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TECHNOLOGICAL ALTERNATIVES AND IMPLICATIONS

Gene G. Ax

1. INTRODUCTION

This short paper will summarize some of the major technological alternatives and implications considered by the primary companies and associations that submitted proposals and/or filings to the FCC in conjunction with Docket 18262 concerning land mobile radio communications in the 900 MHz portion of the spectrum. In this interim paper, an attempt will be made to summarize why the various technological alternatives, as expressed by the indicated companies and organizations, are or are not being considered further. In the final report, I hope to offer some of my own thoughts on these and other technological alternatives which have not been specifically addressed. For example, multiple-access techniques, such as RADA and MADA, will be considered along with others that may be discovered in the technical literature and from discussions with government and industry personnel. If it appears desirable, and can be accomplished rather easily, limited measurements may be made. For example, it may be possible to assess the effect of flat fading on single sideband amplitude modulation systems in the 900 MHz mobile environment by sending a voice message through the channel simulator that ITS has.

2. AT&T

Technological alternative system ideas by this company are taken from Appendix B entitled "Alternative System Concepts" from their technical report [1].

2.1 Time-Division Multiplex (With PAM)

Pulse amplitude modulation (PAM) is considered to, perhaps, be competitive with the FM system being proposed and they plan, as resources permit, to study it further for the following reasons:

1. Broadband pulses that can be resolved between multipath components offer the possibility of inherent time diversity to minimize the frequency-selective fading of the mobile environment.

2. Pulse transmission techniques would add a degree of privacy because it would be hard to synchronize to a particular channel.

3. Hardware complexities of frequency-division multiplexed systems with closely spaced channels could be avoided by multiplexing in the time domain (as would be necessary with PAM).

4. System-operating algorithms and channel arrangements could, through software changes, adapt the timing of the system to better match particular propagation conditions.

2.2 Deterministic Coverage Plan

This plan represents a refinement of their regular contiguous hexagonal cellular system that is based on a statistical description of the radio propagation effects. The cell structure could be based on deterministic measurements of radio propagation conditions in each area with some channel reuse distances being less than those given by the statistical models and others being greater. With this plan it should be possible to lessen the average radio-channel-reuse distance with a resultant greater value for mobiles/MHz/Unit area. Multiple directive antennas at each base station could play a part in tailoring the cell structure to each particular area.

In a deterministic coverage plan one could make use of the known distribution of average signal strengths throughout the cells by comparison with the average signal strengths received from a vehicle at the base station(s) to assign channels in a relatively interference free fashion without the need for special vehicle-locating hardware. This procedure, however, requires a special channel set for call attempts with a much larger reuse interval (distance).

It is claimed that several topics need further study on this base station assignment approach before the procedures can be outlined in detail. These include base station layout procedures; extent and detail of measured field strength required; accuracy and performance of the base station assignment algorithms; size, speed, and complexity of the system controlling computer; the landline interface; and the economics of implementation.

2.3 Frequency-Division Multiplex

A comparison of required transmitter powers and spectrums for FM/FM, FM/SSB, SSB/SSB, and SSB/FM multiplex signals is made with regard to average signal level, flat and frequency-selective fading, and co-channel interference. Their study maintains that conventional FM channels (SSB/FM) require less transmitter power than any of the other three and much less spectrum than for FM/FM and FM/SSB for the UHF mobile telephone application. Flat and frequency-selective fading affects SSB/FM less seriously than it does the others. Flat fading seriously affects SSB/SSB and frequency-selective fading rules out FM/FM and FM/SSB for the high capacity mobile telephone system. Intermodulation can be a more serious problem with SSB/SSB, FM/FM, and FM/SSB since higher peak transmitter powers are required. It is emphasized that these techniques are analyzed in the <u>absence of diversity reception techniques.</u>

It is claimed that the four types of systems considered here are the common types that would normally be considered for mobile radio applications.

2.3.1 Spectrum and Power Requirements

They point out that if one used FM/FM, FM/SSB, or SSB/SSB instead of conventional SSB/FM from base to mobile that the two-way bandwidth required could be reduced between 25 and 50 percent. FM/FM or FM/SSB are not feasbile for mobile to base transmissions and SSB/SSB suffers severely from flat fading. The 25 to 50 percent bandwidth reduction, however, comes at the expense of a peak transmitter power requirement that is from 15 to 20 dB greater than that required for the SSB/FM choice being considered.

The peak power advantage of SSB/FM over SSB/SSB primarily results from the signal-to-noise ratio improvement one obtains with FM over AM for the large modulation index (≈ 4) planned for the SSB/FM technique in their high-capacity mobile radio system. Its advantage over FM/FM and FM/SSB is because of the small modulation index (≈ 0.06) for the subchannels. FM/FM and FM/SSB would have to occupy approximately twice as much bandwidth as SSB/FM in order that the same peak powers would be required. This gain obtained by the increased bandwidth would be accompanied by far higher FM thresholds than for SSB/FM channels.

2.3.2 The Effect of Flat Fading

The effect of flat fading on SSB/SSB is such that it renders it unusable for mobile radio at UHF and higher frequencies. The fading signal has the effect of mixing the time variable transmission coefficient of the medium with the desired modulation. At these frequencies Doppler frequencies (and their harmonics) are on the order of audio frequencies. Thus, the distortion due to fading is not easily removed by AGC techniques. It is claimed that even several branches of diversity reception does not make SSB/SSB usable for telephone quality communication.

The effect of flat fading on FM/FM, FM/SSB, and SSB/FM is approximately the same since their FM thresholds are about the same.

2.3.3 Frequency-Selective Fading

For appropriate modulation design parameters for a high-capacity mobile radio system and for a time delay spread of 4 microseconds FM/SSB and FM/FM multiplex systems would be wide enough in bandwidth such that the intersubchannel interference would render them unsatisfactory for UHF mobile telephony.

2.3.4 Co-channel Interference

For efficient utilization of the spectrum each channel should be reused as often as possible geographically. This is limited, of course, by acceptable co-channel interference. The important point here is to note that SSB/SSB has been ruled out because of its poor performance under the flat Rayleigh fading nature of the UHF mobile radio channel. Under this assumption and the assumption of path loss being proportional to the fourth power of distance the FM/FM and FM/SSB systems require, for the same output signal-to-interference ratios, a total spectrum space several times that required for the SSB/FM system being proposed. If, indeed, SSB/SSB was usable in this flat Rayleigh fading environment, its required total spectrum would only be about one half that needed for the proposed SSB/FM system.

2.3.5 Receiver Intermodulation

It is claimed that SSB/SSB has an intermodulation interference that is from 45 to 60 dB higher before demodulation than for SSB/FM and that the capture effect of SSB/FM gives it an even greater advantage. Likewise, FM/FM and FM/SSB should be unaffected by intermodulation interference unless other multiplex transmissions of approximately equal strength originate from the same base station where the intermodulation interference could again be 45 to 60 dB higher than for SSB/FM.

2.4 Comments

A disconcerting aspect of the whole appendix on "alternative system concepts" is that only one direct reference is given. In fact, outside of the above reference, I don't believe that the whole technical report makes reference to work done outside the Bell System.

3. MOTOROLA, INC.

Alternative system concepts by this company are taken from Appendix 3 of their submission to the FCC on December 20, 1971 [2].

3.1 Techniques Applicable to Multi-channel Systems

They feel that the costly power trade offs at 900 MHz will necessitate high transmitter sites with a consequent premium on available space such that the luxury of one antenna per transmitter cannot be afforded. Thus, they maintain that any multi-channel system must use a minimum number of antennas per system. The following candidate systems are considered:

3.1.1 Combining on Single Antenna
3.1.2 Common Power Amplifier
3.1.3 FDM/FM Multiplex
3.1.4 Single Sideband/Master Carrier System
3.1.5 Time Division Multiplex

3.1.1 Combining on Single Antenna

A common technique for combining multiple transmitters on a single antenna is that used by the Bell System with their IMTS mobile telephone system. This consists of several levels of approximately 3 dB isolation pads; the number of pads halving at each stage from the transmitters to the antenna. For possible systems at 900 MHz the transmitters were limited to four 500 watt units on a single antenna giving 100 watts of power from each transmitter into the common antenna.

3.1.2 Common Power Amplifier

A twenty-channel system is analyzed here to show that the peaking phenomena of common power amplifiers along with reasonable intermodulation specifications for these amplifiers requires amplifiers rated at unreasonably high powers in order to maintain acceptable adjacent channel interference levels. This is true, according to the analysis, even when a guard band as wide as the occupied spectrum is used between the groups of channels. They maintain that there is little practical hope for a common amplifier approach.

3.1.3 FDM/FM Multiplex

This technique of combining several SSB channels together to FM modulate a single carrier solves the common antenna problem very nicely; however, it is not considered to be a good candidate for the mobile telephone environment for the following reasons:

1. Frequency-selective fading produces occasional severe distortion in the higher subchannels regardless of transmitter power (this is characteristic of multiplicative channel distortions).

2. Danger of interference to channels in other blocks if the deviations are not properly controlled.

3. Poor signal-to-noise ratios in the higher subchannels.

3.1.3.1 Field Tests

A field test comparing a 20 channel FDM/FM system with a composite modulation index of 0.35 with a conventional single channel narrowband FM (5 KHz deviation) system was made. Receiver noise figures were the same for both systems. These field tests substantiated numbers 1 and 3 of the reasons given above for the FDM/FM system not being a good candidate system.

3.1.4 Single Sideband/Master Carrier System

In the interest of possible spectrum economy and erasure of the common antenna problem an SSB multiplex system with a master reference carrier was considered. This system was considered to not be usable for the following reasons:

1. Flutter interference due to fading.
2. Poor signal-to-noise ratio performance.

3.1.4.1 Field Tests

Listening tests comparing this multiplex system to the reference narrow-band FM system were made and found to be disappointing. The tests substantiated items 1 and 2 above. The master carrier AGC system tends to reduce the effects of flutter fading on the lower subchannels but only up to about 20 KHz. In any case, the noise rise in the fades was considered to be very objectionable. Because of the poor performance, work was discontinued on this system.

3.1.5 Time-Division Multiplex

Time-division multiplexing (TDM) voice channels utilizing either digital or analog samples was considered. However, digital modulation with TDM requires much greater bandwidth than analog systems for good quality speech transmission. At least 50 kHz of bandwidth per voice channel is required for any reasonable quality. For a well-behaved channel analog samples of voice signals would require much less bandwidth than for digital voice. However, when one matches this modulation to the 900 MHz mobile environment and practical filters considerable bandwidth must be utilized in order to reduce cross-talk to acceptable levels.

Motorola indicates that, even though the multiplexing techniques previously mentioned above do not have merit, they have been investigating a new multiplex technique that may be promising for the 900 MHz mobile environment. No indication of what this technique may be is given. However, they indicate that this technique is under investigation and is being field tested. When the tests are complete it will be reported on.

4.1 EIA

This section will summarize appropriate points of the submission to the FCC [3] concerning Docket 18262 by the Land Mobile Communications Section of the Industrial Electronics Division of the Electronic Industries Association (EIA).

4.1 Frequency Modulation

They concluded that frequency modulation provides the optimum spectrum utilization in the land mobile service.

4.2 Multiplexing

Multiplexing and other forms of modulation have been considered as a means of improving spectrum utilization. The Section concludes that although other forms of modulation can theoretically increase the number of channels in a given segment of spectrum, FM provides for optimum spectrum utilization when sharing in time, frequency, and geographically. In other words, it should maximize mobiles/MHz/Unit Area, a true measure of optimum spectrum usage.

4.3 SSB at UHF

Their conclusion is that SSB, whether single channel or multiplex, would give unacceptable performance for the Land Mobile Radio Services. Two prime reasons for this are given. First is the required frequency stability of 1.5 parts in 10^8. This, although achievable, would be expensive. The second reason is more compelling (cannot be eliminated by sophisticated designs). This has to do with the flutter fading of the signal. For example, this fading rate is given to be 172 Hz for a vehicle traveling at 60 mph. This fading rate and its first few harmonics will be detected and will fall into the audio band. At these high flutter rates AGC techniques cannot work without causing severe speech envelope distortion.

1. Bell Laboratories (1971), "High-Capacity Mobile Telephone System Technical Report," December.
2. Motorola, Inc. (1971), "Technical and Marketing Data on System Design and User Needs at 900 MHz," Docket 18262, December 20.
3. Electronic Industries Association (1969), "Comments of the Land Mobile Communications Section of the Industrial Electronics Division of the Electronic Industries Association." Submitted to the FCC Concerning Docket 18262, February 3.

March 31, 1972

Mr. Tom Kain
Motorola, Incorporated
1301 Algonquin Road
Schaumburg, Ill. 60172

Dear Mr. Kain:

The basic objective of the work I am doing is to arrive at costs for representative system configurations which can be used at 900MHz. Cost models based on this data will enable us to compare alternative systems on an economic basis. This study, of course, is being done for the Office of Telecommunications Policy to support their evaluation of the issues presented by FCC Docket 18262.

Costs for components which are common to presently used systems are on hand, but the costs of receivers, transmitters, transceivers, and supervisory equipment for proposed 900MHz systems are needed. Specifically I would like to have the estimated costs of the following components in projected quantity production.

1. Mobile Transceiver with supervisory package in the following power capabilities: 10 watts, 20 watts, 30 watts, 50 watts.
2. Mobile package as in 1, with 12 channels-20 channels, 800 channels.
3. Base Station Transceiver in power levels of 10 watts, 20 watts, 30 watts, 50 watts, and 100 watts.
4. Base electronic supervisory equipment for channel assignment, ringing, dialing, etc.
5. Cost of repeaters.
6. Cost of satellite receivers.

I would appreciate very much the opportunity to visit with your technical personnel regarding the above. Dale Hatfield, of the Office of Telecommunications, would like to accompany me. He is in charge of the Boulder effort and has previously met with Jim Mikulski, of your Systems Research Lab, with regard to computer simulation models.

Sincerely,

Wesley B. Harding

WBH:ded

Copy to: Art Cooke, OTP, Wash.

SP

Spectrum Policy

October 21, 1971	Berry and Ewing submitted preliminary thoughts concerning program for this area to Hinchman. (SP1)
November 2	Meeting with Hinchman, Thompson, Lynch, Lasher, Berry, and Ewing.
	Of interest are: a measure of how much a user uses this resource, definition of user rights--considering the TEMPO report results, what portion of the electrospace is occupied, analysis of the communications resource using the geostationary orbit, and a study of the earth station network. (SP2a,b)
December 3	Ewing submitted suggestions concerning orbital communications capacity in response to Nov. 2 meeting. (SP3)
December 9	Meeting with Berry, Ewing and CSC personnel to discuss CSC computer program on Communicaton Satellite Costs. (SP4)
December 10	Meeting with Hinchman, Ewing, Berry. CSC program not of high priority. Presented the need to determine the electrospace unused, e.g., in a metropolitan area. (SP5)
December 27	Letter from Ewing to Lynch discussing progress in furthering ideas of Dec. 3 paper in light of Dec. 10 meeting. (SP6)
January 14, 1972	Berry submitted paper, "Metropolitan Spectrum Availability Study" to Hinchman. (SP7)
	Contacted ECAC concerning availability of frequency and equipment data. (SP8)
February 3	Schedule of tasks for assignment policy for the geostationary orbit submitted to Lynch. (SP9)
February 22	Request to Cohn to obtain frequency data. (SP10)
March 3	Justification for frequency data needed from Dean submitted to Hinchman. (SP11)
March 13	Summary of work in defining Orbit Rights and Value submitted to Hinchman. (SP12)
March 16	Further definition of orbit rights submitted to Hinchman. (SP13)

March 22	Review of orbit value project by Hinchman. (SP14)
March 29	Further review of orbit rights project submitted to Hinchman. (SP15)
March 31	Comments concerning orbit rights and orbit value projects submitted to Hinchman. (SP16)

October 21, 1971

Mr. Walter R. Hinchman
Office of Telecommunication Policy
Executive Office of the President
Washington, D. C. 20504

Dear Walt,

Enclosed are some rough notes which are the result of some of the thinking Don and I have done in the area of spectrum allocation. I would like to emphasize that these are merely working notes developed in an attempt to define the problem and a plan of attack, and are subject to revision as we proceed.

We hope to discuss these with you and benefit from your advice when we come to Washington the first week in November. If you want to comment sooner, just call.

Sincerely,

Leslie A. Berry

OT
ITS
Chrono.
Subject
bcc
LAB/pm (10-21-71)

Berry: 10-15-71 DRAFT

How should the electrospace be allocated?

