will be mechanized so that the original letter contents cannot be compromised while being converted for transmission. All materials will be delivered in sealed letter form. Thus the letter will never exist in a form in which it can be read during the time it is in the Post Office. The sanctity of the mail will thereby be preserved.

The system is sized assuming that 70% of the mail will be originated by business users in computer output form. It further assumes that 20% of the mail will be in printed form which can be read by optical character readers. The final 10% of the mail will be handled by full scanning by a system capable of transmitting handwritten documents and graphics with better resolution than present commercial TV. (At present 11% of the total mail volume is personal, with 6% of the 11% being Christmas cards).

Hardcopy letters which are to be transmitted via the Electronic Mail Handling system will be submitted at an EMH served Post Office by the originator. The letter will be submitted in flat open form with the destination ZIP code added in a fixed location. The letter will be inserted by the originator into a maching handling cartridge and will not be handled in open form by any Postal Service employee. Digital data messages will be submitted on magnetic tape reels. High volume users may elect to obtain a direct connection to transfer data via common carrier to Postal Service storage rather than submit tapes.

Hardcopy letters are then processed by optical character readers or graphical scanners in accordance with the patron's desires and converted to a form suitable for electronic storage which will provide inventory control which will minimize lost messages. The message will then be transmitted from an antenna on the postal station to a spacecraft located in a stationary orbit over the United States. The spacecraft will retransmit the message to a receiver in the destination post office. The data is then sorted and automatically printed out in the order the carrier delivers it.

The initial Electronic Mail Handling system will interconnect the 125 largest mail originating locations. One station may serve several closely located cities and thus this system will actually interconnect approximately 180 cities. (A list of the interconnected cities is given in

Appendix I.E. 2.). Several of the cities (e.g. New York, Chicago, etc.) will have a higher daily volume than a single processing unit can handle and thus approximately 160 modules will be required to service the 125 locations.

The estimated EMH load of 30 billion pieces annually by 1981 is predicted upon letter volumes entered in today's postal system by governmental agencies and private businesses. These types of organizations are expected to find the benefits of EMH service appealing and therefore contribute significantly to increased service demand. A growth factor has been applied to projected historical letter volumes to the year 1981 resulting in the values shown in the table below:

Estimated 1981 Standard Letter Mail Volume*

(in billions of pieces)

FROM	TO	
Business	Business	17.87
Government	Business	1.24
Business	Individual Household	32.35
Government	Individual Household	2.65
Business	Government	.83
Government	Government	.41

*Standard size implies length limitations of 5.5 inches to 9.75 inches and width limitations of 3.5 inches to 4.75 inches.

Table values are based upon values entered in table 3.1 of the Kappel Report and were computed under the assumption that approximately 60% of all 1981 letter mail volume would be standard letter size pieces. Recent data indicates that more than 55% of all business mail is generated by large volume mailers who have access to data processing facilities or could benefit from supplying address lists and corresponding letter content to an EMH center. Following a similar line of reasoning, governmental agencies, almost without exception, utilize computer capabilities and may enter as a minimum 80% of their 1981 standard letter size volume to the EMH. Projected system demands of business and governmental volumes indicate that a minimum of 31.5 or approximately 30 billion pieces annually will be available for EMH processing in 1981.

(2) Technical Details

The system described is based on the following assumptions:

a. Peak load capacity of 108 pieces of mail a day.

b. Mail form as follows:
   - 70% character data on digital tapes
   - 20% non-graphic data entirely in OCR recognizable type or print fonts
   - 10% requiring full graphic reproduction

c. All electronic mail to conform to certain minimum format requirements for addressing (primarily mandatory ZIP code)

d. Main traffic load to be routine mail (delivery to station by 5 a.m. adequate) with only a small portion being priority (one hour or less) mail.

A piece of electronic mail for the purpose of this report is defined as one page. A page of electronic mail is defined as 50 lines with 75 characters per line (3750 characters), and, with 8 bits/character, to have 3×10^4 bits per piece if it is in character form. A piece of graphic material is scanned to have 200 lines per inch resolution, and to be 5 inches wide and 8 inches long with 1000 bits per line. Thus a piece of scanned material contains $200 \times 8 \times 1000 = 1.6\ 10^6$ bits. However, data compression of approximately three to one is assumed to reduce this to 500,000 bits per scanned piece.

The average number of bits per piece is thus 7.7×10^4 bits per piece.

A standard postal processing work day of 12 hours (5 a.m. to 5 p.m.) was taken as the time period in which the entire electronic mail volume must be moved. Thus 10^8 pieces of mail per day must move in $12 \times 3600 = 43{,}200$ seconds. This corresponds to a bit rate of 180×10^6 bits per second.

Detailed description of the systems concept discussed in this report is arranged in the following order: input, telemetry link, output, computer and data storage. A block diagram is shown in Figure A V-5.

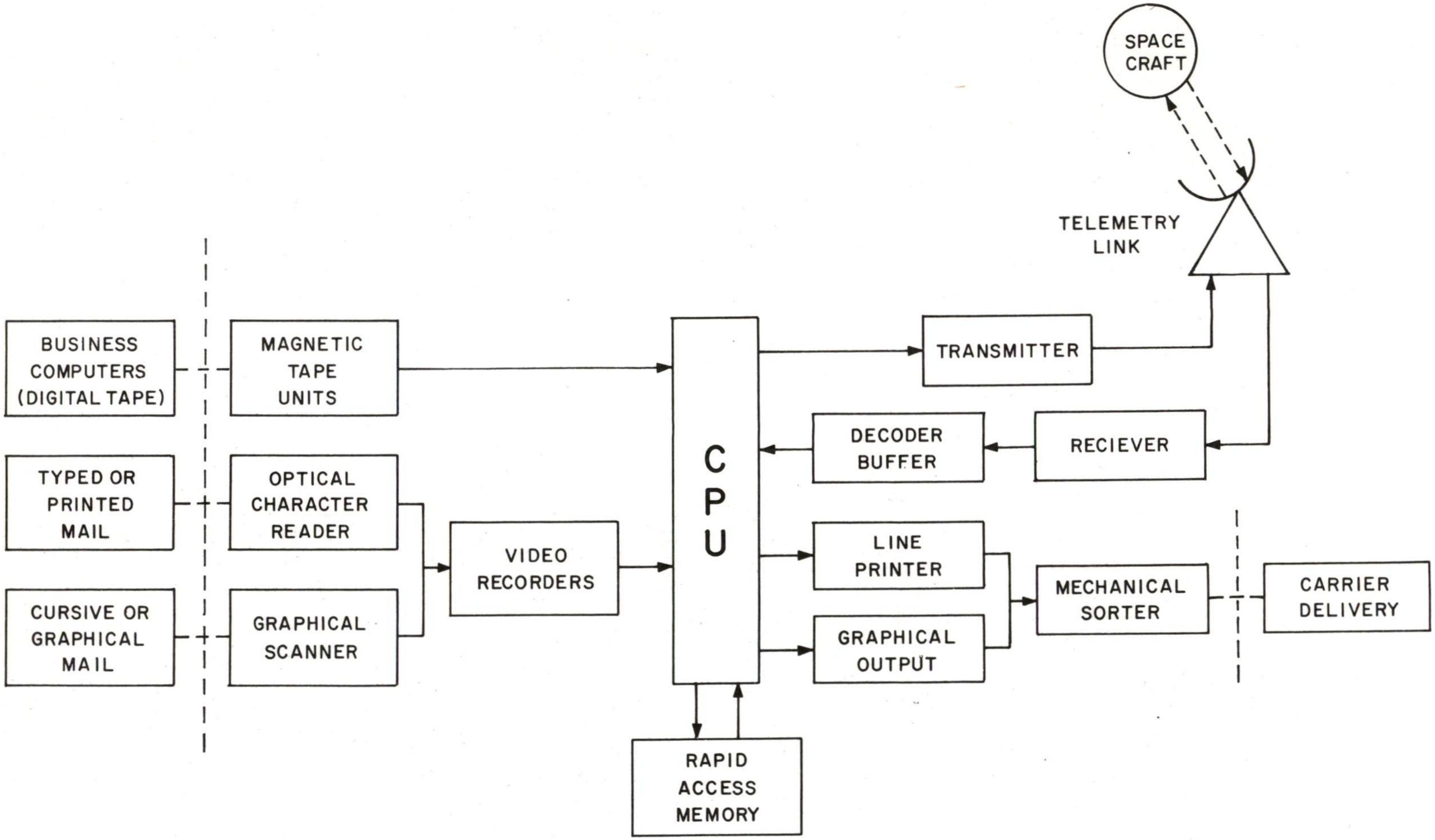


Figure A V-5 Block Diagram for Electronic Mail Handling

There will be 70% of 10^8 or 7×10^7 pieces of mail inputted on magnetic tape each day. With 3×10^4 bits per piece this amounts to 2.1×10^{12} bits per day on tape. Magnetic tape units with a 3×10^5 bits per second rate and a 45% duty cycle (to allow for mounting, demounting, tape spacing, etc.) can handle 6×10^9 bits per day per tape unit. Thus 350 magnetic tape units will be sufficient to handle the incoming digital tapes. These units will be apportioned to the originating stations according to station usage. Magnetic tape units with the required capability are available at approximately $20,000 each.

Twenty percent of the pieces will be put into the system through optical character readers which will take the original letter in its machine handleable container, convert it to electronic form, return the original to the submitter and forward the electronic message to a data storage device. There will be 2×10^7 pieces per day of character mail. One optical character reader can convert one full page per second. Thus (2×10^7 pieces per day)/(4.32×10^4 pieces per day/OCR) = approximately 460 optical character readers.

(The cost estimate for an OCR which can read 34 commercial type fonts is $200,000 per unit.)