An answer requires an understanding of what is being allocated; what the value of the space is; and how allocation is related to actual use. Notice that I have assumed that the spectrum must be allocated--that is, that a completely free, competitive market for electrospace is not an immediately feasible alternative. (See final page of this draft.)

1. How is the electrospace allocated now?

This question must be answered because one of the possible answers to the main question is to continue with the present system. More realistically, any change will have to be sold on the basis that it is better than the present one, and a detailed understanding of the present system is required before a persuasive argument can be constructed.

1.1 How is it now allocated internationally? nationally? in government? non-government? What are the mechanisms, who are the decision makers, what are the salient considerations? Are the considerations different in broadcasting and land mobile, in microwave relay and radar, etc?

1.2 What is now allocated? What are present units? Are input rights or output rights granted? Is the answer the same for government and non-government allocations? Is it the same for different services--for example, in land mobile and broadcasting?

1.3 What are the proposed suggestions for changes in what is allocated and now it is done? Why have these suggestions failed? (or succeeded?) How do they relate to each other? What are the criticisms of them? Have they been tested in specific areas?

1.4 What are the constraints on changing allocation procedures (political, economic, institutional, operational)?

2. What are the units (or dimensions) of the electrospace?

2.1 The units should be technical--that is, they should describe the space rather than the value of the space. I think we cannot solve all of the allocation problem just by a sufficiently clever selection of a unit. If we have a good technical unit, we can then proceed to the value question in terms of dollars per unit, or social value per unit, or whatever. It then follows that it is not necessary for every unit to be of equal value regardless of location, nor must the unit describe all rights associated with the space. The unit simply measures the space.

2.2 What components for the unit are there? Frequency? bandwidth? power? shape of illuminated area? polarization? time?

2.2.1 Is time important at the character length scale?
at the message length scale?
at the hour or day length scale?

2.2.2 Is modulation a part of the unit?

2.2.3 Should the unit be scalar (everyone seems to have assumed so) or vector (which I think it now is)?

2.3 Are the most appropriate units for allocation and sharing the most appropriate ones for computing value of the resource?

2.4 Proposed units should be applied to a number of different systems and services--land mobile, broadcast, radar, microwave relay, satellite--to test their practicality, generality, completeness, etc. They should be able to be measured (for enforcement and/or legal protection purposes).

Can the units be determined from information now filed with the FCC, IRAC, IFRB, etc. ?

3. What is the value of the electrospace?

Unless or until a free market is established (not near) we need to know the value so we can make rational decisions--so we can optimize the allocations in some sense. (Maybe not, we might choose to make rational decisions on the basis of technical efficiency alone.)

3.1 What is the <u>economic</u> value, in dollars per unit of space? as a function of geographic location, time, frequency, etc. ?

3.1.1 How can this value be calculated--plant investment? revenues generated? substitution cost? present market price (possible for broadcast licenses maybe)? To begin to generate answers we could do a number of case studies. A "case" would be a study of the value (or values given by the various methods above) for say, AM radio, or TV, or microwave relay, or weather radar, etc. Displaying these cases, say as scatter lots of values as a function of electrospace unit might suggest trends, identify gross inequities, areas of opportunity, etc.

3.2 Does the electrospace have values which are not economic? what are they? Is it possible to transform them to economic values? If not, ho. can they be entered into tradeoff and sharing analyses?

4. What is the relation of allocation to equipment and operating standards, to sharing and emc problems, to spectrum engineering?

Berry: 10-15-71 DRAFT

Spectrum Resource Allocation

Why should the electrospace (spectrum resource) be allocated? This could be approached as a philosophical question to be answered either immediately on the basis of personal biases towards government control, or after long and subtle analysis of the nature of the resource and of man. However, a practical answer, sufficient for the next five years, is that it must be allocated because it has been allocated. That is, government actions and the business response during the past 40-50 years have produced a numerous, affluent, and therefore, powerful establishment which benefits from the exclusive spectrum rights granted to them free by the government, and protected by law. Opponents of government allocation of the spectrum, who would create instead a free market for it, are too few and too powerless to force an immediate change of policy and behavior.

What coalition would it take to make such a change? Probably at least the OTP (with the President's support), the FCC, and a majority of Congress. And the conviction would probably have to be sustained over several years while the change was challenged in court. At this point, that scenario seems unlikely.

So even if the goal of a free spectrum market is desirable, it can only be achieved by a gradual transformation over a number of years. The transformation might begin with the replacement of rigid block allocations with flexible, regional allocations (which many people recognize as necessary) and with minor deregulation in selected areas (such as that proposed by Whitehead for AM broadcast). It might proceed to charging fees for spectrum use which are proportional to a measure of the value of the spectrum used, and to allocation procedures based on quantitative analysis of the relative value and benefits of various proposals. More flexible rights of subdivision, subleasing, and sale of rights might be granted in some areas of the spectrum. Gradually, the gap between accepted practice and a free market would narrow until it could be leaped.

WORKING PAPER - D. Ewing - October 7, 1971

VALUE OF THE RADIO RESOURCE

It goes without question that the radio resource is valuable. The value of a particular portion of the electrospace is dependent on the number of claimants and the intensity of the need they feel for it.

It is often stated or implied that the objective of electrospace allocation is to allocate the resource to its highest valued use. The value of a particular use must be estimated considering economic, social, and technical interactions. Making such an evaluation is most difficult. It is somewhat difficult even to clearly delineate criteria for evaluating a particular allocation. Though there are countless methods of evaluation it is extremely difficult to devise one representative of national priorities.

One must recognize that an informal evaluation of electrospace use is in operation at the present time and is expressed to some extent by the way the electrospace is currently allocated. The value currently placed on a portion of the electrospace finds expression through a myriad of lobby pressures, social pressures, economics, and spectrum engineering. Perhaps the most significant component of its expression is, however, the fact that there is considerable and growing dissatisfaction with current allocation procedures. The present allocation system of free licenses has no mechanism for letting claimants express the intensity of their need other than the lobby mechanism. Specifically, claimants to the spectrum cannot communicate a dollar value expressive of their need. Perhaps some of the problems in placing a value on the resource can be illustrated by an example. Suppose that two 10 kHz bands are to be licensed by auction for a given time period, say for 3 years. The bands are at 100 kHz and at 10 GHz.

QUESTION: Which of the two bands will bring the highest price? That is, which is more valuable?

The first reaction of many would be that the lower band has more value. Why?

Let us be somewhat more specific about what it is that is being leased. That is, we shall describe the commodity in somewhat more detail. First we assume that the highest bidder will have full access to these frequency bands anywhere in the United States. (We assume for simplicity that there are no real international problems.) We will also assume that subleasing is allowed.

Suppose now that A wants to "cover" the United States, and that B wants to establish a link between San Francisco and Portland. It seems clear that A will want the lower frequency because there he would be able to cover the country with a small number of transmitters, while if he leased the higher band a larger number of transmitters would be needed. Thus for A the lower band has more value; he would be willing to bid higher on the lower band than on the upper band. On the other hand, B will be interested primarily in the higher band, because there he would be able to set up his link and sublease this band in the remainder of the United States. The lower band would be less suitable for B's purpose for there he would not be able to sublease as large an area, nor would he have nearly the number of possible sublease possibilities.

We have established that the value is subjective, that is, because A and B have different needs they value the bands differently. If only A and B attended the auction, the lease would go for a token price. Assuming there are many A's and many B's however, the auction would give some indication of the value. We have not answered the question of the relative values of the bands. We do not know what the high bids would be.

CONSIDERATIONS:

1. In the example, the reason that A and B have different evaluations of the bands centers on the PROPAGATION CHARACTERISTICS at these frequencies and the EQUIPMENT COSTS.

2. The value to the nation may not be expressed by the highest bids. Technical and social considerations are not the primary considerations to the bidders. However, if Adam Smith's "invisible hand" is operative the highest bids do in fact represent the values relative to national priorities.

3. We are accustomed to viewing the spectrum on a logarithmic scale and there it appears that the lower band is a larger piece of the spectrum. However, from an information theoretical viewpoint the two bands have the same information carrying capacity.

4. There are 27 such bands in the LF band (30 to 300 kHz) but 2,700,000 such bands in the SHF band (3 to 30 GHz). This is a ratio of 100,000 to 1 in the supply of 10 kHz bands at these frequencies. It is doubtful that the demand for SHF bands over LF bands comes anywhere close to this ratio. This may be the single most important factor to consider for the question posed.

5. Satellite technology could possibly allow A to "cover" the United States at 10 GHz, hence A may have some interest in the higher band. However, considering equipment and logistics costs, he would likely still prefer the lower band.

Since my thinking regarding the VALUE OF THE RADIO RESOURCE has not progressed to the point where a concise definitive statement can be made, I will conclude this working paper by posing two further questions.

QUESTION 1. What does VALUE of the electrospace have to do with methods of allocation?

It may be helpful to examine two methods of allocation which appear to be extremes. One is the current allocation method of essentially "free" licenses. It is recognized that these licenses are not really free, since regulators control the use of the license to some degree (eg. TV program content). However, this allocation method assumes that a government agency can allocate the resource in an optimum way according to specified criteria. The criteria must be broad enough to implement national goals regarding telecommunications. For such a method to be totally effective, the criteria must allow comparison of any two allocations and a best allocation chosen. This is nearly tantamount to saying that a utility function can be established which gives the national utility for each possible allocation. The difficulty in finding the value of the spectrum lies in the fact that its utility is not easily measured in dollars. Although this utility function would put relative values on each allocation, it is not evaluating pieces of electrospace as in the previous example. We should note that to be totally effective such a utility function must be time dependent for flexibility.

Another extreme is the market system where electrospace "property" is initially auctioned to the highest bidder and subsequently owners are allowed to subdivide, their property. This method of allocation presupposes that electrospace rights can be established which are legally enforceable and which easily permits buying, selling and subdividing the commodity. Under this method of allocation, there is no real need to evaluate portions of the resource, other than to observe the market value, once the market has been established.

Between (or perhaps to the side of) these two allocation methods, lie methods such as licensing for fixed (not auctioned) fees, license by auction, license by auction where subleasing is allowed, and combinations of the above. All have advantages and disadvantages. Although the difficulty in implementation varies, implementation will be difficult in any case and possible only gradually. Clearly, there is an advantage to any system where the value of portions of the electrospace can be expressed by an auction or market. The question then is, "Does an auction or market allocation method allocate the resource to its highest nationally valued uses?"

QUESTION 2. What kinds of VALUE SYSTEMS are there relative to allocation methods?

It seems to me that there are at least three value systems in operation when one considers the overall problem of methods of allocating the electrospace.

First, there is the value of the electrospace as a whole. This value is relative to other national resources and must often be considered regarding resource tradeoffs. Also, it seems to me that this type of value is operative when we are using a utility function comparing allocations. That is, the ideal allocating agency would use such a evaluation to comparing allocations. This evaluation must implement national goals concerning telecommunications.

Secondly, there is the value of portions of the resource as represented by an auction or market. Perhaps it is also possible to come up with this type of evaluation by shadow pricing. This value is a function from the electrospace to dollars as expressed in my

August 25, 1969 draft paper, Consumption of the Radio Resource. Units of value here are measured in dollars per unit electrospace, however, the value varies over the electrospace. The GE Tempo report comments (p. xiii) that although several methods have been proposed to measuring the amount of "electrospace" used, none have given an associated economic value to various portions of the resource, as is needed for allocation and assignment decisions.

Thirdly, there are evaluations made of the resource by individuals as indicated in the beginning example. Although individuals evaluate portions of electrospace differently because of differing needs, we pointed out that collectively they can determine a market value. An important concern of the resource manager is the interaction of these value systems.

U.S. DEPARTME[illegible] OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

SP2a

Date: November 8, 1971

Reply to Attn of:

Subject: Meeting with Walt Hinchman, OTP, November 2, 1971 to discuss PSD activities in the area of Spectrum Allocation Policy

To: Spectrum Policy Project File

Present at the meeting were Walt Hinchman, Cecil Thompson, Mike Lynch, and Seb Lasher of OTP and Les Berry and Don Ewing of OT/PSD.

The following are three directives (as I understood them) resulting from the meeting.

1. There is a need to investigate ways to measure "how much" a user of the electrospace uses this resource. Preferably this measure could be given at least initially without use of probabalistic methods. Closely related to this problem is the problem of defining user rights. Can anything simple be done to alter the rights package of the TEMPO report so that maximum signal levels on "boundaries" can be replaced with something more cognizant of the nature of electromagnetic waves?

2. A "methodology" is needed to display what portion of the electrospace is occupied and to answer the question, "Who must be negotiated with if I place a transmitter here"? Walt said that if we come up with such a methodology, then a case can be made for decentralizing telecommunications management.

3. A possible short term project to give a feel for the overall spectrum resource problem would be to analyze the communications resource using the geostationary orbit. How much of this resource is now planned for or is in use in comparison to the total orbital communications capacity?

Other comments that may be worthwhile listing are the following:

1. Another possible short term study might be the earth station network?

2. We should not spend undue time understanding or describing the current allocation system.

3. OTP has not given this problem detailed thought. These questions have been more something they have thought about "late at night".

Donald R. Ewing

Donald R. Ewing

U.S. DEPARTMEN OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

SP2b

Date: November 9, 1971

Reply to Attn of:

Subject: PSD Washington visit, November 2-5, 1971

To: Spectrum Policy Project File

1. Spectrum Resource Allocation Policy

Don and I met with Walt Hinchman on November 2, also present were Seb Lasher, Mike Lynch and Cecil Thompson. Walt wants us to:

a) Define the resource - its dimensions or relevant factors, and a unit which can measure quantity. He believes that this is essential to any further progress.

b) Describe "rights" which might be allocated, sold, leased, or whatever. These are distinct from units of resource, but are stated in terms of the units. Consider possibilities of input rights and output rights. Consider the effect on spectrum value and use of various definitions of rights.

c) Determine the data and procedures necessary for allocation using the definitions of the electrospace and rights chosen in a) and b). These would include the record-keeping and retrieval systems necessary. (Here, Walt sounded surprisingly like a spectrum engineer - his examples seemed to be close to EMC.)

d) As a special case which could have short term payoff, and will certainly illuminate the problems and potential of the approach, Walt wants us to carry out steps a) - c) for the satellite communications case. He would like to know what the maximum capacity for communications satellites is (under various assumptions) compared to the present and proposed allocations. We could also attempt to determine the value of the electrospace for this service.

e) In the afternoon, Don and I spent a couple hours with Mike and Cecil, who will be our immediate contacts in this area. They are economists. We started learning each other's language.

ACTION ITEM: Mike would like an account on our time share system.

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

SP 3

December 3, 1971

Mr. Walt Hinchman
Office of Telecommunication Policy
Executive Office of the President
Washington, D. C. 20504

Dear Walt,

At our November 2 meeting you suggested that investigation of the orbital communications capacity would be an appropriate sub-problem to get a feel for the larger problem of radio-resource use and potential.

The first obvious statement worthy of expression is that there is no least upper bound to geo-stationary orbit capacity. Rather, there are tradeoffs which must be considered relative to "spectrum engineering" and "economics".

There are several articles treating the "spectrum engineering" aspects. Their overall goal seems to be to maximize the channels per degree of orbit per megahertz. Possibly the most useful for our purpose is Jansky and Jeruchim, "Technical Factors and Criterion Affecting Geostationary Orbit Utilization", AIAA Third Communication Satellite Systems Conference, April 1970, p. 563. This paper deals almost exclusively with FDM/FM telephony systems. The further restriction of the problem to these systems seems acceptable since these constitute the majority of proposed systems and our purpose is to analyze a tractable problem. Since the economies of the orbital capacity is not treated, I feel that a worthwhile effort could be made at integrating cost factors into the analysis of orbital capacity.

The enclosed attachment (1) briefly describes the Jansky-Jeruchim paper, giving a capacity graph not contained in the report, and (2) briefly describes a methodology to relate capacity and cost.

Les Berry and I plan to be in Washington on December 9 and 10. Perhaps we could discuss further plans at that time.

Sincerely,

Donald R. Ewing
Boulder Policy Support Division

There are two major equations obtainable from the Jansky-Jeruchim paper.