There is a third category of mail which must be scanned and sent in facsimile form. A scanner capable of converting one page every six seconds was assumed. Thus approximately 1400 input scanners are required to process the anticipated 10% of mail which will be scanned. A device capable of scanning and transmitting a page every six seconds is currently being demonstrated. The scanner will generate 1.6×10^6 bits of information per piece and a data compression device is required which will reduce this by a factor of approximately 3.1 giving 5×10^5 bits per piece on the average scanned piece. In addition, the originator of the letter will be required to imprint the ZIP code so that the data can be handled and sorted by the automated system. The price estimate for the scanner, data compressor and minimal optical numerical character reader head using the logic in the full OCR device is $25,000.

Letters will be submitted for conversion to electronic form throughout the day. It is necessary to store the converted data until it is convenient to transmit it. Thus both the optical character reader output and the scanner output will be stored on a video tape storage device. This capability will be required at each ground station. A single video tape unit has both the storage capacity and the data transfer rate to process the entire data stream generated by a single station. However, it will be necessary to provide two video tape units for each station to satisfy operational requirements. Thus there will be a total of 320 video tape units. (Video tape units with a total storage capacity of 90×10^9 bits and a data transfer rate of 8×10^6 bits per second are currently available for $50,000 each.)

When the time to begin data transmission arrives, data will be read from the magnetic and video tape units by the central processing unit (CPU). The CPU will attach inventory control and message format information and block the data onto drum storage by destination. The CPU will then generate a transmission channel request and upon approval will forward the data to the transmitter.

Telemetry Link

Upon receipt of a transmission request from the CPU, a channel destination request is sent to the satellite by the transmitter. Each of the 160 ground receiving stations has limited input data rate. If the channel destination request made to the satellite would overload the destination ground station, the requesting station will receive a "no channel available" pulse, which is transferred back to the CPU. The CPU then calls up the next message with a different destination code, and places it on line to the transmitter. The transmitter queries the satellite again. Upon approval of the channel destination request by the satellite, a message transfer request is made to the CPU. The CPU then outputs the message to the transmitter where it is modulated and transmitted on the assigned channel to the satellite. The satellite receives the message, amplifies it and retransmits it to all ground stations. The message is demodulated and transferred to a decoder buffer. When the decoder recognizes the destination code on the front of the message, it outputs the message to a buffer for transfer to the CPU. The buffer generates a message on line request to the CPU and transfers the data to the CPU upon receipt of the transfer request. The CPU then verifies the message and if correct sends a message acceptance pulse to the originating station. If the originating station does not receive a message acceptance pulse within a predetermined time, it will retransmit the message. When the CPU at the originating station receives the message acceptance pulse, it drops the message from storage and updates the message delivered file.

The satellite channel assignment system concept is based on the COMSAT*SPADE System (S ingle Channel Per Carrier P CM Multiple A ccess D emand Assignment E quipment).

Output

Mail in the form of binary data will be accepted from the telemetry receiver into the central processing unit. The address of all character mail will be compared with a stored table to determine which individual carrier route it is destined for. Graphical input mail and character mail which does not have a machine recognizable address will be stored in an appropriate zone of the mass data storage device. A message received code will be generated for transmittal to the originating station to permit it to clear the message from its mass storage device.

Once an hour or at a predetermined volume level the data will be picked from the mass storage device, sorted again to put it in the order in which the postman delivers it on his route, and routed to an output device. Character data will be printed on a line printer at a rate of 6000 lines per minute. The printer will add a transport code on the outside of the batch to assist the final mechanical merge process described below. (Line printers with an 8000 line per minute rate are available at $100,000 each. In this report the printer was derated to approxiamtely 6000 lines per minute to compensate for various forms of operational overhead.)

Each day, 9×10^7 pieces of character data mail, each containing 50 lines or 450×10^7 total lines must be printed. Each line printer can output approximately 450×10^4 lines per day. Thus, 1000 line printers are required.

The scanned material will all be printed on graphical image producers with one required for each scanner input device; thus a total of 1400 are needed.

Hardcopy letters sorted into carrier routes and sequenced for carrier delivery will be printed once an hour from 5 p.m. to 5 a.m. They will then be handled by a mechanical conveyor and collating system which will combine the 12 hourly packets using the escort code to provide a single completely sorted package of electronic mail for each carrier.

Computer and Data Storage

The computer processing unit (CPU) and rapid access memory (RAM) systems are used for both input and output. The CPU will call data off the magnetic and video tape units, examine the ZIP code to determine the destination stage and read the data into a Random Access Memory (RAM) sorted by destination. When a suitable data block has been assembled for a given destination (2.5 seconds gives 90% use of the channel when the 0.25 second channel request/approval delay time is considered, the CPU generates a request for a channel to the telemetry link. When the channel request is approved, the CPU reads the messages from the RAM, sorted by destination. The CPU will add inventory control information to each message and the message will remain in storage until a "message received" signal is returned from the destination stage. The 160 total stations will be allocated to the 125 largest postal user cities such that there is nearly even load distribution. Estimating delay times to get a channel into any given city, to obtain an adequate transmission block length, or to obtain a message received signal is a queueing problem. However, in this systems concept a storage capacity to hold 20 minutes of the total data which can flow through a single station was included in lieu of a specific queueing problem solution. The same memory system is used to store one hour of output data before it is printed. Thus there is a requirement to store 4/3 of an hours worth of data or $4/3 \times 1/12 \times 10^8 \times 7.7 \times 10^4$ bits or 8.5×10^{11} bits. Drum memories with transfer rates of 6.4×10^6 bits per second and total capacities of 3.2×10^9 bits exist and cost approximately $150,000 each. Approximately 270 drums will be required.

The primary CPU function is to act as an input/output controller. There is also a sorting requirement. The entire process, with the possible exception of carrier route sequencing, can be performed in a single computer such as a PDP-11 with storage capacity for 64,000 sixteen bit words. Provision for complete backup, administrative control, and program growth are obtained by providing two CPU's at each ground station.

(c) Minimum EMH Population Center

Summary

A preliminary cost analysis study was performed on an EMH station to determine the minimum sized EMH population center which could economically support the EMH type service. Based on the information which follows, the minimum population center is approximately 14,000 people. The analysis assumes a transmit/receive terminal is present for some other user and can be shared at no cost.

Minimum EMH Station Cost

The minimum hardware configuration must be capable of performing the following functions:

1. Convert Input
2. Process input and output to a transmission terminal
3. Accept data from the transmission terminal and process for output
4. Convert output

A configuration which satisfies the above requirements is shown in Figure A V-6.

In developing the station yearly costs, the following criteria were used:

1. The transmission terminal exists.

2. All equipment will be leased with maintenance included in the lease charge.

3. The building facility exists and building maintenance costs will not increase.

4. The carrier will collate his own mail.

The yearly equipment cost is shown below by equipment category:

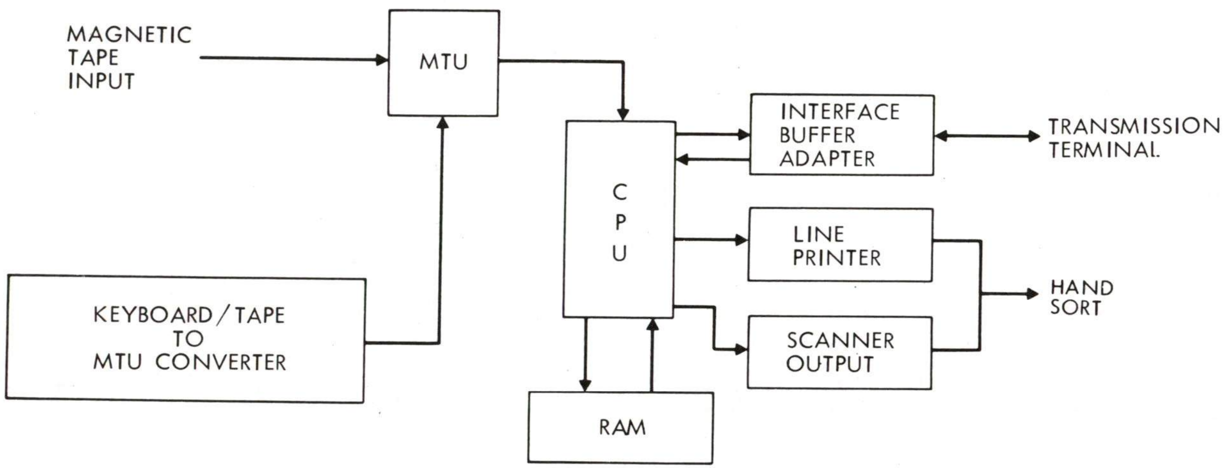

MAGNETIC TAPE INPUT
MTU
KEYBOARD / TAPE TO MTU CONVERTER
C P U
INTERFACE BUFFER ADAPTER
TRANSMISSION TERMINAL
LINE PRINTER
SCANNER OUTPUT
HAND SORT
RAM

Figure AV - 6

Equipment	Capability	Lease/Yr.	Fixed
	32 K Memory		
CPU	(16 bit words)	$ 7,200	
RAM	120×10^6 bit storage	10,500	
Input	Typing rate	2,500	
MTU conversion	Tape rate		
Output scanner	10 pages/min.	6,600	
	120 Kbps transfer rate	6,000	
Line printer	20 pages/min.	7,200	
Buffer adaptor			$5,000
Total		$40,000	$5,000

The yearly labor cost is based on a twelve-hour day, three hundred day per year schedule. This requires a two and one-half shift operation of two operations per shift. The cost per man-year is estimated to be $12,000 per man year.

The total cost per station per year is:

	1st year	2nd and subsequent years
Equipment	$45,000	$40,000
Labor	$60,000	$60,000
Total	$105,000	$100,000

Population Size

In order to determine the EMH mail volume necessary to produce a break point, it is assumed that each piece of mail received at the EMH system produces five cents of savings over the present system. The size of the population center is 7,000 divided by the pieces received per day per person. If each individual receives 1/2 piece per day, the total population is 14,000. The station equipment must have the capability to receive 9.7 pieces of EMH mail per minute. The equipment was sized at approximately twice this required capacity.

The principal cost factor in the EMH station is labor. Eight hundred (800) pieces per day are required to offset each man year ($12K). Using the 1/2 piece per day per person assumption, 8,000 of the population of 14,000 are required to offset labor costs alone. If the station is fully automated and requires no additional operations personnel, a 6,000 population center could thus support an EMH station.

(2) Supporting Experiments Required

The experiments program (V.C-5-a) will be used to define the operational system requirements, and no supporting experiments *per se* are required. When two stations are operational and the spacecraft is in position (See Figure A V-7, introduction schedule, milestone 6), operations tests will be performed to verify experimental data (i.e., station load limits, acceptable transmission error rates, reject rates, etc.) and to gain operational experience prior to implementing EMH service in the next 23 cities. Similar data will be collected once 25 cities are operational and prior to going to full 125 location system.

(3) Introduction Schedule for Postal Service

Figure A V-7 shows the schedule required to develop a fully operational EMH service for 125 locations by 1982. The milestones on the schedule are as follows:

(a) The funding for the experiments program is approved and the experiments project is manned.

(b) The East-West Coast EMH demonstration takes place.

(c) The operational EMH program is approved and funded.

(d) The final specifications for the operational system are approved.

(e) The first operational EMH station is installed and tested.

(f) The second EMH station is operational, and operational tests begin.

(g) EMH service is started between 2-4 cities.

(h) EMH service is available between 25 major cities.

(i) The EMH system is fully operational between 125 cities.

(4) Milestones and Cost

Costing Limitations and Problems

The costs generated in this section are based on processing 30 billion letters per year with the EMH system out of 75 billion first class letter mail expected in 1981. These costs are concerned with those postal functions between the acceptance point at the originating office, and the initiation of the delivery function at the destination office. Although the detailed conceptual design of the EMH system is being developed, certain factors limit the quality of the cost estimates. Unit costs of some types of equipment, such as optical character readers, cannot be precisely estimated. While no new technology is required to implement an EMH system, there is insufficient experience available in some areas to develop complete confidence in unit-cost estimates when the units are required in large quantities. The quality of the cost estimate is also affected by the possibility that C-band communication links between the satellites and the ground stations may not be available. If K-bands are substituted for C-bands links, both investment and operating costs will be higher. However, the cost of added conventional facilities necessary to accommodate the growth in mail volume are estimated to be at least as great as the cost of ground station facilities required for the EMH system.

Investment

To accommodate the growth in postal services required by 1981, it is anticipated that investment in EMH equipment will total about $700M. This investment is broken down by broad categories in Table A V-14.

Operations

Yearly operating costs are estimated in Table A V-15. They assume availability for lease of six 50 MHz transponders at $750K per year each on commercial satellites. The cost per 1000 letters, exclusive of delivery, is $12.12, which is better than the $55.00-per-1000 letter cost of presently deployed mechanical systems. An adjustment factor of .80, based on numerous studies of the best contemporary mechanical system components, reduces expected costs to $44.00 per 1000 letters. The difference of $31.88 per 1000 letters indicates a minimal annual savings of about $1 billion. These savings if realized will enable the postal service to make a large step toward its goal of being financially self-supporting by 1977.

Budgeting

To accomplish the operating system's objectives, including the necessary experimentation, will require funding levels approximately as follows (in 1972 non-discounted dollars):

Investment	FY 73	74	75	76	77	To Completion	Total
	43.1	20.4	20.4	20.4	20.4	565.3	$690M
Ground Systems Operations 1)			7.7	10.8	45		
Total	43.1	20.4	28.1	31.2	49.0		

(1) Assumes an 18 percent level of operation by end of 1977.

(2) Annual total system operating cost is $364M.

The annual cost associated with satellite transmission includes the capital costs of the transmitter-receiver equipment associated with the total of ground complexes and satellite leasing costs. These amount to $11.6M per year. This is currently accepted as the point-to-point transmission of EMH volume. Any other alternative must be economically competitive and hence have annual costs no greater than $11.6M. This is derived by multiplying $48M (see Table A IV-14) by 0.1493 and adding $4.5M (see Table A V-15).

*

Table A V-14
GROUND SYSTEM COST

GROUND SYSTEM	NUMBER REQUIRED	ESTIMATED COST (M$)
MAIL INPUT:		
TAPE DRIVES AT 20K$	525	10.5
OPTICAL CHARACTER READERS AT 200K$	690	138
SCANNER, COMPRESSOR, BUFFER AT 25K$	2160	54
VIDEO SYSTEM (STORAGE) AT 50K$	480	24
TRANSMITTER INPUT (TRANS. BUFFER DRUM) (INCLUDED AS "STORAGE" IN MAIL OUTPUT)	0	0
TRANSMITTER/RECEIVER: TRANSMITTER, ANTENNA, RECEIVER AT 384	125	48
MAIL OUTPUT:		
COMPUTERS AT 50K$	480	24
STORAGE AT 50K$	405	60.75
VIDEO AT 50K$	480	24
LINE PRINTERS AT 100K$	1500	150
REPRODUCTION (XEROGRAPHY AT 20K$	2100	42
MAIL PACKET CONVEYOR/SORTER AT 300 K$	240	72
TOTAL GROUND SYSTEM COST		647.25M
DEVELOPMENT AND SYSTEMS ENGINEERING (6-2/3% of total ground system cost)		43.15M
TOTAL		690.4M
*50% ADDITIONAL UNITS ALLOWED FOR SPARES AND PEAK OPERATIONS		

6. PROGRAM INITIATIVES FOR DISASTER WARNING

a. Experiments

(1) Purpose of Experiment

The inauguration of a National disaster warning communications system necessitates the solution of a number of system, technical and operational problems which point to the need for conducting system-sharing trade off studies leading to a pilot or experimental phase of system operation prior to finalization of an operational system. This experiment will be conducted on a limited time/area basis, and will address the following specific points:

(a) Demonstrate each of the elements of operational system to assure the integrity of the system design and obtain data on system performance, effectiveness, resistance to unintentional jamming, survivability, etc.

(b) Evaluate system interaction with and acceptance by the user public, including individuals, local public safety and law enforcement entities, commercial organizations, and local and state Government.

(c) Develop data based on propagation phenomena peculiar to a satellite disaster warning system for use in sizing power requirements and signal design for the operational system. Topics to be studied include margin requirements imposed by signal reception in the severe man-made noise environment encountered in urban areas, attenuation of satellite signals by reception inside buildings, and signal distortion produced by multipath reflections in congested reception areas.

(2) Experiment Description

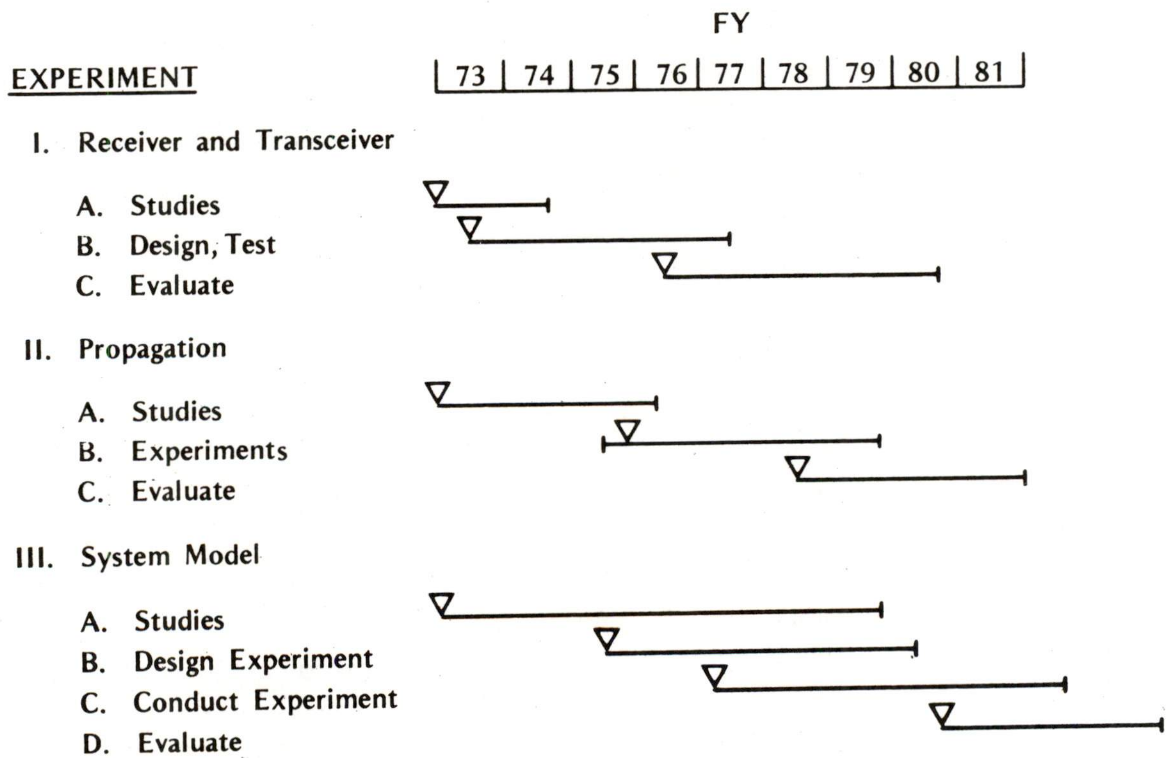
In the experiment, a specific area or two will be selected and a moderate number (1,000) of receivers and transceivers distributed to local public service entities and possibly individuals in order to evaluate the operation of the system and its interface with the populace. In order to be effective, the experiment must closely approximate the operational system, and so must use a space segment and an area large enough to provide a real service should a disaster occur during the experimental state. This, and consideration of engineering and qualification test costs, leads to the conclusion that the spacecraft should be a pre-prototype of the operational configuration.