TRADEOFF EQUATION

$$(1 + 9.5\, M^3)\, N_i (D/\lambda)^2\, \theta^{2.5} = C$$

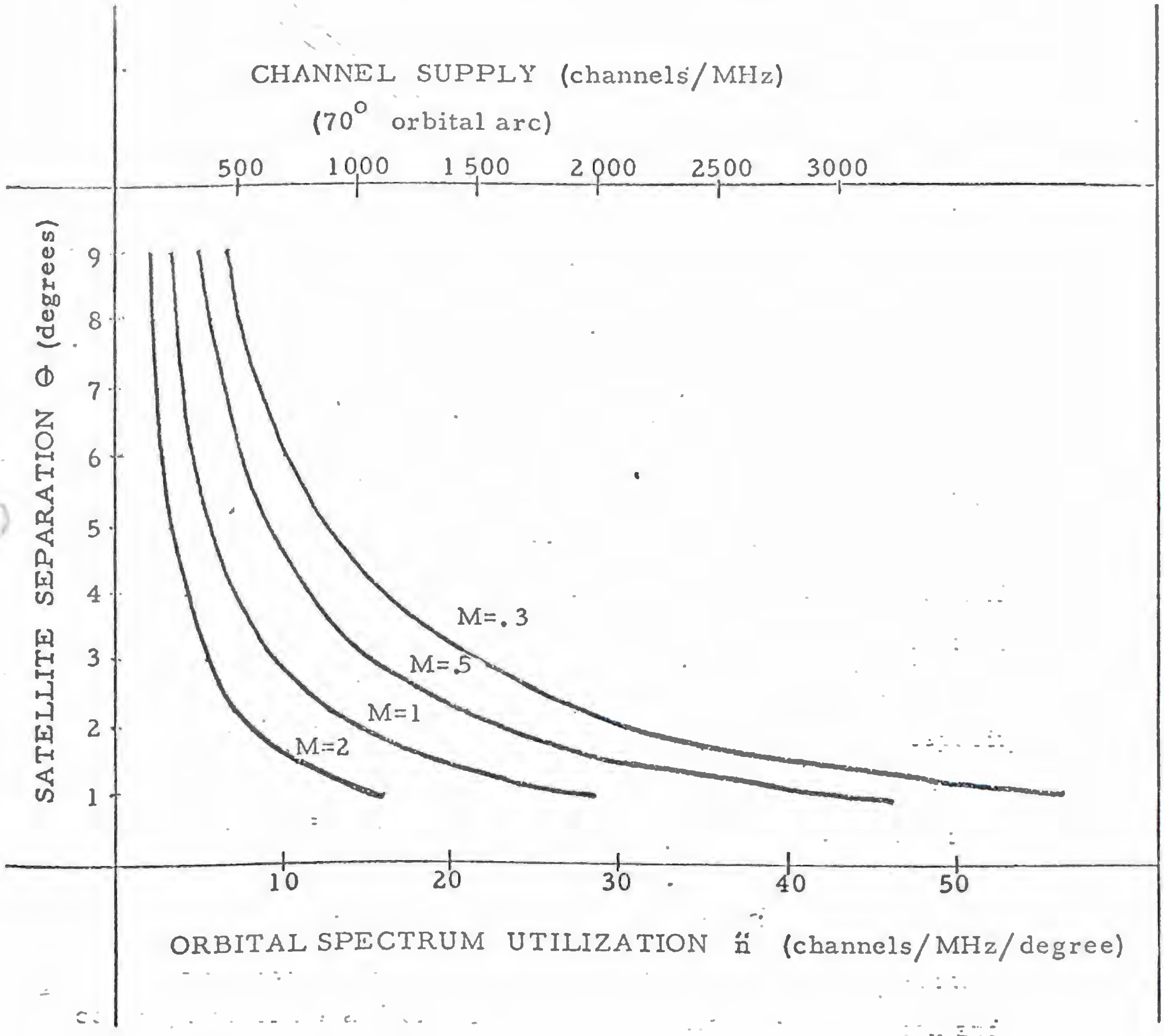
ORBITAL SPECTRUM UTILIZATION EQUATION

$$\ddot{n} = \frac{\dot{n}}{\theta} = \frac{119}{(\sqrt[4]{10}\, M + 1)} \left[\frac{(1 + 9.5\, M^3)\,(D/\lambda)^2\, N_i}{C} \right]^{0.4}$$

M	=	rms modulation index of the multichannel baseband
N_i	=	interference noise in pW0p
D/λ	=	ratio of earth station antenna diameter to wavelength
θ	=	satellite separation in degrees
C	=	a "constant" depending on the polarization and offset isolation parameters. If 14 and 10 dB are used (respectively) then $C = 2.036 \times 10^9$.
$\dot{n}$	=	$119/(\sqrt[4]{10}\, M + 1)$, the satellite channel capacity in channels/MHz (per satellite)
$\ddot{n}$	=	a measure of orbital spectrum utilization in channels/MHz/degree

Both equations are downlink equations and assume earth coverage antennas and uniform systems utilizing polarization and offset isolation. They represent the state-of-the-art maximum satellite communication capacity with FDM/FM telephony systems. The engineering tradeoffs are discussed in detail in the paper and summarized in figure 3, page 587.

The following graph gives an idea of the geo-stationary capacity.



The first equation is a tradeoff equation because from a cost or spectrum utilization standpoint each of the parameters on the left should be made as small as possible; yet one parameter cannot be reduced without increasing the others. Basically the tradeoffs are between cost, reliability, and resources used, although the paramters in the equation are not exclusively any one of these.

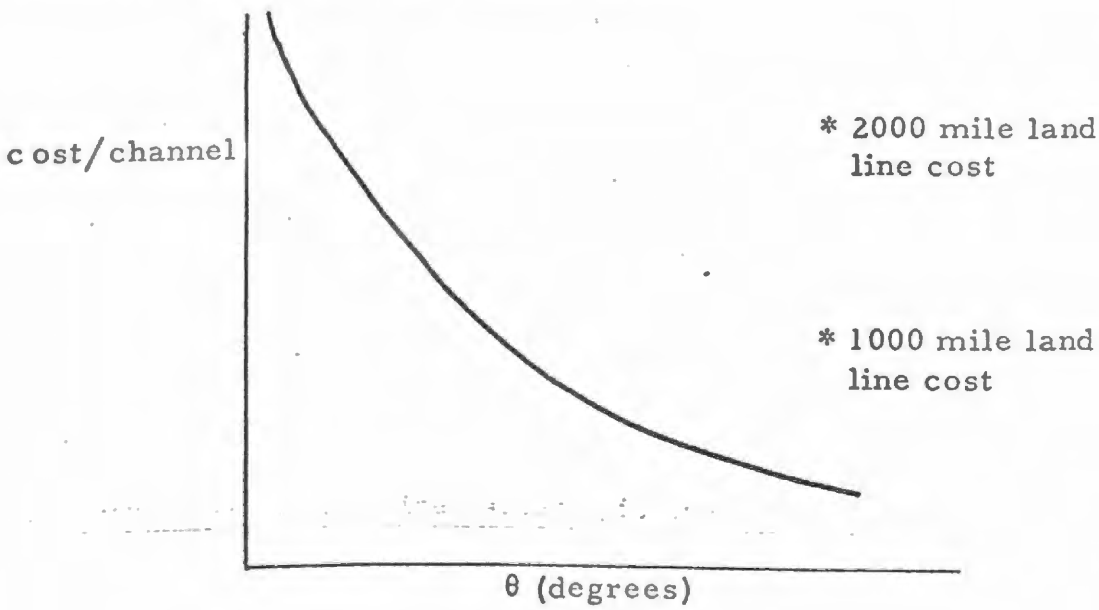
We see from the <u>utilization equation</u> that $\dot{n}$ can always be increased by increasing M, D/λ or N_i (which decreases θ). Hence, theoretically there is no upper bound. The task then becomes one of minimizing cost or at least relating cost and utilization.

If good satellite system cost information can be obtained, tradeoff equation parameters M, N_i, and D/λ can be chosen to minimize system cost, for fixed θ.

A possible methodology for computing the minimum cost per channel as a function of satellite spacing is

1) derive a cost function $C(M, N_i, D/\lambda)$, and
2) use the method of LaGrangian multipliers to minimize cost per channel subject to the tradeoff equation constraint.

Regardless of the minimization technique used, the result would be a graph such as shown below.



It may be instructive to plot the values of M, N_i, and D/λ yielding these "minimum costs". Another possible chart resulting from these calculations is a plot of cost per channel vs. capacity.

U.S. DEPARTMENT OF COMMERCE
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Boulder, Colorado 80302

Date: December 21, 1971

Reply to Attn of:

Subject: Meeting at Compter Science Corporation with George Knouse, John Spoor, John Illgen of CSC, Les Berry, and Don Ewing of PSD on Dec. 9, 1972

To: PSD File

We went to CSC believing that they had an improved GE computer program which estimated communication satellite cost.

We were given an overview of major CSC programs, then specifics of their Broadcast Satellite Cost Study for NASA. They described their program as a study of performance/cost tradeoffs, including sensitivity analysis. Their estimates are for the downlink of a broadcast satellite, specifically aimed at the India broadcast system. The analysis includes satellite, link, and ground costs and performance. The satellite cost is "minimized" over EIRP (which is directly related to satellite weight). The ground cost is minimized over antenna diameter (?).

CSC feels that their program has advantages over the GE program in that (1) they are not a "hardware house", hence are more objective, and (2) their cost estimates are more firmly based on data. They claimed that GE cost estimates were overly optimistic.

An obvious deficiency of their program is that it is tailored only for one system, that system not being of particular interest to us. A rough estimate of 1 man-year effort was made for altering the program for an FDM/FM system considering uplink and downlink and more complex receiving terminals.

Donald R. Ewing

Donald R. Ewing
Boulder Policy Support
Division

December 22, 1971

Donald R. Ewing

Meeting with Walt Hinchman, December 10, 1971

PSD file

Les Berry and I met with Walt from 2:30 to 3:30. The major items were:

1) PSD will soon be asked to give OTP short term task definitions including time schedules.

2) We discussed Bud Thompson's forthcoming work proposal. He wanted to review the proposal before a committment was made.

3) We reviewed the meeting with Computer Science Corporation the previous day. He suggested that this effort NOT have top priority. He was especially concerned that a two way system with multiple access, etc., would be a much larger job than they indicated to us.

4) We discussed in length the activity in the Spectrum Policy Area. Walt feels that it is important to be able to identify those areas of the electrospace that are unused (or unassigned). A demonstration is needed to visualize how much of the resource is in fact unused. He suggested that a way to begin would be to choose a metropolitan area where spectrum "crowding" is severe, then somehow display the used and unused portions of the spectrum. Perhaps an emphasis should be placed on the method of "display" since this is part of an educational process. He emphasized again the importance of dimensioning the electrospace and being able to measure its use. He feels this exercise would be a good beginning on the problem, since in this "simple" exercise we will be forced to decide which dimensions of the electrospace are the important dimensions, and much will be learned by it. Walt also briefly discussed the possibility of building some kind of a display model which would illustrate the multidimensional character of electrospace.

December 27, 1971

Mr. Michael Lynch
Office of Telecommunications Policy
Executive Office of the President
Washington, D.C. 20504

Dear Mike,

As a result of our discussions December 10, I felt that I should see what I could do to help you relate the tradeoff parameters to cost items as discussed in my December 3 letter to Walt Hinchman. I will be working at this, but now I can only send a copy of the Jansky-Jeruchim report.

I have had a timeshare computer program written and entered in your account, file /ML/, which allows sensitivity analysis on the tradeoff equation. For each set of values satisfying the tradeoff equation, the following are also calculated:

$\dot{n}$ telephone channels/MHz/satellite

$\ddot{n}$ telephone channels/MHz/orbital degree

the total number of telephone channels possible using 85 degrees of orbit and 40 MHz bandwidth.

Enclosed are the following which I hope will be helpful:

1) The Jansky-Jeruchim paper
2) A sample run on the timeshare computer
3) A graph giving the ratio of antenna diameter to wavelength--an input to the computer program.

Sincerely,

Donald R. Ewing
Policy Support Division

Enclosures

METROPOLITAN SPECTRUM AVAILABILITY STUDY

1. BACKGROUND

For the past 20 years there have been recurring reports that we are running short of radio spectrum space, and that we must start setting priorities and rationing spectrum to the most important or most economic uses. Recently there have been counter arguments that we are not really short of spectrum space (or electrospace) but that if we define the space with a sufficiently large number of dimensions (including time, polarization, direction, etc.) and use sufficiently sophisticated spectrum engineering techniques and sufficiently large data bases we will be able to fit in many more users. Some accept the argument that the electrospace is scarce, and propose that a spectrum market or pseudo-market be established to distribute the resource in an economically efficient way.

There is yet another alternative--that in fact there is a great deal of empty spectrum space under simple definitions of the space, and that existing data bases are adequate, but rigid administrative procedures (allocation tables) cause an apparent shortage of spectrum.

2. SPECIFIC OBJECTIVE

Determine the proportion of unassigned spectrum between 50 MHz and 1 GHz in a large metropolitan area, using simple definitions of electrospace, available data, and conservative assumptions.

Present the quantitative results in a way which effectively displays the possible allocation policy alternatives.

3. STUDY BENEFITS

The study will provide specific, detailed quantitative information on the amount of spectrum available (under various alternative allocation policies) in a "congested" metropolitan area. It will indicate whether sophisticated data bases and spectrum engineering are necessary now, or whether relaxation of rigid allocation policies would release large electrospace territories for development.

The methods for retrieving and analyzing assignment data can be extended to study other regions of the electrospace.

Comparison of the results with actual electrospace occupancy measurements made or contemplated by other agencies will provide further insight into the options open to spectrum allocators.

4. APPROACH

We will choose a simple definition of electrospace acceptable to all, and a large metropolitan area. Using conservative assumptions about propagation and assuming that all assigned frequencies are in use all the time, we will inventory the electrospace in that area. We will then determine how much of the available electrospace is being used in various bandwidths, not necessarily corresponding to service bandwidths.

The unit of electrospace we will use will be the power density as a function of location and frequency only: $P(\overline{r}, f)$, where $\overline{r}$ is a space vector (its components would normally be latitude, longitude, and height) and f is the radio frequency. To simplify visualizing P, consider only two space dimensions ($\overline{r} = (x, y)$) so that P is a function in a three-dimensional (x, y, f). (See figure 1 below.) A physical analogy to P might be the density of a gas in real space.

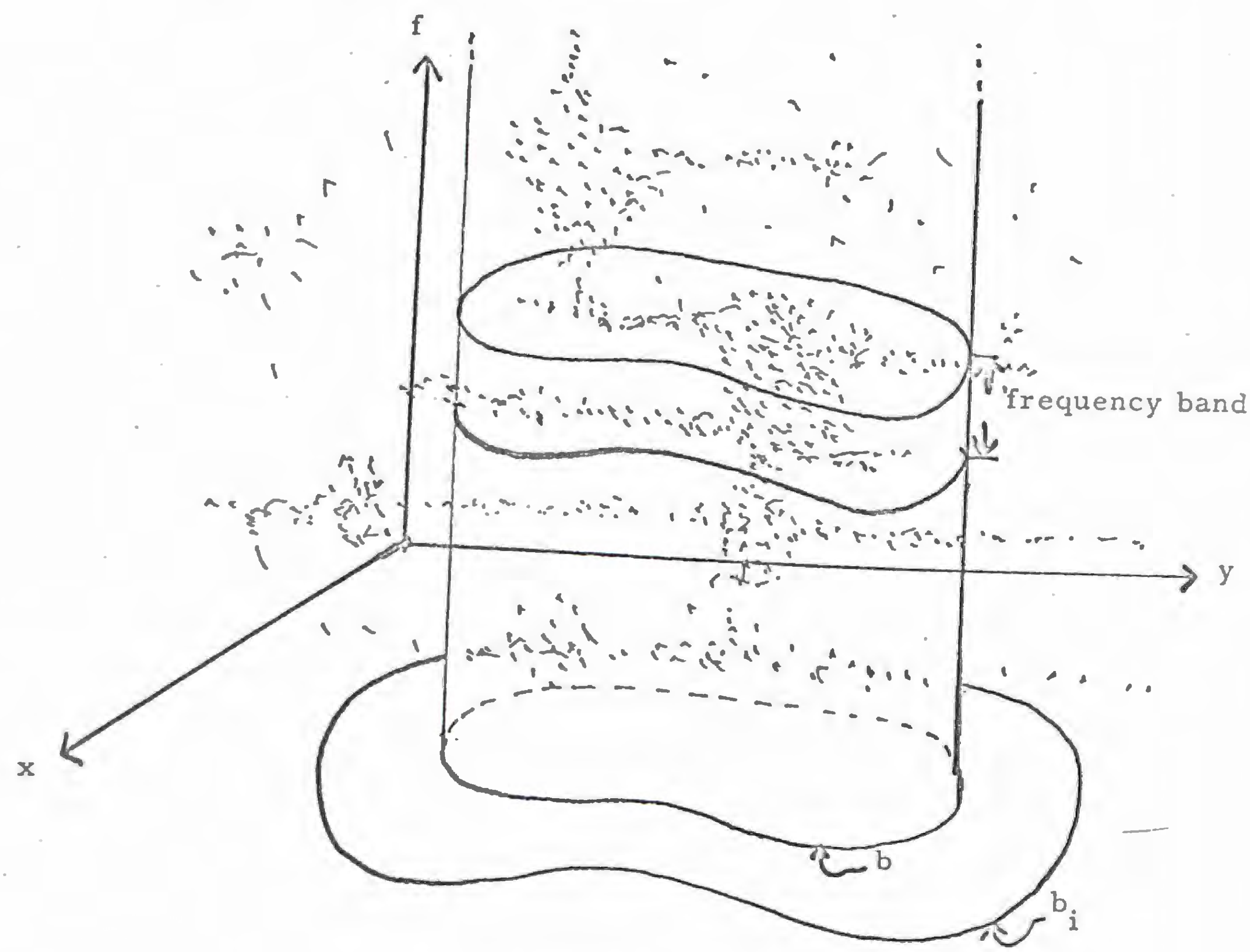

Figure 1

We could produce the following types of displays to achieve the desired accuracy.