Candidate areas for the experiment are the East and Gulf Coast areas (hurricanes), the Midwest (tornadoes), and the West Coast (tsunamis and earthquakes). In order to be effective, all elements of the system pre-disaster warning, post disaster, communications, and the dissemination of Severe Environmental Weather Information must be exercised. All of these elements can be supplied, for instance, in an experiment in the tornado belt, where warnings are needed on short notice to a very local area within a broad area; post disaster communications are very necessary and are frequently not now available, and severe environmental weather information is desirable and useful in winter as well as during tornado season.

Data will be taken in all parameters of the system, from citizen reaction, radio penetration of buildings, to spacecraft and ground equipment performance in order to further optimize the operational system.

(3) Key Milestones

The key milestones in the Disaster Warning Experiment are Experiment Definition, System Design and Development, and Operations and Evaluation, as given below:



(4) Cost and Schedule

The schedule is as given under (3) above. The costs for the experiment include satellite design, development and production of two satellites, two launch vehicles, one ground station, five regional stations and several transceivers.

Launch Vehicles	$14.5M
Design and Development	$51 M
1st Spacecraft	$62 M
2nd Spacecraft	$34 M
Ground Station & 5 Regional Stations	$ 3.3M
Receivers & Transceivers	$ 1 M
Propagation Studies	$ .5M
Operations	$ 4 M
Systems Studies	$ 2 M
	$172.3M

Budget The $172.3M to be used for this experiment is part of the $232.5M estimated as the investment for the operational disaster warning system.

FY	74	75	76	77	78	79	80	81	Total
Funds (Millions)	28	42	41	37	16	4	2.3	2	172.3

(5) The current communications systems using commercial circuits will continue to be used for present services. They will play a major role in the disaster warning system except when disabled.

b. Operational Systems

(1) System Description

The proposed disaster warning system consists of (1) a number of ground stations that originate disaster warnings and transmit them to one of two satellites in earth synchronous orbit, (2) the two satellites which receive, amplify, and redirect the messages back to the United States, (3) the disaster warning receivers which are automatically turned on by the emergency transmission and four (4) portable transceivers distributed throughout the United States. A sketch of the system is given in Figure A V-8. Two hundred and fifty ground transmitting stations are distributed throughout the country and have the responsibility for originating disaster warning messages for the geographical areas assigned to them. The decision of the responsible official assigned to the station is sufficient for the origination of a disaster warning. Once an enable message signal is received from a central control, the warning message is transmitted directly to the satellite, with no intermediate interconnections which might cause delay. The initial portion of the transmitted signal consists of a digitally coded address which identifies the specific geographical area for which the message is intended. Following this address is the voiced disaster warning message. The warning signal is received by the satellite, and retransmitted to the disaster area. Within each home, school, factory, government office, and other place where persons are likely to be assembled, the warning is received by the disaster warning receivers. In those receivers with internally stored addresses that match the address code at the beginning of the warning message, the speaker output is enabled and the ensuing emergency message is heard. Messages may be repeated in different languages to warn non-English speaking persons.

In addition to the capability of addressing individual disaster warning areas, the system can address selected groups of areas. These groups can be sized to cover the area to be affected by a flood or hurricane, and can even include the whole country.

The proposed disaster warning system has 100% geographical coverage. The satellite beams cover the entire United States, and can be received by mobile receivers in automobiles and boats. The system operates 24 hours per day. When one satellite is in the earth's shadow, the second satellite, spaced more than 18 degrees away in longitude, remains in sunlight and continues the function of relaying the disaster warning signals. The second satellite also adds to the reliability of the system. The satellites in orbit are far removed from terrestrial disasters. This remoteness increases overall warning system reliability.

The system of selectively distributed ground stations linked together by a satellite and the 100,000 portable transceivers provide an emergency communication network for use when terrestrial communications are disrupted by disaster. Emergency environmental information is distributed as needed to the warning receivers via the satellite.

The proposed disaster warning system requires 2.25 MHz of bandwidth in the UHF band and 750 KHz of bandwidth at S-band.

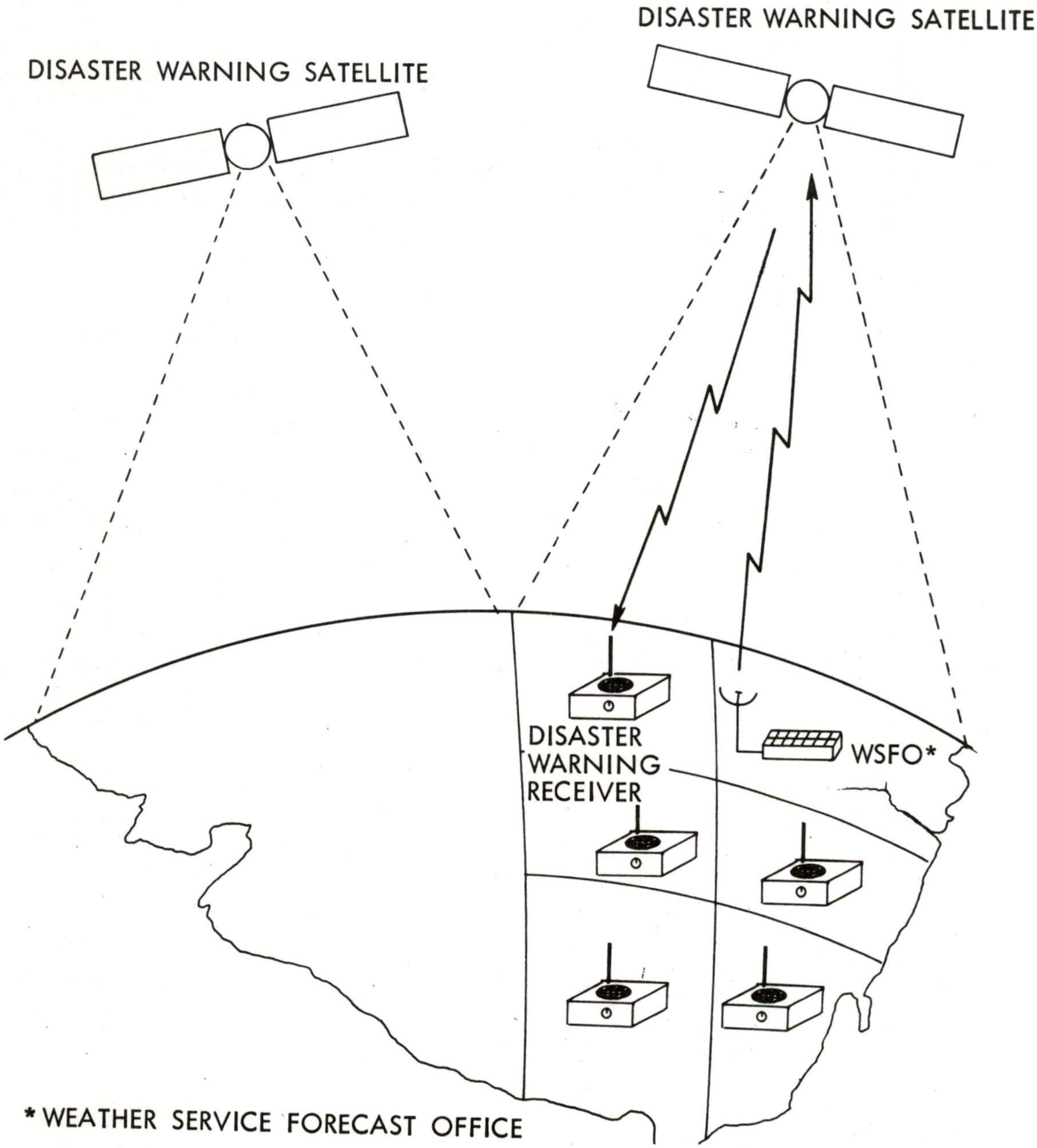


Figure A V- 8 Disaster Warning System

(a) Terrestrial Disaster Warning Stations

For the purpose of disaster warning, the nation is divided into several thousand disaster warning areas. If the divisions were made by county, approximately 3200 disaster warning areas would be required for the 50 states. Disaster warnings for groups of 10 to 15 areas are issued by a regional disaster warning station. These stations would be located at the 50 Weather Service Forecast Offices (WSFO) and the 200 Weather Service Offices (WSO) presently in operation in the United States. Each WSFO or WSO station could issue separate disaster warnings to each of the 10 to 15 areas within its jurisdiction, or selected groups of areas could be sent the same warning. The regional station has a 300 watt transmitter and two 6-foot, fixed pointing antennas capable of transmitting directly to the satellites. The disaster warnings are issued over 16 different voice bandwidth channels. The 3200 different areas are covered by time-sharing the channels. The system can transmit up to three separate simultaneous warnings.

The satellites are controlled in orbit by a master station, which also serves as a co-ordination center for the disaster warning system. The master station issues warnings affecting combinations of disaster warning areas that cross state lines. Co-ordination between the WSFO and WSO stations and the master station is accomplished through separate duplex voice channels transmitted through the satellites. Use of the satellite for this function increases the system's chances for survival.