OUTPUT 1 — Area Map of Power Density for a Fixed Frequency
This is a horizontal slice of the previous figure.

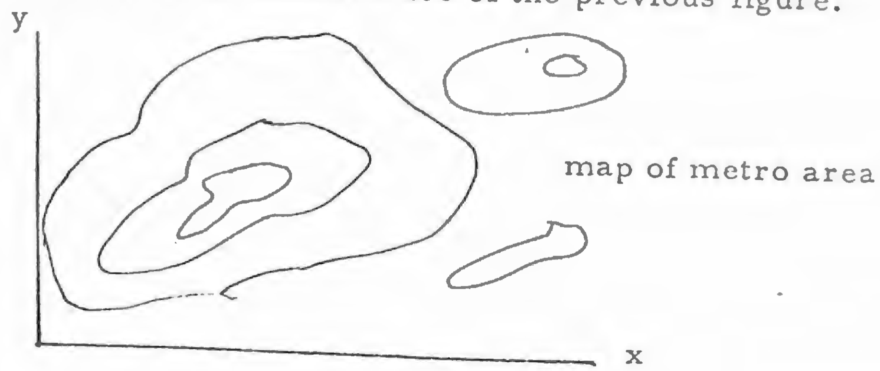

Figure 2

OUTPUT 2 — Power Density as a Function of Frequency for a Fixed Location. Essentially this is represented on a vertical line in the first figure. Since we have fixed two dimensions here, we need not use shading to represent power density.

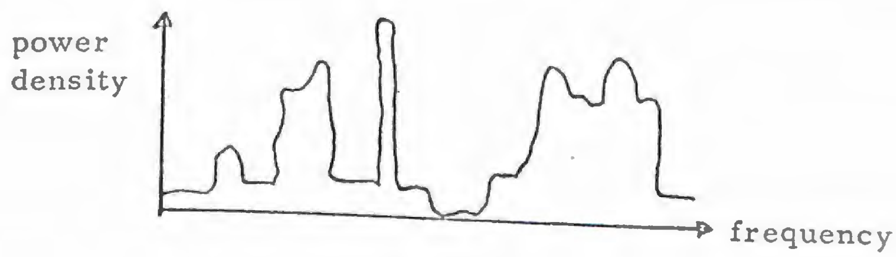

Figure 3

OUTPUT 3 — Distributions of Power Density
The following distributions may prove useful:

a) Distribution over frequency - location fixed
b) Distribution over the region - frequency fixed
c) Distribution over the frequency-region "volume".

If a power density representative of "unused spectrum" is chosen (such as slightly above the ambient noise), we immediately have a figure of what percent of the spectrum is used (a) at a given location, (b) at a given frequency, (c) over the frequency-region volume.

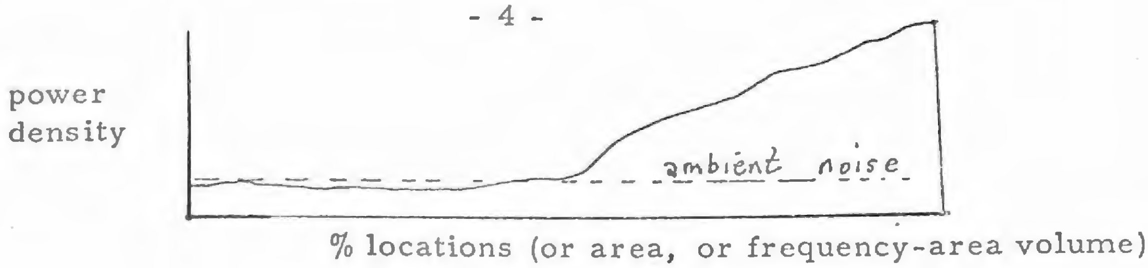

Figure 4

The question we seek to answer is: are there rarefied regions in the space, that is, are there regions in which $P(x, y, f) < P_o$? when P_o is some specified small value (perhaps P_o is the ambient noise level).

The space (x, y, f) is theoretically infinite but in practice it is bounded in all dimensions. The user is only interested in communicating to a bounded geographical area or in any event a transmitter will produce a usable signal over only a finite region. In figure 1 this area is bounded in the (x, y) plane by the closed curve b. So the user seeks a rarefied region in the cylinder with cross section b. The cylinder is not infinitely long but is bounded above and below by available technology and propagation characteristics. Current administrative procedures restrict the search for a rarefied region to thin slices of the cylinder--the bands allocated to the contemplated service.

For policy purposes, we would like to know what percent of the space inside the cylinder or any chosen slice of the cylinder is "full" (power density greater than some nominal reference value) and what percent is "empty"? We can answer that question by computing the congestion function

$$C_R(f) = \frac{\text{volume between } f + \Delta f \text{ that is full}}{\text{volume between } f \text{ and } f + \Delta f} ;$$

"full" means that the power density $P(x, y, f) > R$, a reference level. A plot of $C_R(f)$ might look like the figure below:

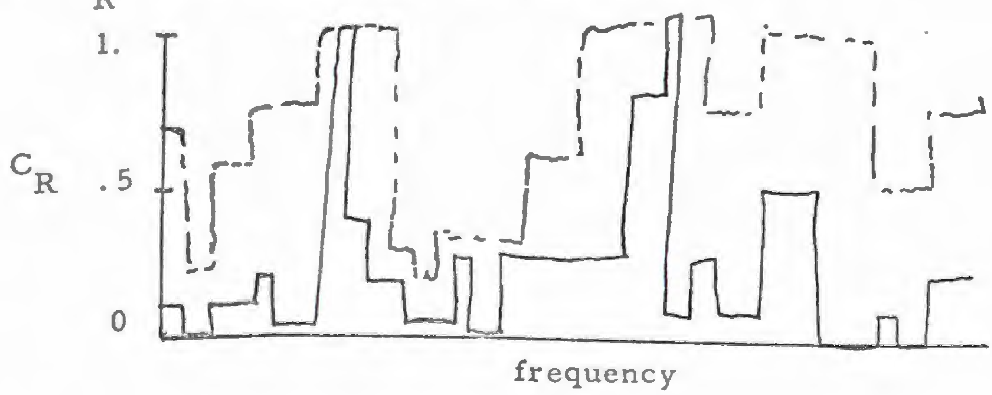

Figure 5

A result similar to the solid line in figure 5 would support the hypothesis that there is much empty electrospace available for assignment under the definition and assumptions used. A result similar to the dashed line would indicate that a more sophisticated definition of electrospace (and hence a more detailed data base) or less conservative assumptions about use of assignments are needed.

The result depends of course on the reference level R. C should be computed for several values of R to show the sensitivity of the conclusions to this choice.

5. TASKS AND SCHEDULE

1. In consultation with OTP, select a large metropolitan area. Selection considerations will include availability of general and special data and absence of complicating factors such as irregular terrain. Tentative selection is Chicago. Complete by January 21.

2. Obtain basic data in as refined form as possible. The Frequency Management Division of OT can provide the government and FCC assignments within a chosen geographic area. Perhaps they can use fast-cull routines to provide the function P(x, y, f) over a specified grid. We must include not only the assignments within the chosen area, but also those from adjacent areas that will reach into the chosen area. That is, assignments will be collected for the region enclosed by b_i in figure 1 where the distance between b and b_i is 50 to 75 miles. Since some assignments are classified it may be necessary to establish need-to-know to get the data, but we will try to avoid this. OTP will supply the authorization if necessary. Complete by February 15.

3. If a suitable estimate of P(x, y, f) is not available from OT, compute P_u, an upper bound on P, by adopting the following conservative assumptions:

   A. All assigned transmitters are in place and operating at full power all the time.

   B. The power density is equal to the peak assigned power all across the assigned bandwidth, and zero outside it. The power computed under assumptions A. and B. will be called the "assigned power density".

   C. Power propagates as well as in free space, that is, P is proportional to $1/d^2$, where d is the distance from the transmitter.

   D. Power is radiated in all directions with value equal to that in direction of maximum radiation.

Produce samples of output discussed above. Complete by March 15.

4. Choose reference values of power: the median and 99% values of ambient noise, a receiver noise figure, ? . Complete by March 15.

5. Compute C_R (f) for chosen values of R, and analyze results. Complete by April 15.

6. If C_R(f) supports hypothesis that there is much empty space, write report. Draft due by May 1. If not, make more realistic assumptions (for example, more accurate propagation function, consider time loading of channels, actual spectrum density of emission if known, etc.) and repeat steps 3-5. Report will be delayed accordingly.

U.S. DEPARTMI OF COMMERCE
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Boulder, Colorado 80302

SP 8

Date: January 14, 1972

Reply to Attn of: C. J. Chilton

Subject: ECAC Data Base

To: Leslie A. Berry

I contacted George Whitley of the Electromagnetic Compatability Analysis Center, Annapolis, Maryland, with regard to obtaining the ECAC data base. His FTS number is (301) 267-2252.

Mr. Whitley was referred to me by Ralph Bergman who has used the ECAC data base for determining spectrum occupancy in the 6 GHz band as input to a mathematical computer model for predicting interference signals at 6 GHz, seen from a satellite antenna in geostationary orbit (see attached paper). Mr. Bergman informed me that he is prepared to give the PSD group a formal presentation of what he has done with ECAC, IRAC, and FCC data bases, if so desired and requested.

In my telephone conversation with George Whitley (13 January) I was given to understand that we could request and receive data tapes of the unclassified data immediately and that we could also receive the classified (DOD) data, but this would entail some additional work, security clearance, etc. The data is up to date to within six months and is continuously being updated (weekly) both from IRAC and DOD's own sources. The data can be requested for any geographical area within the continental USA for any frequency band. They can put on tape just about anything you request: frequency, bandwidth, transmitter location, power, antenna elevation, modulation type, etc. For the unclassified data all that is required is a letter from us requesting what we want; for the classified data, which can be requested concurrently, he said that the higher up in the organization the signer of the letter, the better.

The mailing address is:

Mr. George Whitley
ECAC
Dept. of the Navy
Annapolis, Maryland 21402

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
Boulder, Colorado 80302

February 3, 1972

SP 9

Mr. Michael Lynch
Office of Telecommunications Policy
Executive Office of the President
Washington, D.C. 20504

Dear Mike,

I am enclosing a schedule of tasks for our part in your proposed program to study assignment policy for the geostationary orbit. The tasks I have listed are not in much more detail than in your program proposal. However, it would be helpful to have your reaction, especially to the choice of activities for PSD.

I am working on a first attempt to describe an allocation alternative for a beginning. This should help to surface some of the problems we will face. I will send this as soon as possible.

Sincerely,

Don

Donald R. Ewing
Policy Support Division

Enclosure

GEOSTATIONARY ORBIT ASSIGNMENT STUDY

TASK 1. Make definitions of the electrospace commodity, units, and consumption for the orbital spectrum resource. Discuss alternative definitions, if applicable, along with implications of these definitions.

TASK 2. Delineate property rights for the orbital-spectrum resource relative to several assignment proceedures, eg. auction, lease, license.

TASK 3. Combine the results of tasks 1 and 2 to demonstrate a complete system of rights to the geostationary orbit-spectrum resource and a mechanism for assignment. Make recommendations for further action.

The output for each task will consist of a working paper. The time estimate is two man-months per task. Although this time frame does not allow a complete study, it is anticipated that major issues will be exposed.

FAX sent 2/22/72
11:55 KW.

Draft 2-22-72

SP 10

Mr. Stanley I. Cohn
Program Coordinator, Frequency Management
Office of Telecommunications
U.S. Department of Commerce
Suite 250, 1325 G Street, N.W.
Washington, D.C. 20005

Dear Mr. Cohn:

The purpose of this letter is to request that one or more runs of the Program Graphic Display Model (GDM) on the Univac 1108 be made using the Government Master File (GMF) as the data base; the frequency range over which the run is desired is from 50 MHz to 1 GHz and the geographic area is Metropolitan Chicago out to a radius of 100 miles. The output from this run (the graphic pictorial display, Graphic Channel occupancy display and lists, a magnetic tape of the input data retrieved from the GMF, and a copy of the COBOL and FORTRAN deck of the graphic display model routine) will be used to form the basis for a metropolitan spectrum availability study under the direction of Mr. Leslie Berry, OT/PSD at OT, Boulder.

Some discussion of what would be required has already taken place between Mr. C. J. Chilton and Mr. George W. Garber. In the event that this request is authorized Mr. Chilton or Mr. Berry will contact Mr. Garber to work out the details. The reason for requesting a magnetic tape of the input data retrieved of the GMF and the Program Deck of the GDM is that if feasible, additional programming will be done to extend the results that can be obtained from the GDM using the computer at OT/Boulder.

Sincerely yours,

Robert M. Lowe, Chief
Policy Support Division

FAX sent 2-23-72-p.m.

To Leslie A. Berry from C. J. Chilton, 2-23-72

The following programs and subroutines are known to be needed for the printout of the tables, graphic display and the power density histogram; these are the FORTRAN/COBOL listings as found in Volumn #15 dated 8/26/71.

PROGRAM - The Weighted Power Density Calculation p. 113

Subroutines	Page
INFOFO	126
YEH	131
GRIDWT	123
ADFS	117
GREAT	121
HORIZ	125
EMP1	119
EMP	118
GRIDIM	122
STGW	129

PROGRAM - The Power Density Histogram Program p. 133

Subroutines	Page
ENVLHD	97
ACMPWR	139
HISTFO	142
EWRNM	141
NEWPG	101
HISTWT	146
WPWR	150

No listings were found on the following Subroutines: SSORT(might possibly be COBOL program ENG-SORT), SORT, RREL, RRET, and ERTRAN(1).

According to the Operations Manual Vol. III, the graphic display run sequence in the 1108 calls for a number of additional programs than those above and the question is just where would the tape that is to be generated fit into this sequence? If we are giong to read this magnetic tape on the CDC-3800 we need to know exactly what the record configuratin is with a listing of a few records using both an octal and the decimal translation if at all possible.

As good a center for the Chicago area as any appears to be the location of the Main Post Office whose coordinates are:

	LATITUDE	LONGITUDE
Chicago, Ill.	41 deg. 52 min. 28 sec.	87 deg. 38 min. 22 sec.

OT FORM 10
(1-71)

OFFICE OF TELECOMMUNICATIONS

SP 11

March 3, 1972

Mr. Walter R. Hinchman
Office of Telecommunications Policy
Executive Office of the President
Washington, D. C. 20504

Dear Walt,

Enclosed are:

A two page description of the "method of cataloging spectrum usage/ availability, which I wrote to answer Will's question about it.

The work statement for the Metropolitan Spectrum Availability study which contains objectives and philosophy. (see SP 7)

I hope these two items will provide enough information to spring the data so that the study can get underway.

Also enclosed is a draft description of the TV technology review, for discussion purposes. I will be happy to discuss it over the phone, by mail, or in person as soon as you or Seb are ready.