(b) Spacecraft Description

The two disaster warning satellites are in geo-stationery orbits and, to an observer on earth, appear at fixed positions in the sky. The satellites function as repeaters, receiving warning messages sent from the ground, changing their transmission frequency, and amplifying them to high power levels before retransmission to the United States. Each satellite is capable of transmitting 2500 watts of radiofrequency power, directed into narrow beams by means of a nineteen foot diameter transmitting antenna. The large aperture antenna focuses the power into the desired coverage agea. Separate feeds on the antenna provide beams directed towards Alaska and Hawaii. The power source for the satellite is a 5 kilowatt, high voltage solar array. Weight in orbit is 1560 pounds. Synchronous orbit can be achieved using a Thor-Delta launch vehicle for launch into a low altitude circular orbit, and then spiralling out to synchronous orbit using ion engine thrusters.

(c) Disaster Warning Receivers

The emergency messages transmitted through the satellite are received by the public on low-cost, ac/battery receivers, (Figure AV- 9). The receivers are fixed-tuned to the frequency channel that covers their intended area of use. A printed circuit address card causes turn on of the receiver only for messages that carry a matching address code. Severe environmental information service is provided in the same manner as disaster warnings except that the receivers are not automatically enabled, and severe environmental information is heard only at those receivers which are switched to the "weather" mode.

The post-disaster communication service is provided by linking 100,000 portable transceivers with the 250 WSFO's and WSO's. The transceivers are selectively placed throughout the country at disaster co-ordinating centers, the Civil Defense Emergency Operating Centers, for example. Fifty duplex voice channels relayed through the disaster warning satellite provide this service.

The transceivers require 10 watts of UHF power and a simple low gain antenna for transmission to the satellites. Satellite power requirements for the post-disaster communication system are equivalent to two disaster warning channels. Therefore, when the post-disaster channels are being used, the two-satellite system would have its capability reduced to 14 simultaneous disaster warnings.

The channel and bandwidth requirements of the disaster warning system just described are given in Table A V-16.

(2) Supporting Experiments Required

The Disaster Warning System requires no new technologies requiring major experimentation other than experiments currently planned through ATS-G. Specific spacecraft systems will be developed and then flown on the prototype spacecraft. The disaster warning receivers and the post-disaster communications transceivers will require design studies to minimize their per-unit cost. Supporting experiments will be required using the prototype spacecraft to demonstrate the technology to be used on the operational version. For a description of these experiments see section V.C-8, Communication Services Technology Development Program.

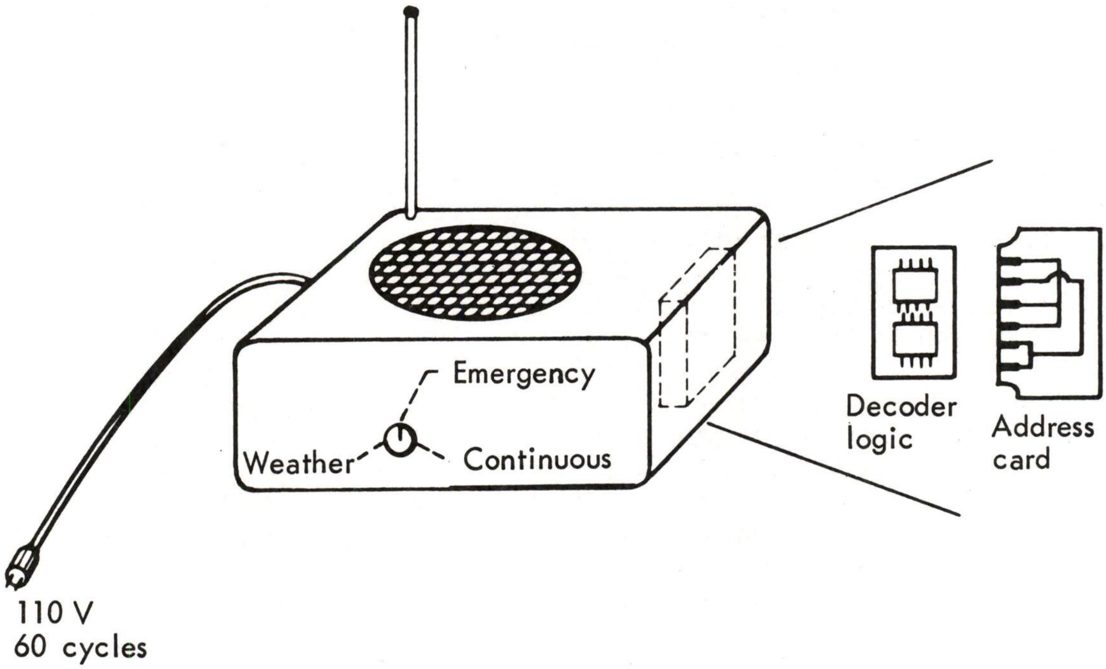


Figure A V-12 Disaster Warning Receiver

Table A V-16

Disaster Warning System, Channel and Bandwidth Requirements

GROUND STATION TYPE	NUMBER REQUIRED	NUMBER OF CHANNELS	BANDWIDTH PER CHANNEL		TOTAL RF BANDWIDTH	SERVICE NO. (See Notes)
			BROADBAND	RF		
MASTER TERMINAL	1	16 SIMPLEX VOICE	3 KHz	25 KHz	400 KHz	1,3
		10 DUPLEX VOICE	3 KHz	50 KHz	500 KHz	1,3
		50 DUPLEX VOICE	3 KHz	50 KHz	1250 KHz	2
		20 DUPLEX TTY	150 Hz		50 KHz	1,3
REGIONAL TERMINALS (WSFO'S and WSO'S)	250	[1 SIMPLEX VOICE	[3 KHz	[25 KHz	[25 KHz	1,3
		10 DUPLEX VOICE	3 KHz	50 KHz	500 KHz	1,3
		50 DUPLEX VOICE	3 KHz	50 KHz]	1250 KHz	2
		1 DUPLEX TTY]	150 KHz]		2.5 KHz]	1,3
WARNING RECEIVERS FIXED	100×10^6	[1 SIMPLEX VOICE	[3 KHz	[25 KHz	[25 KHz	1,3
MOBILE	100×10^6	1 SIMPLEX VOICE]	3 KHz]	25 KHz]	25 KHz]	1,3
PORTABLE TRANCEIVERS	100,000	[1 DUPLEX VOICE, TUNEABLE]	[3 KHz]	[25 KHz]	[50 KHz]	2

NOTES: [ ] INDICATES CHANNELS ACCOUNTED FOR ELSEWHERE IN TABLE.

SERVICE NUMBERS :
1. DISASTER WARNING SERVICE
2. POST - DISASTER COMMUNICATION SERVICE
3. SEVERE ENVIRONMENTAL INFORMATION SERVICE

(3) Introduction Schedule

One of the major problems of establishing a Disaster Warning System is the method of supplying the population with warning receivers. Three possible alternatives are:

(a) Require all manufacturers of boats, automobiles, radio and television sets to install the receivers in all new boats and automobiles and in a limited number of new-production radio and television sets manufactured after a specified date. These receivers may be energized by the available power source for everyday, continuous duty.

(b) Market the warning receivers through domestic manufacturers as an A.C. or battery powered-portable appliance.

(c) Provide government subsidy to manufacturers and distribute the receivers to the population as A.C. or battery-powered portable appliances.

The estimated lead time required before completion of initial satellite deployment is about 67 months. This lead time should be adequate for the legislation and planning necessary to implement the first alternative. The second alternative appears to offer no real certainty that the nation's population would be outfitted with an adequate number of receivers. The third alternative would require a definite governmental policy decision to provide the receivers in this fashion. With the first alternative the user is required to accept a receiver with the purchase of a boat, automobile, radio or television. Although the first alternative is most desirable with respect to reaching the entire population successfully, there is a 12-year period needed to ensure that 85-90% of all automobiles, boats, televisions and radios are equipped with receivers. If production were to begin in 1975, some form of each of the three alternatives would be required until 1987 to ensure coverage.

During this period all new boats, automobiles, radios and televisions would be equipped with receivers. Portable instruments could be marketed to people interested in buying them. Those unable to purchase the receivers might be supplied with them through government subsidy. The demand for receivers as an individual portable appliance is estimated to be about 100,000 per year.

(4) Milestones and Costs

(a) Milestones

Key milestones in the implementation of the proposed Disaster Warning System are shown in Figure A V-12. This figure displays milestones for both the experiment and the operational system because the experimental hardware becomes the operational system after deployment and checkout.

(b) Costs

An estimate of the investment required to establish a Disaster Warning System is $233 Million, expressed in constant fiscal year dollars. This amount includes the $172.3 million for the experiment as will be shown below under R&D.

Cost estimates for the FM warning receivers for the nation's population have been made; these costs are given below and are included in the annual operating costs. The receivers will not be funded by the national program but will be purchased directly by the citizenry. The cost estimates for the home receivers were developed by using the detailed engineering estimate technique; the costs include parts, labor, overhead, profit and distribution.

The cost estimate for the satellites was made with the aid of a well-established cost-estimating relationship. This estimating relationship is a function of satellite power (5KW), weight (1565 pounds), control system (370 pounds), equivalent engineering units (4.3) and control system (3-axis). Considered in this estimate are design, development and production of a prototype (first) and second satellite. The estimate costs are $51 million for design and development, $62 million for the prototype and $34 million for the second satellite. The costs and distributions for the total system (including the experiment) are given below.