Sincerely,

Leslie A. Berry
Policy Support Division

Enclosures

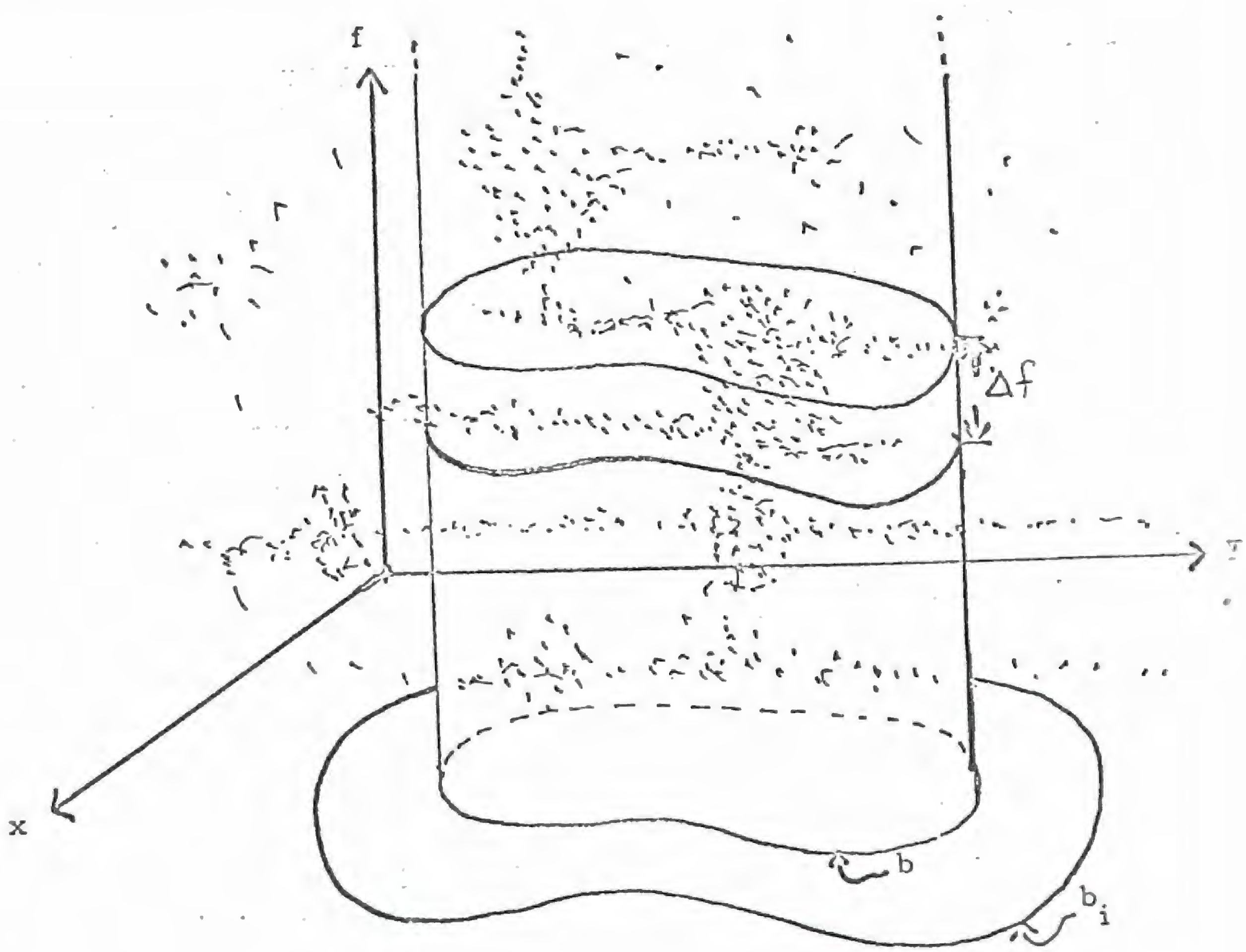
FILE COPY

SURNAME	DATE	SURNAME	DATE

The spectrum congestion function:
a method of cataloging spectrum usage/availability

In an attempt to quantify and display in a way readily grasped by non-specialists the scarcity of radio spectrum we have defined the "congestion function," which is just the ratio, as a function of frequency, of the spectrum space used to the spectrum space available. While simple in concept, this definition could be subject to almost endless elaboration in the details of what is meant by "used" and "available." We will begin by applying very simple and conservative definitions of "used" and "available" to a specific case, and let the results indicate the complications that need to be added to achieve a practical result.

To simplify visualizing the congestion function, consider a three-dimensional space such as that pictured below, which has two space dimensions (latitude, x, and longitude, y) and the third dimension is frequency, f. Our fundamental quantity is the electromagnetic power density, P(x, y, f), at each point in space. A physical analogy to P might be the density of a gas in three dimensional space, and it is illustrated by the dots in the figure.



We specify a geographic region by its boundary, b. We can now examine the power density as a function of f in the cylinder with cross-section b. Consider a thin slice of the cylinder between f_o and $f_o + \Delta f$. In some fraction of this slice, P is greater than some reference value, R. If we let Δf become very small, this fraction is the value of the congestion function, $C_R(f_o)$. Mathematically,

$$C_R(f) = \lim_{\Delta f \to 0} \frac{\text{volume between f and f} + \Delta f \text{ in which } P > R}{\text{total volume between f and f} + \Delta f}$$

R should be chosen sensibly, so that $P \leq R$ represents space that is "unused". For example, R might be the average ambient noise level. If desired, R can vary with frequency.

$C_R(f)$ will vary between 1 (band completely used) and 0 (band unused). For various analyses it can be averaged over any desired frequency band to give the average congestion of the band.

We anticipate a number of problems in applying the definition. The most obvious is knowing the power density, P(x, y, f). Initially we intend to use instead an upper bound of the assigned power density. We will take the simplistic view that each assigned transmitter is in place and operating at maximum assigned power all the time over its assigned bandwidth. We will assume that the energy is radiated efficiently in all directions and will compute the upper bound of the power density using a conservative transmission loss function. Thus, this calculation is seen to be the next logical step beyond the tabulation of assignments by frequency such as was done by the Metropolitan Congestion Task Group.

To make these initial assumptions somewhat more palatable, we will restrict ourselves to the frequencies between 50 MHz and 1 GHz in the first application.

Under these assumptions, we expect to find some bands (e.g., LMR) completely used, and some bands (e.g., uhf TV) virtually unused. The plot of the congestion function will be a graphic, easily-grasped presentation of the information. We can then experiment with the effect of various refinements of the assumptions: realistic time loading factors, estimates of the percentage of assignments that are actually operational, more accurate transmission loss calculations, more accurate antenna pattern information (where available), information on actual emission spectra (if available), etc The sensitivity of the congestion function to the assumptions will indicate the most fruitful areas for policy initiative.

ET...:11822 2.15
BYR 10,
1-12-72 LAB

METROPOLITAN SPECTRUM AVAILABILITY STUDY

1. BACKGROUND

For the past 20 years there have been recurring reports that we are running short of radio spectrum space, and that we must start setting priorities and rationing spectrum to the most important or most economic uses. Recently there have been counter arguments that we are not really short of spectrum space (or electrospace) but that if we define the space with a sufficiently large number of dimensions (including time, polarization, direction, etc.) and use sufficiently sophisticated spectrum engineering techniques and sufficiently large data bases we will be able to fit in many more users. Some accept the argument that the electrospace is scarce, and propose that a spectrum market or pseudo-market be established to distribute the resource in an economically efficient way.

There is yet another alternative--that in fact there is a great deal of empty spectrum space under simple definitions of the space, and that existing data bases are adequate, but rigid administrative procedures (allocation tables) cause an apparent shortage of spectrum.

2. SPECIFIC OBJECTIVE

Determine the proportion of unassigned spectrum between 50 MHz and 1 GHz in a large metropolitan area, using simple definitions of electrospace, available data, and conservative assumptions.

Present the quantitative results in a way which effectively displays the possible allocation policy alternatives.

3. STUDY BENEFITS

The study will provide specific, detailed quantitative information on the amount of spectrum available (under various alternative allocation policies) in a "congested" metropolitan area. It will indicate whether sophisticated data bases and spectrum engineering are necessary now, or whether relaxation of rigid allocation policies would release large electrospace territories for development.

The methods for retrieving and analyzing assignment data can be extended to study other regions of the electrospace.

Comparison of the results with actual electrospace occupancy measurements made or contemplated by other agencies will provide further insight into the options open to spectrum allocators.

4. APPROACH

We will choose a simple definition of electrospace acceptable to all, and a large metropolitan area. Using conservative assumptions about propagation and assuming that all assigned frequencies are in use all the time, we will inventory the electrospace in that area. We will then determine how much of the available electrospace is being used in various bandwidths, not necessarily corresponding to service bandwidths.

The unit of electrospace we will use will be the power density as a function of location and frequency only: $P(\overline{r}, f)$, where $\overline{r}$ is a space vector (its components would normally be latitude, longitude, and height) and f is the radio frequency. To simplify visualizing P, consider only two space dimensions ($\overline{r} = (x, y)$) so that P is a function in a three-dimensional (x, y, f). (See figure 1 below.) A physical analogy to P might be the density of a gas in real space.

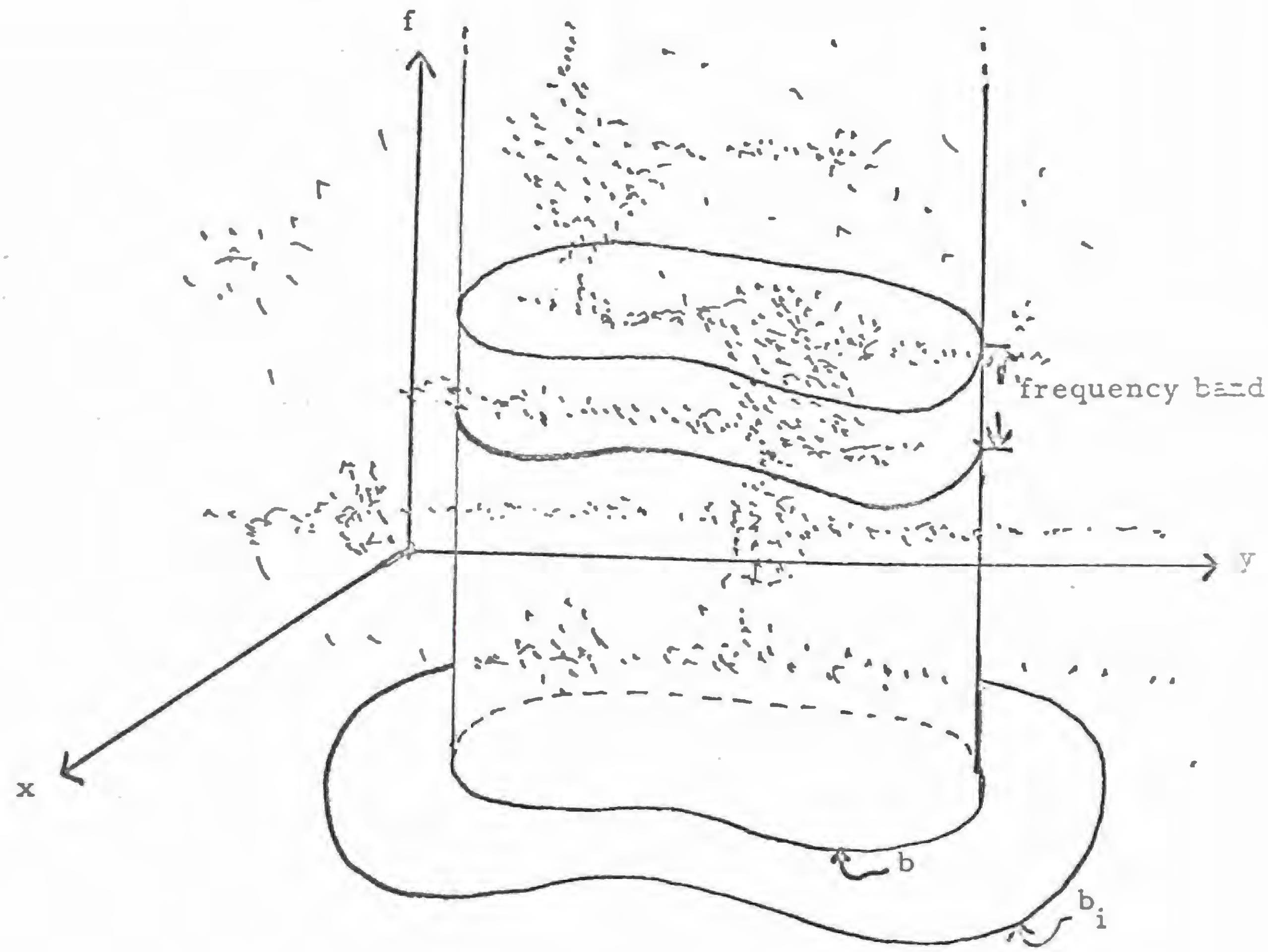


Figure 1

We could produce the following types of displays to achieve the desired accuracy.

OUTPUT 1 — Area Map of Power Density for a Fixed Frequency

This is a horizontal slice of the previous figure.

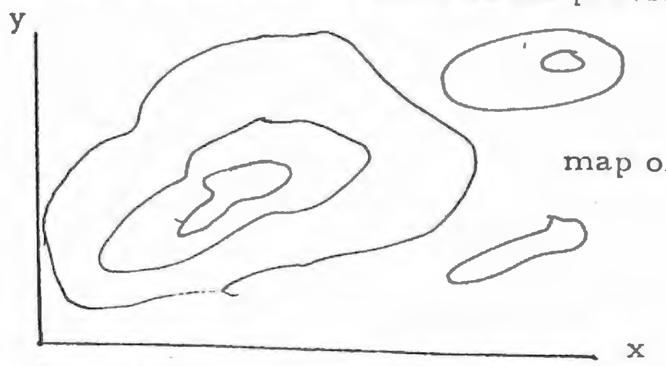


Figure 2

OUTPUT 2 — Power Density as a Function of Frequency for a Fixed Location. Essentially this is represented on a vertical line in the first figure. Since we have fixed two dimensions here, we need not use shading to represent power density.

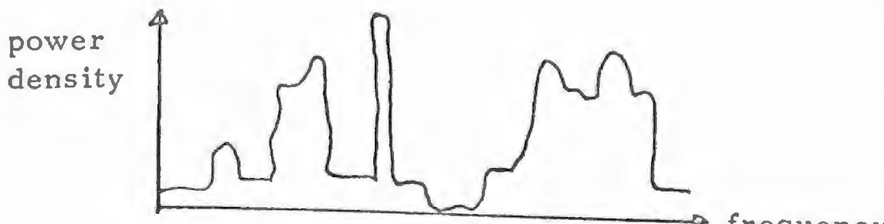


Figure 3

OUTPUT 3 — Distributions of Power Density

The following distributions may prove useful:

a) Distribution over frequency - location fixed
b) Distribution over the region - frequency fixed
c) Distribution over the frequency-region "volume".

If a power density representative of "unused spectrum" is chosen (such as slightly above the ambient noise), we immediately have a figure of what percent of the spectrum is used (a) at a given location, (b) at a given frequency, (c) over the frequency-region volume.

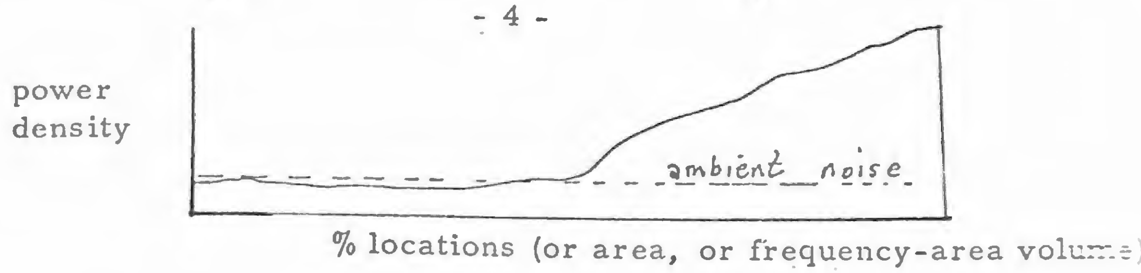


Figure 4

The question we seek to answer is: are there rarefied regions in the space, that is, are there regions in which $P(x, y, f) < P_o$? when P_o is some specified small value (perhaps P_o is the ambient noise level).