OPERATIONS

Staffing

Central Station

Technical operations

16 people/shift x 5 shifts/week = 80 people @ $15K	$ 1.20 M
Meteorologists and monitors 3 people/shift x 5 shifts/week = 15 people @ $18K	.27 M

250 Regional Stations

1 person/shift x 5 shifts/week = 250 stations @ $15K	18.75 M

Maintenance

10% of investment cost of $68M	6.8 M

Home Receivers

23 Million receivers/year @ $11.50	264.5 M
Total Annual Operations	$291.5 M

CAPITAL RECOVERY

Satellite design, development and production of 2 satellites (5 year life @ 8%)	$ 36.8 M
Launch System (5 year life @ 8%)	3.6 M
Ground Stations (10 year life @ 8%)	2.7 M
Transceivers (10 year life @ 8%)	7.5 M
Total Annual Capital Recovery	$ 50.6 M

DISASTER WARNING SYSTEM

INVESTMENT

Satellite		
Design & Development		$ 51 M
Prototype		62 M
2nd Spacecraft		34 M
	Subtotal	$147 M
Launch System		
Thor/Delta (2)		$ 12 M
Hg Ion Thrusters (2)		2.5 M
	Subtotal	$ 14.5 M
Ground Stations		
1 Central Station		$ 3 M
250 Regional Stations		15 M
	Subtotal	$ 18 M*
Transceivers		
100,000 Portable Transceivers purchased @ $500 to be distributed at the local government level		$ 50 M
Studies		$ 3 M

Summary of Total Investment:

Satellite System		$147 M
Launch System		14.5 M
Ground Stations		18 M
Transceivers		50 M
Studies		3 M
	Total	$232.5 M

*For modifications to existing facilities (buildings) and for transmitters, receivers and antennas.

(c) Budgeting

To accomplish the objectives of the proposed system, the approximate annual funding levels are shown in the following table until 1981 when constant operating cost levels are reached. During the period 1973 to 1981, the budget (or actual annual costs) for the entire system is given by the line labeled budget. After 1982, it is assumed that the annual budget is equal to the cost of operation plus the capital recovery cost. Thus, the annual budget will be the uniform annual costs which are shown in the table. The annual operating costs of $292 M include $264.5 M for home receivers. The actual cost to the government for annual operations is $22 M. The uniform annual cost of $343 M is used as the annual cost to determine the benefit-cost ratio of this system and thus includes operations, capital recovery and home receivers.

(d) Cost of Warning Receivers

The cost of a 110V, 60 cycle or DC powered disaster warning receiver will be dependent upon the method of manufacturing and distributing the receivers. As discussed above, the alternatives are:

1. Manufacture receivers in a parent appliance.
2. Manufacture and distribute receivers as a portable appliance through existing facilities on a basis of demand by the consumer.
3. Provide government subsidy to manufacture and distribute receivers as a portable appliance.

The costs of components for the portable receivers including labor and materials are estimated to be about $4.25. Allowing for overhead, profit, and distribution, the cost to the consumer rises to about $13.50 when produced in quantities of 10 to 20 million. When produced in a parent appliance or an automobile with a radio, the cost of the receiver to the consumer is about $11.25 when produced in quantities of 10-20 million. This decrease results from sharing common components with the parent appliance. With respect to the alternatives, the first ensures that the demand for the receivers will be about 23 million dollars annually. This alternative will also ensure a high volume demand for the specialized integrated circuit components of the receivers, thus guaranteeing a lower cost for the receivers.

DISASTER WARNING SYSTEM* (MILLIONS OF DOLLARS)

Fiscal Year	73	74	75	76	77	78	79	80	81	82	83	Annual Recurring	Total
1. Investment													
R&D*		28	42	41	37	16	4	2.3	2				172.3
Hardware		1	13	13	17	9	3	2.2	2				60.2
Investment Total		29	55	54	54	25	7	4.5	4				232.5
2. Annual Operations and Maintenance**								74	217	292		292	
3. Capital Recovery		6.3	18.3	30.1	41.9	47.3	48.6	49.7	50.6	50.6		50.6	
Budget (Actual Annual Costs)** (1 + 2)		29	55	54	54	25	7	79	221	292			
Uniform Annual Costs (2 + 3)**		6.3	18.3	30.1	41.9	47.3	48.6	124	268	343		343	

* R&D Costs = Experiment Costs

** Includes Home Receivers Cost of $264.5M

If alternative two is selected, the demand for home receivers is expected to be similar to that for automobile seat belts before they were required equipment. Low demand would increase the cost appreciably which in turn would further reduce demand. Thus, alternative two is not viable by itself.

Alternative three would ensure a lower cost per receiver than alternative one or two because there would be no profit added to the distribution cost. However, there is no guarantee of constant production for replacement once implemented unless redistribution is made at a constant rate.

The minimum weighted cost of $11.50 was developed by assuming alternative one for 20.5 million automobiles, televisions, and radios produced annually as a parent appliance and 2.5 million portable receivers produced for vehicles and boats without radios and for individual consumer demand.

(e) Benefit Cost Ratio

The annual benefit of the satellite Disaster Warning System was estimated by NOAA to be $350 M. The annual cost of the fully implemented system is estimated to be $343 M. The benefit-cost ratio is thus equal to 1.02.

7. PROGRAM INITIATIVES FOR HUD

a. Experiments

At the present time broadband communications systems (cable television) are being installed at a very rapid rate. The new growth of these systems will be in the urban areas of the nation where there is a high number of potential subscribers per cable mile. The rate of return on capital invested depends primarily on market penetration and market penetration rate depends on the number of acceptable broadcast signals now being received. If additional services (e.g., two-way service) of a nature not now offered by broadcast are available in the area serviced by the cable network then market penentration may be increased to a profitable level. Good data on subscriber preference for two-way service are not available and the pilot phase of this program would seek such information. However, one recent poll by Stanford Research Institute found that over 30% of California households would pay from $20 to $50 per month if fire detection and intrusion detection services, and better quality educational programs were offered. Young adults (under 30) appeared to be willing to accept higher cost services than the older population group. From this it would appear that such systems would be most attractive in new communities having a significant portion of their population within this age group. Experimentations will be needed to verify these indications and to find the optimal use of such systems.

(1) Purpose

The purpose of experiments is to carry out a demonstration program that will lead to the ability to implement the wired city concept on a nation-wide scale.

(2) Description

This program will be carried out in four phases with the first three phases to run concurrently and the fourth phase to follow after these phases are well underway. These phases are described individually below.

<u>Phase I</u> - Development of System Components

The most important task in this phase will be to evaluate prototype components of the system that have already been developed by industry. If these components do not meet the specifications for system use, some type of federal support for research and development will be necessary. This will include the evaluation and/or development of a subscriber response unit capable of sending digital information from the user to a head end, and a local storage unit to receive and store single frame video for constant viewing on a TV monitor. The design of alternative head end equipment configuration will be undertaken in order to provide services that will be needed; such as computer programming for information retrieval system and other special services offered, fire detection systems, intrusion detection systems, an emergency signaling system, utility monitoring, and polling capability.

Phase II - Pilot Broadband Networks

In this experiment two to four pilot networks will be planned, designed and constructed in order to provide all services possible to 4 community centers and 100-150 user homes in each network. The best equipment available at the time will be used with the major objective of providing data points needed to project economic viability of services, alternative methods of allocating costs, and standards and criteria for national regulation policies. User reaction from families utilizing the 100-150 home terminals and several hundred occasional users from the 4 community centers in each of these pilot networks will provide the social data needed for evaluation.

Phase III - Community Information Center

This experiment will have as its objective the creation of an experimental operating community information center in a central city neighborhood remote from city hall. This remote center may be viewed as a little city hall and should be an integral part of at least one of the networks described in Phase II. Experimental services provided by the center will include a referral function directed at providing any citizen with information on procedures such as where to get the service or information he needs, or actual service requests. Information about the efficiency with which these requests can be handled will be needed in order to design a municipal information center that will be relevant for citizens' use and that can be implemented for home terminal use on the broadband communications network.

Phase IV - Prototype Broadband Network

At least one city-wide system will be demonstrated in this phase and the information gained from Phases I, II, and III will be integrated here for the first time. This demonstration will identify and solve city-wide system problems, test data already obtained on user reaction and software requirements, and make final evaluation of cost data.

In addition, a data base for criteria and standards for hardware, software, and service classes for implementation will be generated in a realistic environment.

(3) Key Milestones

Phase I - Development of System Components

- Design - identify components now under development by industry. Prepare RFP's for research components not now under development. Identify software requirements. Test and evaluate procedures specified (3 months).

- Pre-test and Selection of Components - test prototype components developed by industry - begin development of other components as needed under contract (1 month).

- Develop components and software not available (12 months).

- Monitor Operations Test Performance and make software modifications (6 months).

- Evaluation - evaluate all components as a system according to criteria in first milestone (3 months).

Phase II - Pilot Broadcast Networks

- Design Study - identify hardware and software now available. Identify software to be needed immediately (1 month).

- System Design - determine hardware configuration and procure equipment. Procure and/or develop software. Develop operator training program (7 months).

- System Implementation - Install, test, and debug equipment. Train operators (3 months).

- Operations Test - Place system into service with trained operators. Monitor performance and make modifications (9 months).

- Evaluation - Evaluate effectiveness of system. Survey users (3 months).

Phase III - Community Information Center

- Design Study - this task will identify information and interfaces between citizens and the local government agencies. A classification scheme or other suitable access technique will be devised and system capacity will be determined. Time estimate - 6 months.

- System Design - the hardware system configuration will be determined and equipment procured. Software will be developed and test and evaluation procedures specified. An operator training program will be developed. Time estimate - 9 months.

- System Implementation - equipment will be installed, tested and debugged. Operators will be trained. Time estimate - 3 months.

- Operations Tests - the system will be placed into service with trained operators. Performance will be monitored and software modifications made. Time estimate - 9 months.

- Evaluation - the system will be evaluated according to criteria developed in task (b). Time estimate - 3 months.

- Service Expansion - improvements in the system and expansion of service functions will be studied. Design and cost projections for the final multi-location system will be carried out.

Phase IV - Prototype Broadband Network

- Design Study - identify hardware and software needed from Phases I, II and III (1 month).

- System Design - procure system configuration and equipment. Develop final operator training program (7 months.)

- System Implementation - install, test and debug equipment. Train operators (3 months).

- Operations Test - place system into service with trained operators. Monitor performance and make modifications (9 months).

- Evaluation - evaluate effectiveness of system. Survey users (3 months).

(4) Costs

Phase I

Hardware (components provided by industry)	$ 0
4 man-years for professional personnel	$200,000
2 year total	$400,000

Phase II

Hardware

subscriber response units - 150 @ $500	$75,000
video tape recorder	90,000
computer remote terminal - 75 @ $400	30,000
metering devices - 150 @ $150	22,500
fire detectors - 150 @ $500 per home	75,000
intrusion detectors - 150 @ $400 per home	60,000
broadcast quality video tape recorder - 5 @ $2000	10,000
head end studio	100,000
tape library	20,000
computer	18,000
bulk storage disc or drum	15,000
installation at head end	10,000
	$525,500

Personnel and Overhead

Director	
System Analyst	
Analyst/Programmer	
Human Factors Specialist	200,000
Operators (12)	300,000
Community Center Operators (4)	100,000
	$600,000
TOTAL	$1,125,500
Four Pilot Networks	$4,502,000
2 Year Total	$9,004,000

Hardware Costs

1 computer with communications interface such as PDP II	$18,000
1 disc or drum (2 megabit) (rental)	10,000
1 hi-speed paper tape reader/punch	6,000
1 ABR 33 teletype-punch/reader	1,700
6 buffered CRT terminals	24,000
data sets	9,000
installation	6,000
	$74,700

Personnel Costs (includes all overhead)

Project Director	$5000/mo.	for	30 mo.	$150,000
System Analyst	4000 "	"	"	120,000
O. R. Analyst	4000 "	"	"	120,000
Analyst/Programmer	3500 "	"	"	105,000
Clerk/Typist	1500 "	"	"	45,000
O. R. Analyst (2)	3500 "	"	18 mo.	126,000
Human Factors Analyst	4000 "	"	16 mo.	64,000
6 Service Operators	2400 "	"	10 mo.	144,000
				$874,000

Total Program Cost $948,700

Hardware

assume cable is provided	
headend	$460,000
home terminals - 25,000 @ $800 - assume 3/4 of costs are provided 20 mil.	$5,000,000
equipment for Class II services - assume provided	$ 0
operation and evaluation of experiment	$300,000
TOTAL	$5,760,000

b. Operational Systems

It is anticipated that the basic system for the urban portion of the nation will be built with private capital by the year 1980. Systems capable of two-way video transmission are now being built in urban areas. By 1976, many of these systems will already be operating in the manner described below.

The nation-wide system should be complete by 1986. This is primarily a collection of up to 3,000 local urban systems, interconnected for certain special purposes, rather than a single system which is inherently national in scope. Present television networks are capable of satisfying most news and high cost entertainment productions; hence, the more immediate usefulness of broadband cable systems will be primarily local in nature. Local systems can and will be interconnected for dissemination of program material over an entire large city, to neighboring cities, or even nation-wide on some occasions; but the bulk of the special interest program material which will be carried on local systems need not occupy space on a nation-wide network.

The local system serving up to 25,000 home terminals will consist of:

(1) A head end

(2) A branching system of coaxial cables going up to homes, businesses, and institutions

(3) A set of terminals in these locations

The head end includes equipment for processing signals and launching them on the cables; a time shared computer on a communication link to such a computer; a file of video tapes for broadcast reply or for transmittal to home recorders; an information bank accessed through the computer; and a communication link to the regional and nationwide network.

The home or institution terminal consists of some or all of the following:

(1) Television receiver (designed especially for cable operation)

(2) A subscriber response unit for sending simple response and control signals to the head end

(3) A video recorder or other means for storing single frame video

(4) A teletypewriter unit or computer terminal

c. <u>HUD (Wired City) Costs</u>

The target population for this system is 50 million subscribers. These subscribers will be divided into groups of 17 thousand or fewer subscribers. Each group will be served by a single Head End. The cost estimate for this system will be developed from cost estimates for head end equipment, personnel, maintenance and capital recovery costs, home terminal and cable costs.

HEAD END EQUIPMENT	IN THOUSANDS OF DOLLARS
Studio for local origination	$150
6 video tape recorders	$ 12
Tape Library	$ 20
Minicomputer with communications interface	$ 18
Bulk storage disk or drum	$200
Installation	$ 10
Computer Software	$ 40
	$450

HEAD END PERSONNEL	
Director	$ 20
Systems Programmer (Computer)	$ 15
Technical Maintenance	$ 15
Operators (5)	$ 60
Clerical/Secretarial (2)	$ 15
Billing Support	$ 20
Custodial	$ 6
Fringe Benefits (15%)	$23
	$174

FACILITY OPERATIONS	$ 86
CAPITAL RECOVERY	
Head-End Equipment @ 8% for 5 years (annually)	$113

HOME TERMINAL	In Dollars
Basic Equipment	No Cost
TV Monitor (Assumed in place)	
Metering system*	$150
Subscriber response unit	$200
Audio-video tape recorder	$600
	$950
Optional Equipment	
computer remote terminal (TTY)	$400
Fire detection devices (5)	$500
Intrusion detection devices (4)	$400
	$1300
Cable per mile	$6000

* To be funded initially by utility companies

OPERATIONAL SYSTEM REQUIREMENTS

Target Population	50 Million Subscribers
Front-End Units 25,000 Subscribers Per Unit	3000 Units
Cable (Urban Mileage)	208 Thousand Linear Miles
Optional Services	
Remote Computer Terminal (1%)	500,000 Subscribers
Fire Detection (10%)	5 Million Subscribers
Intrusion Detection (10%)	5 Million Subscribers

OPERATIONAL SYSTEM COSTS

HEAD-END	
3000 Head-End Unit $450k each	$1.35 Billion

HOME TERMINALS

Basic Service for 50 Million Subscribers	$47.5 Billion
Remote Computer Terminals (500,000)	$ .2 Billion
Fire Detection 5 Million	$ 2.5 Billion
Intrusion Detection 5 Million	$ 2.0 Billion
	$52.2 Billion
Cable 208,000 Miles	$ 1.25 Billion

ANNUAL OPERATIONS

Personnel	$.522 Billion
Facility Operations	$.258 Billion
Capital Recovery	$.339 Billion
	$1.119 Billion

TOTAL SYSTEM INVESTMENT COSTS

Head-End Unit	$1.35 Billion
Home Terminals	$52.2 Billion
Cable	$1.25 Billion
	$54.8 Billion

FUNDING

The implementation period for this system is 1970 to 1980. Presently (1971) there are 4.5 million CATV subscribers. 50 Million subscribers are projected for 1980. The prototype head-end units will be fully implemented and will begin operations at the beginning of 1975. Full system de-

Table A V-17

FUNDING IN BILLIONS OF DOLLARS*																	
	PREVIOUS PRODUCTION	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	TOTAL
CABLE**	0.7	0.09	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.14							1.25
HEAD - END UNITS						0.1	0.14	0.16	0.16	0.16	0.16	0.16	0.16	0.15			1.35
HOME TERMINALS						1.5	3.5	6.2	6.2	6.2	6.2	6.2	6.2	5.5	5.5		52.2
OPERATIONS						0.1	0.2	0.34	0.52	0.69	0.83	0.95	1.03	1.09	1.12	1.12	8.0
	0.7	0.09	0.13	0.14	0.14	1.84	3.98	6.8	7.0	7.2	7.2	7.3	7.4	6.7	5.6	1.12	62.8

* COSTS ARE GIVEN FOR IMPLIMENTATION AND DO NOT INCLUDE PROJECTIONS FOR WHICH MAY BEGIN IN 1986 OR 1987.

** 9% COMPLETED DURING PAST TEN YEARS.

ployment of the head-end units will begin in 1976 and 100% operation is projected for 1986. (See Table A IV-17)

8. COMMUNICATION TECHNOLOGY DEVELOPMENT PROGRAM

a. Purpose

The objective of the Communication Technology Development Program is to evolve and demonstrate within the United States the communication technology which will fulfill the needs as defined within this document and to do so in such a manner as to allow for technologically and economically viable alternatives within the system which satisfy the desires for individual, private and institutional initiative and independence.

From the communications system point of view the purposes are:

(1) to develop the unique technology, including that for users-system interface for such a communication system,

(2) to perform experiments which will demonstrate the use of this technology,

(3) to assess the impa-t of such communication systems upon social, political and economic entities,

(4) to provide a method of obtaining information for confirming or modifying preliminary user requirements, and

(5) to determine the approaches to be made for operational systems which will satisfy the finally determined requirements.

b. Description

The general approach of this program is to build upon and mesh with the on-going technology demonstration programs, such as ATS, which can provide facilities for the experimentation and evaluation necessary for a firm determination of technical requirements for operational systems. The results of these experiments will also be used to determine further experimental approaches where necessary.

The timing and direction by which results of a given user experiment, within present programs or within future programs, can be developed into an operational service varies greatly among the identified users. Some of the users have, at present, communications systems which need expansion and updating, and therefore already have well defined requirements. Others will need an extensive period of experimentation and evaluation before their ultimate requirements can be defined. For such experimentation, satellite facilities must be present both for the user-directed experiments and for the demonstrations of necessary technology. The following Table A V-18 lists existing and programmed satellites which are, or will be, applicable to a given area. The progression from left to right in an area in the table indicates a progression which can result in allowing greater experimental flexibility for the user as well as a progression toward the demonstration of more technology that is directly applicable to the final user communication system.

In addition, there are many terrestrial experimental facilities or techniques which can be used. Some of these facilities are given in Table A V-19.