The space (x, y, f) is theoretically infinite but in practice it is bounded in all dimensions. The user is only interested in communicating to a bounded geographical area or in any event a transmitter will produce a usable signal over only a finite region. In figure 1 this area is bounded in the (x, y) plane by the closed curve b. So the user seeks a rarefied region in the cylinder with cross section b. The cylinder is not infinitely long but is bounded above and below by available technology and propagation characteristics. Current administrative procedures restrict the search for a rarefied region to thin slices of the cylinder--the bands allocated to the contemplated service.

For policy purposes, we would like to know what percent of the space inside the cylinder or any chosen slice of the cylinder is "full" (power density greater than some nominal reference value) and what percent is "empty"? We can answer that question by computing the congestion function

$$C_R(f) = \frac{\text{volume between f and f} + \Delta f \text{ that is full}}{\text{volume between f and f} + \Delta f};$$

"full" means that the power density $P(x, y, f) > R$, a reference level. A plot of $C_R(f)$ might look like the figure below:

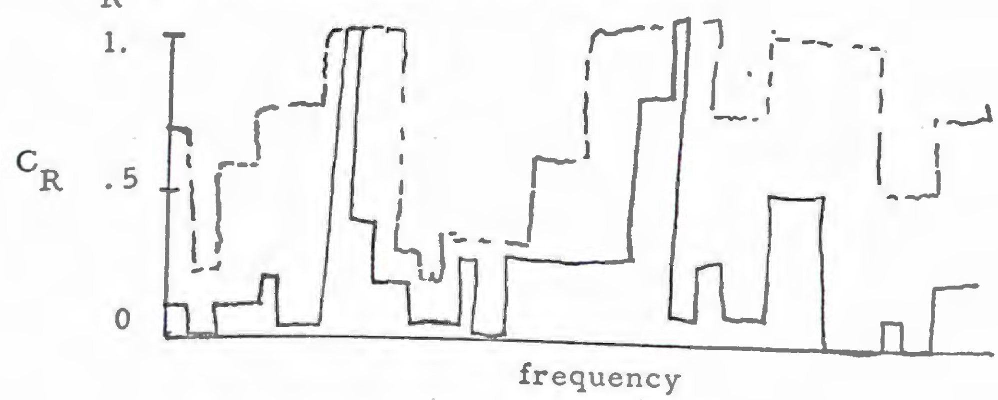


Figure 5

A result similar to the solid line in figure 5 would support the hypothesis that there is much empty electrospace available for assignment under the definition and assumptions used. A result similar to the dashed line would indicate that a more sophisticated definition of electrospace (and hence a more detailed data base) or less conservative assumptions about use of assignments are needed.

The result depends of course on the reference level R. C should be computed for several values of R to show the sensitivity of the conclusions to this choice.

5. TASKS AND SCHEDULE

1. In consultation with OTP, select a large metropolitan area. Selection considerations will include availability of general and special data and absence of complicating factors such as irregular terrain. Tentative selection is Chicago. Complete by January 21.

2. Obtain basic data in as refined form as possible. The Frequency Management Division of OT can provide the government and FCC assignments within a chosen geographic area. Perhaps they can use fast-cull routines to provide the function P(x, y, f) over a specified grid. We must include not only the assignments within the chosen area, but also those from adjacent areas that will reach into the chosen area. That is, assignments will be collected for the region enclosed by b_i in figure 1 where the distance between b and b_i is 50 to 75 miles. Since some assignments are classified it may be necessary to establish need-to-know to get the data, but we will try to avoid this. OTP will supply the authorization if necessary. Complete by February 15.

3. If a suitable estimate of P(x, y, f) is not available from OT, compute P_u, an upper bound on P, by adopting the following conservative assumptions:
   - A. All assigned transmitters are in place and operating at full power all the time.
   - B. The power density is equal to the peak assigned power all across the assigned bandwidth, and zero outside it. The power computed under assumptions A. and B. will be called the "assigned power density".
   - C. Power propagates as well as in free space, that is, P is proportional to $1/d^2$, where d is the distance from the transmitter.
   - D. Power is radiated in all directions with value equal to that in direction of maximum radiation.

Produce samples of output discussed above. Complete by March 15.

4. Choose reference values of power: the median and 99% values of ambient noise, a receiver noise figure, ? . Complete by March 15.

5. Compute C_R (f) for chosen values of R, and analyze results. Complete by April 15.

6. If C_R(f) supports hypothesis that there is much empty space, write report. Draft due by May 1. If not, make more realistic assumptions (for example, more accurate propagation function, consider time loading of channels, actual spectrum density of emission if known, etc.) and repeat steps 3-5. Report will be delayed accordingly.

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

SP 12

Date: March 13, 1972

Reply to Attn of: PSD/DRE

Subject: Regarding the Orbital Rights Project

To: Walter R. Hinchman, OTP

The geostationary orbit offers great potential for national communications. At the present time there is relatively little competition for this resource, since the technology has only recently become available and the demand is below supply. However, if historical trends are an indicator, the demand will soon rise to meet the supply. When this happens, the resource will acquire value, and expedient regulatory policies are required to allocate the resource.

It is desirable to develop a national policy for the administration of this resource which would allow a market-like mechanism to be operative. The objective is to allow the "market place" to make the value judgments associated with resource allocation. Ideally such a system would be self-regulating.

The type of resource users and the intensity of their use depends on the definition of "property rights". Thus the definition of exclusive, flexible, and transferable rights to the resource becomes all important to the viability of a system, and is critical to the public utility derived.

A resource allocation package must include a definition of the resource, a system of rights for its use, and the legal basis for its regulation. Such packages for the geostationary communications resource will be developed, analyzed, and compared with each other and with the present allocation system. Methods applicable to the more general problem of electrospace rights will be noted.

Output will be in the form of working papers and memoranda, short position papers on various aspects of the problem, and finally a summary of the work completed. Donald R. Ewing is spending one-half time, and Philip L. Rice is spending one-third time on the project after May 1.

Donald R. Ewing

Donald R. Ewing, PSD

Philip L. Rice

Philip L. Rice, ITS

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

SP 12 (con

Date: March 13, 1972

Reply to Attn of: PSD/DRE

Subject: Regarding the Orbit Value Project

To: Walter R. Hinchman, OTP

The project description for the Orbital Value project is attached. It is basically the same as described in my December 3, 1971 letter to you. Dr. Russell B. Chadwick of ITS will be devoting half time to the project for the remainder of the fiscal year.

Donald R. Ewing

Donald R. Ewing
Policy Support Division

Attachment

ORBIT VALUE

BACKGROUND

When a resource becomes in short supply, it is imperitave that the resource manager be able to objectively judge the value of the resource. As a prerequisite he must have an understanding of the major components of the resource as well as an understanding of costs of its use and costs of alternatives.

Although the geostationary communications resource is not yet in short supply, it may be in the not too distant future. If the history of communications is a guiede, regardless of the large communications potential here, the traffic will increase to meet capacity.

Because there is a practical limit on the number of satellites which can use the same frequency in geostationary orbit, this orbit - spectrum resource is one which should be analyzed. By viewing the orbit as a tradeoff with equipment and spectrum, the value of the orbital resource can be measured. An understanding of the tradeoff relations is vital to efficient utilization of the resource involved.

A user will pay no more for a marginal unit of orbit than it costs to attain an equivalent communications improvement by equipment. Thus the tradeoff between the orbital communications resource and equipment serves to effectively place an upper bound on the value of the orbit.

OBJECTIVE

Determine a methodology for measuring the tradeoff relation between equipment and the geostationary orbit for FDM/FM telephony systems.

APPROACH

The approach will be to use two major equations obtainable from Jansky and Jeruchim, "Technical Factors and Criterion Affecting Geostationary Orbit Utilization", AIAA Third Communications Satellite Systems Conference, April 1970, p. 563. These equations are relative to FDM/FM telephony systems.

TRADEOFF EQUATION

$$(1 + 9.5\,M^3)\,N_i(D/\lambda)^2\,\theta^{2.5} = C$$

ORBITAL SPECTRUM UTILIZATION EQUATION

$$\ddot{n} = \frac{\dot{n}}{\theta} = \frac{119}{(\sqrt[3]{10}\,M + 1)}\left[\frac{(1 + 9.5\,M^3)\,(D/\lambda)^2\,N_i}{C}\right]^{0.4}$$

M	=	rms modulation index of the multichannel baseband
N_i	=	interference noise in pW0p
D/λ	=	ratio of earth station antenna diameter to wavelength
θ	=	satellite separation in degrees
C	=	a "constant" depending on the polarization and offset isolation parameters. If 14 and 10 dB are used (respectively) then $C = 2.036 \times 10^9$.
$\dot{n}$	=	$119/(\sqrt[3]{10}\,M + 1)$, the satellite channel capacity in channels/MHz (per satellite)
$\ddot{n}$	=	a measure of orbital spectrum utilization in channels/MHz/degree

Both equations are downlink equations and assume earth coverage antennas and uniform systems utilizing polarization and offset isolation. They represent the state-of-the-art maximum satellite communication capacity with FDM/FM telephony systems.

The first equation is a tradeoff equation because from a cost or spectrum utilization standpoint, each of the parameters on the left should be made as small as possible; yet one parameter cannot be reduced without increasing the others. Basically the tradeoffs are between cost, reliability, and resources used, although the paramters in the equation are not exclusively any one of these.

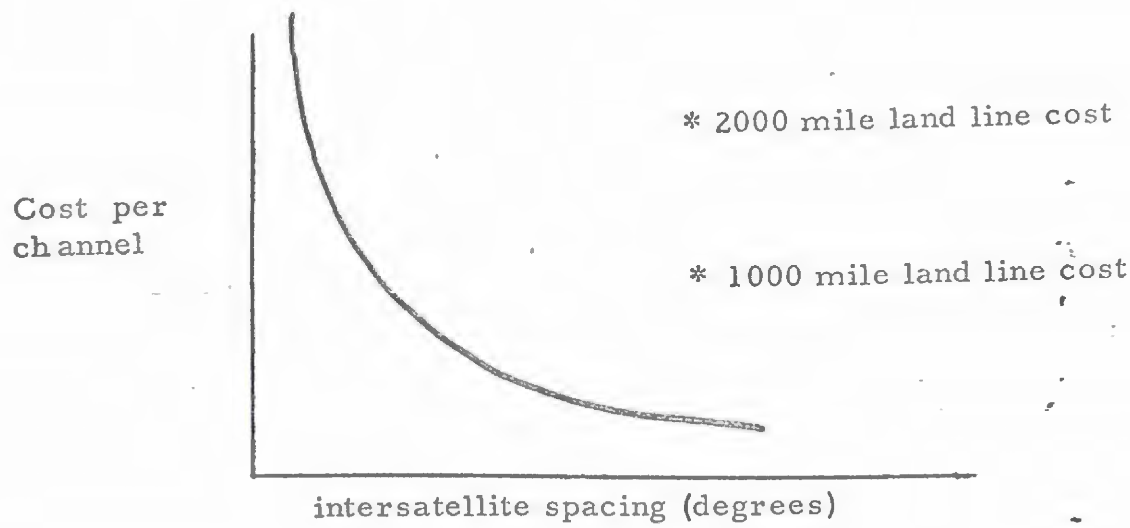
We see from the utilization equation that $\dot{n}$ can always be increased by increasing M, D/λ or N_i (which decreases θ). Hence, theoretically there is no upper bound. The task then becomes one of minimizing cost or at least relating cost and utilization.

If good satellite system cost information can be obtained, tradeoff equation parameters M, N_i, and D/λ can be chosen to minimize system cost, for fixed θ.

A possible methodology for computing the minimum cost per channel as a function of satellite spacing is

1) derive a cost function $C(M, N_i, D/\lambda)$, and
2) use the method of LaGrangian multipliers to minimize cost per channel subject to the tradeoff equation constraint.

Regardless of the minimization technique used, the result would be a graph such as shown below.



It may be instructive to plot the values of M, N_i, and D/λ which yield these "minimum costs". Another possible chart resulting from the calculations is a plot of cost per channel vs. capacity.

TASKS

1. Investigate the relationship between the tradeoff parameters D/λ, M, and N_i and system cost items. (2 mm)

2. Determine a preliminary cost function $C(D/\lambda, M, N_i)$. (2 mm)

3. Develope a methodology to minimize cost per channel using the cost function. This task may necessitate reiteration of tasks 1 and 2. (2 mm)

4. Prepare final report including documentation of the model and a summary of current literature relative to the geostationary communications resource. (2 mm)

SCHEDULE & COSTS

Total - 8 man months - $30 K

Since some of the tasks can be assigned in parallel, it is anticipated that the program could be completed by June 30, 1972.

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

SP 13

Date: March 16, 1972

Reply to Attn of: PSD/DRE

Subject: Regarding the Definition of Orbital Rights

To: Philip L. Rice, ITS

The dimensions of the orbital resource

The primary dimensions of the orbital communications resource are those of frequency and orbital arc. The signal intensity will not be considered a dimension of the resource, but rather an indicator of the amount of the resource used. These primary dimensions are chosen because they are dimensions now used to distinguish between signals. The definition of rights will be made relative to these dimensions. It will be left to the entrepreneur to develop secondary dimensions of the electrospace such as polarization and modulation.

Since highly directional antennas are used in most satellite communications, one may at first consider direction of signal an important dimension of the resource. However, because of the earth-orbit geometry this component is closely related to the orbital arc. Thus it cannot usefully be used as an independent dimension.

Definition of output rights

Consider the following type of rights definition for the orbital resource.

- The rights to a spectrum-arc block consist of the use of frequencies between f_1 and f_2 and the placement of transmitter-receiver antennas between r_1 and r_2 degrees longitude in geostationary orbit.
- Earth coverage down-link antennas may be used subject to the CCIR flux density limitations (CCIR Rec. 358-1).
- Up-link antennas must be of such directivity and pointing accuracy so that X watts/Hz/m is not exceeded at the boundary of the spectrum-arc block.

Criticism: The intensity of signal from narrow beam antennas roughly decreases proportional to the 2.5 power of the angle from the beam axis. Because of this, the attempt to specify output rights at the boundary of an electrospace region suffers from the same criticisms that Hinchman made concerning the terrestrial broadcasting services which GE Tempo defined in an analogous manner (Rostow Report). Specifically, it can be shown that it is extremely important where your neighbor locates his satellite within his arc. If we try to remedy this fault by specifying that all satellites must be located at the center of their arc, then transferability (subdivision or accumulation of resource regions) suffers. Apparently this type of problem arises in the frequency domain also. As compared to the terrestrial broadcasting services, there should be less incentive to locate one's satellite anywhere but at the center of his arc. Still, a user is dramatically affected by subdivision and accumulation of neighboring arcs.

An alternative?

It seems to me that the cause of the problem mentioned here lies in the fact that rights at boundaries were specified. In the cases mentioned, the rights holder really doesn't care what the intensity of a signal is at his boundary. He cares about the intensity of interfering signals at the satellite receiving antenna. In the terrestrial broadcasting services, the user again doesn't care about the interfering signal at the boundary. The boundary is presumably much further from the transmitter than any service area. That is, the "fence" lies in a necessary buffer zone. Here again the user is concerned about the interfering signal in his service area (i.e., at the receivers of his audience).

Why can't a maximum interference signal level be defined over the area (or arc) and not just on the boundary? Then, if neighbors subdivide, their interfering signals collectively must not exceed this maximum. Or, if neighbors combine, the owner of the combined regions may interfere up to the "sum" of the tracts that he purchased. The maximum signal would not be constant over the area, but perhaps equivalent to that caused by the "original neighbor". In this way the user's rights are certain regardless of the actions of his neighbors.

I expect that there are difficulties with this concept. I would appreciate your pointing them out and/or suggesting an improvement.

Donald R. Ewing

Donald R. Ewing
Policy Support Division

cc: Les Berry, PSD
Roger Salaman, PSD
Walt Hinchman, OTP

DRE:db

OFFICE OF TELECOMMUNICATIONS POLICY
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20504

March 22, 1972

To: Donald R. Ewing

From: Walter R. Hinchman

Subject: Orbital Rights Project

I have reviewed your project description on Orbit Value, which you forwarded with your memo of March 13.

I am concerned that your approach does not truly address the central problem of defining the resource and establishing a system of rights for its use and the legal basis for its regulation. I do not feel it is possible to talk about costs of a resource prior to defining just what the resource is. Furthermore, while your background statement cites as a prerequisite an understanding of major components of the resource, you describe a methodology for determining minimum cost of a single limited component, viz. FDM/FM telephony systems.

It appears to me that you are undertaking a complex and involved task, the results of which will be of very limited value toward the project as a whole.

If you have questions concerning my misgivings, Michael Lynch will be happy to amplify these remarks if you would give him a call.

Walt

Walter R. Hinchman

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

SP 15

March 29, 1972

Mr. Walter R. Hinchman
Office of Telecommunications Policy
Executive Office of the President
Washington, D. C. 20504

Dear Mr. Hinchman:

I am replying to your memo of March 22 to Don Ewing concerning the Orbital Rights project. I am working on a related project, concerning orbit value of the geostationary orbit, to which you referred in your memo. You pointed out the necessity of defining a resource before attempting to determine costs or value of that resource and I agree completely. The existing literature on the subject indicates that a normalized communication channel capacity is an adequate measure of the resource. The most common normalization appears to be in both orbital width and spectral width so that the resulting measure of the resource has units of bits per sec/degrees/Mhz. Thus, the resource can be defined as the useful capacity, per Mhz of spectrum, of a system of geostationary satellites and has units of bits per sec/degree/Mhz.

My current work, which is a part of the Orbital Value project, is an effort to determine the cost of using the geostationary orbit resource and to understand the associated tradeoffs. It appears that the two most important parameters in this problem are the size of the ground station antenna and the bandwidth expansion factor. The size of the antenna determines the amount of interference from other satellites and the bandwidth expansion factor determines how immune the system is to noise. The size of the antenna determine its cost in a known way and this is a major cost of the ground station. This determines how one resource (money), is used. It is well known that PCM systems trade bandwidth and complexity for noise immunity, and with solid-state devices, complexity is a minor cost item. Thus the parameters of the PCM system determine how another resource, the spectrum, is used. It should not be too difficult to find a trade-off between the money resource and the orbit spectrum resource.

Although the detailed analysis has not been attempted, I feel that it can be made somewhat independently of specific system design. Also it seems that most of the major cost items are in technologies which are well developed and thus will not experience severe price changes in the next several years. The results obtained should be valid for this same length of time.

If you wish to discuss any of these remarks further, my phone number is (303) 499-1000, ext. 3646. I would also be happy to learn of any suggestions you may have on the problem of defining the resource.

Sincerely,

Russell B. Chadwick

Russell B. Chadwick
Tropospheric Wave Propagation
and Radio Meteorology

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

Date: March 13, 1972

Reply to Attn of: PSD/DRE

Subject: Regarding the Orbital Rights Project

To: Walter R. Hinchman, OTP

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Output will be in the form of working papers and memoranda, short position papers on various aspects of the problem, and finally a summary of the work completed. Donald R. Ewing is spending one-half time, and Philip L. Rice is spending one-third time on the project after May 1.

Donald R. Ewing

Donald R. Ewing, PSD

Philip L. Rice

Philip L. Rice, ITS

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
Boulder, Colorado 80302

March 31, 1972

SP 1-

Mr. Walter R. Hinchman
Office of Telecommunications Policy
Executive Office of the President
Washington, D. C. 20504

Dear Walt,

There were two project descriptions which I sent to you. One is entitled Orbit Rights, and the other Orbit Value. Since the subject of your memo was Orbit Rights, but you discussed Orbit Value, I wondered if you received both descriptions. A copy of the Orbit Rights is attached.

I share some of your misgivings concerning the Orbit Value project. Let me comment.

1. Dr. Chadwick feels that the restriction to one modulation system will not be necessary.

2. I view the project as being exploratory and as a first approximation rather than the involved and complex project that it could be.

3. The desired result is a shadow price for the orbital communications resource as Levin uses the term.

4. It seems that a feel for resource tradeoffs is a very important part of resource management. Here we are attempting to measure the dollar tradeoff with the orbital communications resource.

I hope that Dr. Chadwick's companion letter will convey his perspective of the project.

Sincerely,

Don

Donald R. Ewing
Policy Support Division

2 enclosures
1-Copy of Memo dtd 3-13-72
re the Orbital Rights Pr
2-Ltr from R. B. Chadwic 3-29-72

B

Broadband Services

October 5, 1971	Meeting with Besen and Partch.
	Not enough time to contribute to CATV policy statement.
	Would like more general investigation of industry with emphasis now on modeling.
	Want Comanor/Mitchell program: running and tested and accessible from Washinton, variable output format, and validation of data such as system costs, also add other models. (B1)
October 14	Initiated assistance from ITS to obtain cost information. (B2)
October 29	Besen notified that Comanor/Mitchell program now available for access. (B3)
November 4	Demonstrated use of Comanor/Mitchell program at OTP.
November 18, 19	Received briefings on current status of CATV by attendance at PLI institute on CATV.
December 2	Seminar on history of CATV regulation.
December 6	Memo from Espeland outlining cost study. (B4)
December 8	Interim report submitted discussing Rand CATV model. (B5)
January 12, 1972	Comments concerning CATV computer model received from Besen. (B6)
January 19	Meeting with Besen and Partch to discuss computer CATV model. (B7)
February 18	Comments submitted to Besen on RMC Interim Report "Investments Costs for Major CATV Components". (B8)
	Report on work on defining CATV equipment cost received from ITS. (B9)
February 19	Request from Hinchman for Partch to attend Theta-Com seminar on microwave systems for local CATV distribution. (B10)
February 28	Request from Hinchman to review CATV Demand Study Work Statement. (B11)
February 29	Final report on CATV costs received from RMC.

(B12)

March 3	Comments on OTP CATV Demand Study submitted to Polishuk. (B13)
March 8	Approach to survey of home terminals for CATV systems received from ITS. (B14)
March 10	Attended RMC briefing at OTP.
March 13	Comments on RMC report submitted to Weinberg. (B15)
March 14	Outline of cost survey of local origination equipment for CATV systems received from ITS. (B16)
March 20	Comments concerning follow-up work on RMC results received form Besen. (B17).
April 5	Letter to Besen transmitting Stanford and Rand CATV model programs as revised by PSD for OTP. (B18)
April 5	Sample runs of Stanford and Rand programs: Rand CATV Financial Model, and Comanor/Mitchell CATV Financial Model submitted to Hinchman. (B19)

file Broadband Project

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

B1

Date: October 5, 1971

Reply to Attn of: JEP

Subject: Meeting with Stan Besen, OTP, to discuss CATV program.

To: Roger Salaman

Memorandum for the Record

At the suggestion of Walt Hinchman I met with Stan Besen of OTP to discuss our program in the CATV area. He felt we would not be able to make a meaningful contribution to their forthcoming policy statement, since it is due in two weeks. They expect to continue to need analyses in this area and would like us to pursue a more general investigation of the industry. Specifically, they would like us to work on computer modelling of CATV systems. They have given us a program written by Comanor and Mitchell as a starting point. This program was first generated for NCTA and has been presented in "The Bell Journal of Economics and Management Science," Spring 1971. Stan stressed the following points concerning the program:

1. They would like to get the program running and tested as it is now written.

2. They would like access to it via time share from Washington, D. C.

3. They may want the program on a local Washington system for ease of access. This would not be necessary if there are no problems accessing the Boulder computer.

4. The present output is too long. They would like a variable output format.

5. We can question and attempt to validate the data (such as system costs).

6. Think in terms of other models (e.g. updating of old CATV systems).

7. Add other models as they become available (e.g. program industry model could be added).

8. Rand and SRI also have CATV system models.

Stan mentioned that OTP has let a contract to an economic analysis firm to investigate the program industry. They expect a report in December and will keep us informed of the progress of this study.

Richard Nelson of OTP also has an interest in this computer model. He is familiar with the use of a time share computer.

Jerry

J. E. Partch

U.S. DEPARTME.. ' OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

B2

Date: October 14, 1971

Reply to Attn of: JEP

Subject: Participation of ITS in the Policy Support Division's Program in Broadband Services.

To: Roger Salaman.

The objective of our program in the area of broadband services is to gain the understanding necessary to model the broadband services industry. We presently have a working computer model that we obtained from OTP of an individual CATV system; however, it has many areas that need additional study or confirmation.

I would propose that Bernie Wieder be asked to investigate the costs of equipment for CATV and other broadband services. The study should include both the equipment presently available and in common use, and the equipment that will be available five years from now. The study should typically be aimed at providing the range of costs for:

.... upgrading present systems to 20 or more channels.

.... providing new 20 or more channel systems.

.... special 20 or more channel receivers.

.... local origination (mobile and fixed).

.... two way communication capability.

The question of special television receivers has taken on new importance with the recent announcement of a CATV receiver leasing arrangement in a trial system. The study should not be merely a price list from equipment manufacturers, but should include the past experience and future projections of actual system operators, and the imagination of the investigators to envision future services.

I would hope that even though this task is a fairly large effort the working relationships between PSD and ITS can be informal. It is to our mutual benefit since we are both going through a period of problem definition. There will also be other small efforts required of ITS personnel in this program area as it develops.

It would also be appropriate to suggest that ITS investigate the area of technical standards for CATV, using the August 5, 1971 letter to Congress by Commissioner Dean Burch as a guide. However, this area has not been identified as our concern by OTP and thus we could not support the effort.

Jerry

Jerome V. Partch
Policy Support Division

Broadband B3

October 29, 1971

Mr. Stanley M. Besen
Executive Office of the President
Office of Telecommunications
Washington, D. C. 20504

Dear Stan,

The CATV simulation program has been squeezed onto the timeshare computer and is being debugged. I expect to be able to demonstrate it for you when I am in Washington next week. I have enclosed some timesharing manuals for you.

I hope to see you next week.

Sincerely,

Jerry Partch
Policy Support Division

Enclosures (3) as stated

Chrono.
Subject
bcc
JEP/pm (10-29-71)

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

B4

Date: December 6, 1971

Reply to Attn of: ITS/RHE

Subject: Some thoughts on the task of surveying the cost and capabilities of equipment for CATV and other broadband services.

To: Jerry Partch

This memo has three parts: (A) a brief description of the systems to be surveyed, (B) a listing of sub-units for the purpose of categorizing components to facilitate the cost and capabilities survey and (C) the breakdown of costs into several different categories.

At the onset of this survey, no great amount of time will be used to determine an optimum system, instead efforts will be put forth to cost and describe a system to which changes can be readily made as new information is acquired and new questions arise. Also as the literature is searched and contacts are made, a file (catalogs, brochures, reports, etc.) will be maintained for reference in the general area of broadband cables services.

A. Broadband Systems

(1) Twenty or more channel CATV System - This system would be similar to many of the present CATV systems, except that it would have a twenty channel capability.

(2) Twenty or more Channel Broadband (two-way) System - This system would have at least 20 channels and two-way capability. The emphasis here is to compare the costs of two-way vs one-way equipment in a basic system such as 1 above. To include more would confuse the comparison because of the many possible system configurations.

(3) Local Origination and Broadband Services - This category will include the items of equipment (such as interfacing, readout, printout, monitoring, interrogation, etc.) needed to utilize the capabilities of a two-way broadband cable system.

B. Broadband CATV System Sub-units -

In items (1) and (2) of Broadband Systems (above), it is possible to group the equipment into sub-units. These sub-units are:

(1) Antennas -
This sub-unit includes those antennas, mounts, and accessory equipment necessary to bring in the desired over-the-air TV and FM signals plus other broadband services for which full system distribution is desired.

(2) Head-end -
The head-end equipment is generally located at the antenna site and consists of signal processors used to separately stabilize the visual and aural carrier levels and to adjust these carriers levels for desired system distribution. At this point a signal can be converted to channels different from the one on which it was received before distribution on the cable.

(3) Transportation Trunk -
If the antenna site is remote from the area of signal distribution, it may be necessary to have a transportation trunk. It consists of a coax cable with properly spaced repeater amplifiers to overcome cable attenuation. The trunk connects the antenna site to the distribution hub.

(4) Distribution Hub -
At this point in CATV system the signals are processed for customer distribution. This is the input for local origination and could be the tie-in point for both the up-stream and down-stream signals in a two-way broadband service.

(5) Distribution Lines -
The distribution lines can take on a myriad of configurations depending upon the area to be served. The line consists of coax cable with proper amplifiers to allow for the desired distribution and to maintain a specified signal quality.

(6) USER'S Termination -
In a (one-way) CATV system this might be a simple (75 to 300) transformer to properly terminate the incoming cable and to couple to the users TV set.

A (two-way) system could conceivably require more terminating equipment, but what portion becomes user owned and optioned and what is system owned and required is not clear at this time.

C. Cost Breakdown -

The expenditures for a cable system could be grouped into the following general categories:

(1) System Design and Engineering
(2) Survey and Layout
(3) Right-of-way (easements)
(4) Purchase of Equipment
(5) Installation Costs
(6) Checkout (operational)

The first efforts on this task will be to obtain catalogs, brochures, and reports pertinent to CATV and broadband cable services; to make contacts with representatives and engineers of equipment manufacturers and cable T.V. companies; and to begin the task of costing the CATV system hardware. The expenditures for items 1, 2, 3, 4, and 5 under cost breakdowns (above) may be available from materials and studies on existing CATV systems or even other utilities.

Richard H Espeland

Richard H. Espeland

cc: B. Wieder

December 8, 1971

Dr. Stanley M. Besen
Executive Office of the President
Office of Telecommunication Policy
Washington, D. C. 20504

Dear Stan,

We are finally going to complete the comparison of the Rand and Mitchell CATV computer models. In order to facilitate the comparison, the Rand model was put on our computer. I have enclosed an interim report from ITS concerning the Rand model. Computer-generated flow diagrams of both programs have been obtained; however, they are in such detail that they are useless. I feel that sample runs will be more useful. I hope that we can send you a report on the comparison, including example runs, by December 13.

Sincerely,

Jerry Partch

Enclosure as stated

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

Date: December 2, 1971

Reply to Attn of: ITS/JSW

Subject: Interim report on the RAND CATV system financial model

To: Jerry Partch

RAND extensively rewrote the Mitchell program on the CATV Simulation Model and adapted it for use in a study of possible CATV systems for the Dayton, Ohio area. The RAND program generates the financial predictions for such a CATV system for a ten year period.

Basically, the RAND program makes certain economic assumptions about the segmented Dayton area and attempts to demonstrate certain results on a per sector per year basis. The program considers as inputs: (1) the number of homes, final penetration, homes per mile of plant, fraction of plant constructed underground, and cost per mile of underground plant; all on a per sector basis; (2) the percent of final penetration reached in each year per sector; (3) the percent of plant constructed during each year per sector; (4) the yearly subscription for the first outlet during each of the 10 year period; (5) ditto for the second outlet; (6) the installation fees in years 1 to 10; (7) several definable parameters including inflation factors, cost of equipments, payroll information, rental fees, debt equity ratio, power costs, business expenses, taxes, receivables and payables; (8) the additional revenue items; (9) the additional capital expenditure items; (10) the payroll classifications; (11) the number of additional employees; (12) the operating expense items; (13) the vehicular costs; and (14) the additional overriding operating expense items.

Correspondingly, the outputs are concerned with the financial predictions in years 1-10 for: (1) the sector growth and parameters; (2) the CATV system growth and revenue; (3) the payroll; (4) the operating expenses; (5) capital expenditures; (6) the income statement; (7) the sources and use of funds; (8) the balance sheet; and (9) the internal rates of return.

The program is up and running on the CDC 3800 of the Boulder Laboratories and if desired a program manual describing deck setups, input cards, input parameters, the general throughput, and outputs can be created in the near future. Also, flow charts for the RAND program and the Mitchell program are attached for your information.

James S. Washburn

James S. Washburn

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

Date: January 12, 1972

Reply to Attn of: PSD/JEP

Subject: Telephone call to Stan Besen

To: Warning System file

We discussed the CATV computer model. His present thoughts are:

1. Get all data out of program.
2. Wants "standard case" input to test policy assumptions, plus ability to vary this input.
3. Selected policy decisions will be chosen as part of the input data.

They are now receiving the results from their cost contract and are now in a position to more fully define the model. Stan would like to meet for a day as soon as possible to outline the model.

He also asked for clarification of the budget and manpower listing that Dale Hatfield prepared for OTP.

Jerry

Jerry Partch

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

B7

Date: January 25, 1972

Reply to Attn of: PSD/JEP

Subject: Meeting with Stan Besen, OTP, January 19, 1972

To: Broadband Services File

1. <u>RMC Contract</u>: OTP has received an interim report from RMC concerning capital investment costs for CATV systems. We are to use their cost information in our cable financial model. Stan would like comments on the report. He would like me to attend a seminar RMC will be giving in a few weeks in which they will discuss their results.

2. <u>OTP Demand Contract</u>: OTP is about to let a contract which will result in better demand data. The contract would take advantage of a previous market survey conducted by cable interests.