For experiments requiring the use of a single small locality, terrestrial experimental facilities will usually be best from standpoints of flexibility and cost. Experiments requiring the use of dispersed population samples or localities separated by considerable distances will usually be more flexible and less expensive if satellites are used for the linkages.

c. Key Milestones

The key milestones of the Communication Technology Development Program are composed of five segments: the experimental and developmental program using satellites, the development of user-interface technology, the experimental and the developmental program of terrestrial segment linkages, the development of the necessary software to support the experiments, and the evaluation of the experiments and the decisions resulting therefrom.

The milestones from these segments are given in the following tables:

Table A V-18

SPACE SEGMENT EXPERIMENTS

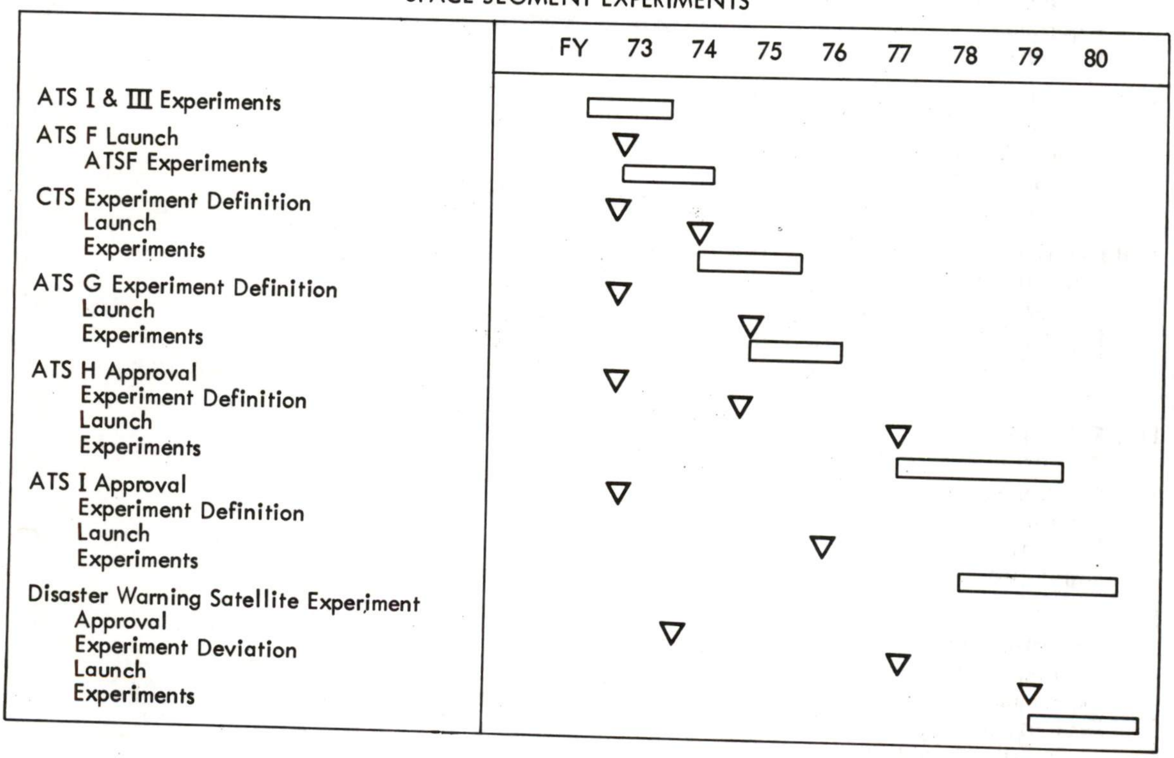


Table A V-19

USER - INTERFACE TECHNOLOGY EXPERIMENTS

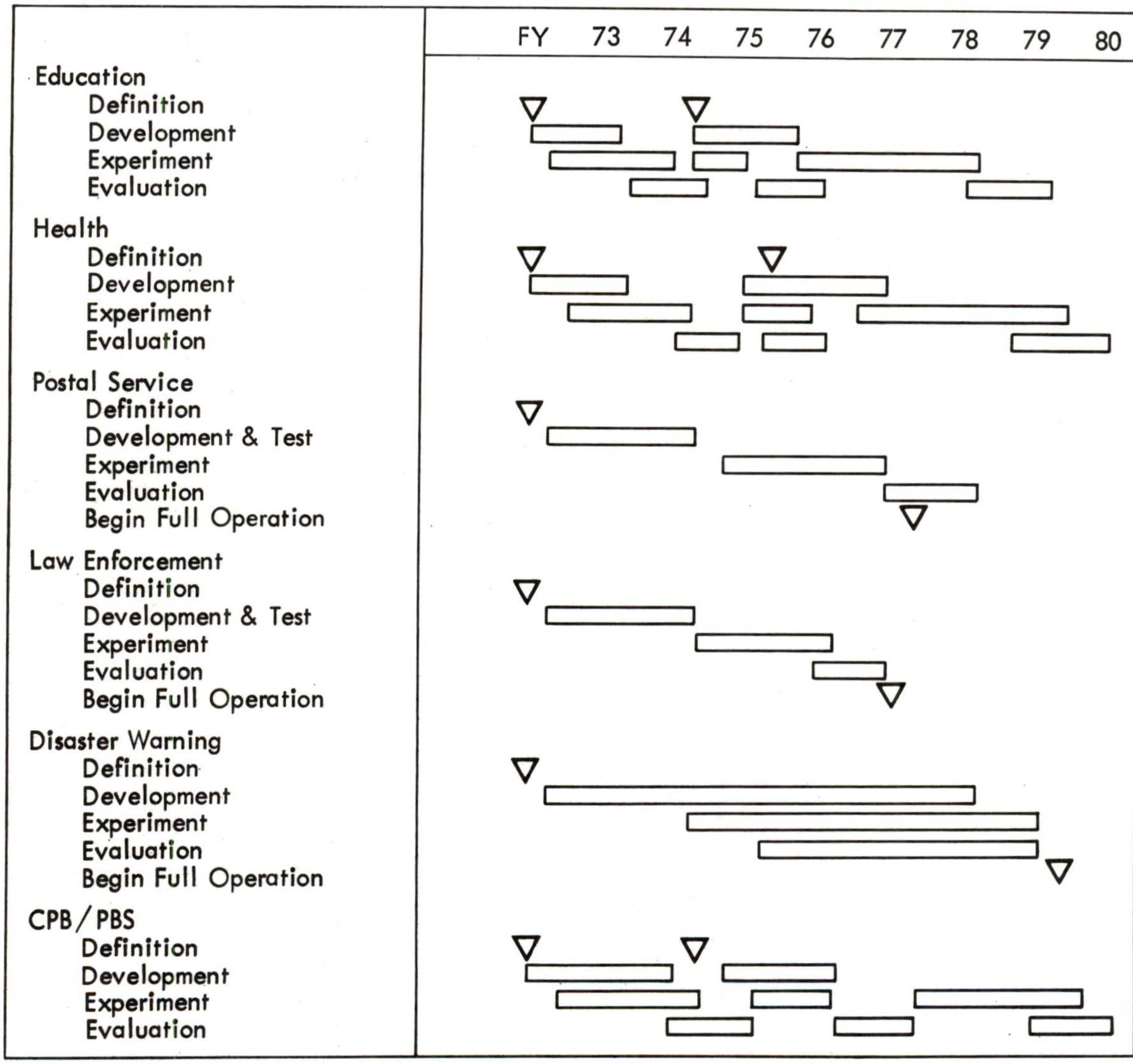


Table A V-20
SPACE SEGMENT EXPERIMENTS COST ESTIMATES

FY	73	74	75	76	77	78	79	Cost to Completion	TOTALS
ATS-F	3.0	4.0	1.5						$ 8.5 K
ATS-G	1.0	4.0	5.0	2.0					$ 12.0 K
CTS	1.0	2.0	4.0	3.0					$ 10.0 K
ATS H & I	2.5	20.0	54.9	79.7	56.7	24.5	5.7	2.0	$246.0 K
	7.5	30.0	65.4	84.7	56.7	24.5	5.7	2.0	$276.5 K

Terrestrial Linkages	FY 73	74	75	76	77	78	79	80
Major Linkages In		∇						
Secondary Linkages In				∇				
Minor Linkages In								∇

(d) Software Support

The development of software in a timely manner for the educational and Public Broadcasting experiments is necessary both for the success of these experiments and for any meaningful evaluation of these experimental results.

It is noted that the milestone schedules for Health, CPB/PBS and Education indicate a continuing and reiterative process for these services. This is because of the present and future difficulty of clearly defining their communication problems without a large sampling of their ultimate user population. This means that they must graduate from simple, small experiments in the near time period to more sophisticated and extensive experiments later, with the earlier experiments serving as a technological development sieve. It should be noted that accomplishment of this progression will require that a facility having capability for the requisite flexibility and large area sampling be available within the 1975-1980 time frame. An experimental satellite such as the proposed ATS H/I would seem to fill this requirement in the optimum manner.

Assumptions

The life span of equipment employed in the experiments generally is not a factor in the estimation of costs since equipment normally outlasts the experimental requirements. Additionally, for simplicity, it is assumed that experimental equipment has no residual value at the end of the experimental projects; even though it might be incorporated directly into a subsequent operational system.

Within the main cost areas of Investment Costs, Operations Costs, and Annual Budgeting, the estimates for all users are summed and lodged against the particular satellites that will be employed. Investments and operations costs are not separately identified in the Space Segment of the experimental program. In those cases where an experimental program is being expanded, only the costs for the increase in the program scope are estimated.

Cost Estimates for the Set of Space Segment Experiments

Table A V-20 displays the budgeted estimates of experiments planned in the Space program.