3. <u>Cable Financial Model</u>: We discussed the cable model at length and arrived at a fairly detailed model outline. Stan was going to circulate our ideas among the OTP personnel that would use the model and ask for comments.

Three areas of the model were discussed:

i. Internal data and decision routines.
ii. Input variables.
iii. Output.

<u>Internal data and decision routines</u>

The majority of the cost data will be placed in two subroutines rather than in the main program. The subroutines will represent high and low estimates (or plain and fancy systems) and will be chosen as part of the input variables.

This same technique will be used to select from among various demand equations. Initially only the Park equation will be included.

The program will contain various accepted "rules of thumb" relating route miles to trunk and feeder miles. The selection of a rule will be an input variable.

The following copyright fee structure will be internal to the program:

1% of gross receipts up to $40K
2% of gross receipts from $40K to $80K
3% of gross receipts from $80K to $120K
4% of gross receipts from $120K to $160K
5% of gross receipts greater than $160K.

Some further thought should be given to the copyright fee area as this plan seems rather inflexible.

Input Variables

The input variables can be separated into two areas, policy variables and market variables. The program would normally be executed in one of two ways. A standard set of policy variables would be imposed and the market conditions would be varied. Or a standard market would be imposed and the policies would be varied.

Input variables would include:

- Demand equation option
- Cost option (high or low)
- Local stations carried:
  - Network
  - Independent
  - Non-commercial
- Imported off-the-air:
  - Network
  - Independent
  - Non-commercial
- Imported via microwave:
  - Network
  - Independent
  - Non-commercial
- FM Service (yes or no)
- Households passed by cable
- Subscriber fees:
  - First outlet
  - Additional outlets
  - FM service
  - Connection charge
- Other revenues
- Average household income

Proportion of color TV sets
Percent of route underground
Route miles
Trunk/feeder ratio
Rule-of-thumb option
Two way capability
Channel capacity
Franchise fees
FCC fees
Public access channels
Local origination
Local education channels

Output

The model would not consider methods of financing, but would indicate rate-of-return based on costs and revenues. Income taxes will be neglected in the rate-of-return calculation (there is no way to include them independent from the financing).

The salvage value as discussed in the Rand model will be used in the calculation of rate of return. The output will be similar to the Comanor-Mitchell model with the exception of data concerning debt, equity, depreciation, and taxes.

Stan will be sending his version of the model outline with comments from the OTP staff.

Jerry Partch

OT FORM 10
(1-71)

OFFICE OF TELECOMMUNICATIONS

B8

February 18, 1972

PSD/JEPartch

Comments on RMC Interim Report UR 170

Stan Besen

I have reviewed the RMC Interim Report entitled "Investments Cost for Major CATV Components" and have some comments to make. My comments are not meant to detract from the very thorough job they have done in compiling the information, but are only intended to avoid possible embarrassment to OTP and to maximize its usefulness to our financial model development. I have not bothered to list typographical errors, as I am sure they will be discovered by RMC.

Item 1: Reference pp. 12, 24 ff. The use of a VHF to VHF converter was ignored. This converter is used to change the channel assignments of VHF channels. It is a common item in areas of high over-the-air signal strength.

Item 2: Reference pp. 12, 15, 16. The pilot carrier generators should be represented schematically in the same manner as the "other channel inputs" in fig. 5-1 and "input-other" in fig. 3-2, as inputs to the directional coupler and splitter.

Item 3: Reference pp. 14 ff. The use of the terms modulator and demodulator is confusing in the context of the discussion on page 14 ff. They are confused by the fact that two carrier frequencies, microwave and VHF, are involved in the discussion. In the CATV industry, the common usage of the term modulator indicates a device that accepts video and audio signals and generates a standard vestigial sideband television signal on a standard channel. This type is sometimes referred to as a television modulator. Other modulators used in the CATV industry accept audio signals and generate signals in the FM band. Still others are used to produce a blank screen with audio programming on standard television sets.

In the microwave industry, the common usage of the term "microwave modulator" indicates a device which modulates or adds information to a microwave carrier source. In figure 3-2, the term "microwave modulator" is used to indicate the use of a television modulator designed to accept the audio and video signals from a microwave receiver rather than from a television camera, but it is not a microwave modulator. The

SURNAME	DATE	SURNAME	DATE

list of equipment on page 14 could be made unambiguous by the use of the prefixes television and microwave as appropriate.

Item 4: Reference pp. 22, 26, 28. The discussion of the FM system is incorrect and incomplete. There are essentially three different ways to provide FM service on a CATV system.

1. The entire off-the-air FM band can be carried on the system at its normal broadcast frequency, 88 to 108 MHz, and can be received by the subscribers with a normal FM receiver. This service would require a single headend FM antenna, either directional or omnidirectional, and a pre-amplifier. An FM tuner would not be necessary. This method would probably be used in an area where a large number of FM stations were available off-the-air at the headend.

2. Selected FM stations can be received and rebroadcast on the cable in the FM band for receipt by a subscriber's FM receiver. This service requires an FM antenna, directional or omnidirectional, a pre-amplifier, tuner, and FM modulator. Figure 3-4 neglects to indicate the use of an FM modulator and this is perhaps only a matter of terminology. The use of more than a single FM antenna is questionable and would only be necessary if you were in extreme fringe areas. Some average is clearly indicated.

   This service would be attractive in an area without an adequate number of local off-the-air signals.

3. A third system is a variation of the second. Rather than rebroadcasting in the FM band, the selected stations can be processed such that they may be received on a television channel with the screen remaining blank. The modulator required is mentioned in Item 3. This type of service would be especially attractive in an area with a concentration of hotels, so that both normal television services and audio programming could be offered on an ordinary television set.

   This section of the report should be revised to indicate some of the common alternatives in FM services and to clarify the number of FM antennas necessary.

Item 5: Reference Fig. 3-6. This figure needs clarification. Is it a pictorial or schematic representation or a combination. The large block and small circles need to be identified.

Item 6: Reference p. 49, line 6. The objection in selecting cable is to minimize the total system cost. It is a cost/loss tradeoff. If the objective were merely to minimize loss, you would increase the size of the cable until you encountered higher order propagation modes. This cost/loss tradeoff is clarified by tables 4-22 and 4-23 in which the smaller (and lossier) cable turns out to be the most economical from a system viewpoint.

Item 7: Table 4-8. A subscriber converter is not necessary in an activated dual cable system unless the capacity is greater than 24 channels.

Item 8: Table 4-10. The columns listing subscriber drop costs in dual cable systems should indicate the effect of channel capacity. For instance, column 34 would be $33.00 for 24 channels or less and $63.00 for greater than 24 channels.

Item 9: Construction Costs. RMC has tabulated in a very thorough manner all the costs associated with underground cable installations. However, the information is difficult to apply to our financial modelling. It would be very helpful if they would discuss some typical pavement specifications or typical costs in various market areas.

Jerry Partch
Policy Support Division

bcc:
Subject
Daily

JEPartch:jlr (2-18-72)

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

Date: February 18, 1972

Reply to Attn of: ITS/RHE

Subject: Studies of the CATV trunk and distribution amplifiers manufactured by Jerrold Electronics Corporation and Kaiser CATV.

To: Jerry Partch

As a result of our discussions and review of RMC's first draft of CATV systems costs and capabilities and as part of the possible tasks outlined in my earlier memo to you (Dec. 6, 1971) on costs and capabilities of equipment for CATV and other broadband services, I have completed a study of the available CATV amplifiers of two major manufacturers of these components. These studies were conducted with an emphasis toward the equipment with two-way capability, but include for price comparison the earlier lines of both companies.

The "series 3" CATV trunk amplifiers of both companies are the amplifiers designed for installation in systems requiring two-way capability or with future option for two-way capability. These amplifiers can be purchased at three price levels:

(a) "one-way" which is compatable with existing systems or for upgrading to two-way (these units would require filters, reverse amplifiers, etc. for upgrading).

(b) "Two-way" which would probably be purchased for a dedicated two-way system but the reverse capability is not required immediately (these units require only plug-in options for two-way operation) and

(c) "complete two-way" which provides immediate head-end-to-top two-way operation.

The two companies selected for this cost study (Jerrold and Kaiser) carry a line of amplifiers designed to be used in the conventional CATV system (that is the head-end, trunk line, distribution line concept as opposed to multiple hubs and/or switch capabilities at the hubs which have been proposed as possible concepts). This equipment could be used in single or multiple cable installation.

For making price comparisons between the two companies, two facts should be remembered concerning the prices of Kaiser equipment. One is that their AGC equipment in "series 2" and "series 3" use a dual pilot control which is comparable to the ASC equipment offered by Jerrold. A second is that the Kaiser housings as priced are adequate for underground use in a vault, whereas, in the Jerrold line a price adjustment (see the table) is required if underground installation is anticipated.

The information in this study should be useful in extending a CATV economic model to include two-way capability because it is the amplifier requirements that are most effected and have the greatest cost impact when expanding from one-way to two-way capability.

The study is in two parts. The first covers the Jerrold equipment which includes brief component description as well as the price listing, whereas, the second covers the Kaiser equipment price listing only.

Richard H. Espeland

Richard H. Espeland

cc: B. Wieder

Enclosure: Study 1.
Study 2.

STUDY No. 1

CATV Amplifiers

The following paragraphs are a summary of what is currently available in CATV amplifiers and a brief description of how they are used. Jerrold's CATV product catalog was used as the primary reference. This catalog does not include an overall "amplifier line" use description or breakdown so this information has been deduced from the technical data in the catalog.

Jerrold refers to their amplifiers as stations. A station includes the housing, power pack and the necessary modules to meet the reouire ments for that station. The attached figure 1 shows the cost breakdown of the three lines available from Jerrold by station name and figure 2 shows cost data of the line extender amplifiers.

1) Trunk Amplifier -

This unit is solely a trunk line amplifier with manual gain control. It is intended as a main line cascader in open areas. Operational gain of these units is 23 dB to 26 dB.

2) Trunk amplifier with AGC -

This unit is used in the trunk line where automatic gain control is required. An AGC unit is usually required every second or third amplifier depending upon the temperature range for which to compensate. It uses a pilot tone generated at the head-end as a control signal. Operational gain is 23 dB to 26 dB.

3) Trunk and Bridging Amplifier -

This unit is used where AGC is not needed in the trunk line but where distribution lines are to be connected. It has a manual gain control. The operational gain through the trunk amplifier is 22 dB to 26 dB and through the bridging amplifier is 40 dB to 42 dB.

4) Trunk and Bridging Amplifier with AGC -

This unit has a capability similar to the trunk and bridging amplifier but also has the AGC control. It is used where both bridging and AGC are required and where up to four distribution lines are to be connected. It also uses the pilot tone as a control signal. The operational gains are of the same range as the trunk and bridging amplifier above.

5) Distribution Amplifier -

These amplifiers are used on the trunk line where distribution is desired but where no trunk-signal amplification is needed and as a distribution line termination where additional distribution lines are created.

The high-gain distribution/bridging amplifiers have a bridging gain range of 32 dB to 44 dB and the low-gain distribution line termination amplifiers have a gain range of 26 dB to 32 dB.

6) Trunk Amplifier with ASC -

This unit available only in the high-capacity series is similar to the trunk amplifier with AGC. The difference is that it uses a dual-pilot for control of gain and slope. Standard TV cable channels are used as pilot carriers such as 4 (low band) and 11 (high-band) operational gain is 25 dB.

7) Trunk and Bridging Amplifier with ASC -

This unit is very similar to the trunk and bridging amplifier with AGC except that it uses the dual-pilot control to compensate for both gain and slope automatically. Operational gains are 24 dB for the trunk amplifier and 42 dB for the bridging amplifier.

8) Automatic Slope Amplifier -

This unit is designed to correct residual tilt. It has no effect on the normal equalization. It operates with one high-band and one low-band modulated carrier. It offers unity gain and is installed directly after a trunk amplifier station in the system. The number required varies from one at every seventh, eighth or ninth station to maybe only one for the whole system.

Full Two-Way Capability

When a full tap-to-headend return capability is desired, additional modules are used with the high capacity two-way equipment. These are available in sub-split (5-30 MHz) and mid-split (5-108 MHz) bands. The functions of the modules for the two bands are essentially the same but with some variations in costs and the frequency ranges in which they can be used. The brief function description are as follows.

1) Trunk Return Amplifiers -

These units are used where needed to compensate for cable loss of the return signals. They are available in the two frequency ranges each with or without AGC. AGC units use a pilot tone for control which is at a different frequency then the forward AGC pilot tone. Forward trunk amplifiers with AGC must use trunk return amplifiers with manual gain control. Forward trunk amplifiers without AGC may use trunk return amplifier with either AGC or MGC. Operational gain is 18 dB for the 5-30 MHz modules and 23 dB for the 5-108 MHz modules.

2) Trunk Filter -

These units are used in the trunk line with the trunk return amplifiers. Two are used, one at the input and one at the output. Using the filter designed for the sub-split amplifier creates pass bands of 5 to 35.5 MHz and 46 to 300 MHz. The filters designed for the mid-split amplifiers creates pass bands of 5 to 120 MHz and 144 to 300 MHz.

3) Distribution Filter -

This unit is used in the distribution line where bridging amplifiers are used in the two-way system. One filter is used in each line. A single filter is used with either the sub-split or mid-split modules. The pass bands created are 5 to 34 dB and 50 to 300 MHz.

4) Equalizers -

Several types of associated hardware such as equalizers, plug-in-pads, directional couplers, thermal equalizers and feedermakers may be used in any given CATV installation. One of these specifically called for in the two-way capability described here is a variable equalizer. The two types are for the sub-split and mid-split bands and offer cable compensation in the range of 11 to 20 dB.

5) Feedermaker -

The function of this item is to create from one to four feeder line outputs at any distribution amplifier location on the main trunk line.

Line Extender Amplifier

The line extender amplifiers are used in the distribution lines to compensate for cable loss. In the extenders series there are not as many types and variations. Those available are described without trying to categorize by capacity.

One model has a fixed gain of 9 dB and fixed tilt of 5 dB and operates in the 40 to 240 MHz range.

A second model which uses manual gain and tilt control operates with 25 dB gain and its frequency range is 40 to 245 MHz.

A third model operates over the 40 tq 260 MHz range and can handle 30 channels. It features manual slope and gain adjustments with plug-in facilities for slope and gain control and two amplifiers may be cascaded. It has an operating gain of 25 dB.

The fourth model operates over the 40 to 300 MHz range and offers a one-way or two-way capability. Up to four amplifiers may be in cascade. This series features either manual or automatic gain control and provides 25 dB gain.

A return amplifier must be purchased for two-way capability. It operates in the 5 to 30 MHz range with a gain of 15 dB.

Figure 1 a. CATV Trunk Amplifiers

Station	Series 1 50-220 MHz 12 Channel	Series 2 50-240 MHz 20 Channel	Series 3 40-260 MHz 30 Channel		Complete *** two-way 40-260 MHz	
			one-way	two-way	sub-split 5-30 MHz	mid-split 5-108 MHz
Trunk Amplifier	$390.00	$495.00	$570.00	$640.00	$827.75 (1)	$907.75 (2)
Trunk Amplifier with AGC	485.00	555.00	655.00	725.00	900.75 (3)	970.75 (4)
Trunk & Bridging Amplifier	540.00	700.00	825.00	895.00	1120.65 (5)	1200.65 (6)
Trunk & Bridging Amplifier with AGC	635.00	750.00	890.00	960.00	1173.65 (7)	1243.65 (8)
Distribution Amplifier High-Gain	375.00	545.00	625.00	695.00	908.65 (7)	978.65 (8)
Distribution Amplifier Low-Gain	455.00 (A)	545.00	-	-	-	-
Trunk Amplifier with ASC	-	-	755.00	825.00	1000.65 (3)	1070.75 (4)
Trunk & Bridging Amplifier with ASC	-	-	990.00	1060.00	1273.65 (7)	1343.65 (8)
Automatic Slope Amplifier	635.00	635.00	635.00	635.00	635.00	635.00

Explanation of noted values see figure 1b.

Figure 1b. ADDITIONAL MODULES FOR TWO-WAY RETURN

	MGC		AGC/ASC		Bridging MGC		Bridging AGC/ASC	
	sub-split	mid-split	sub-split	mid-split	sub-split	mid-split	sub-split	mid-split
Return Amplifier *	127.00	207.00	115.00	185.00	127.00	207.00	115.00	185.00
Hi-Lo Split Filter (2 each) @ $24.50	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00
Distribution Hi-Lo Filter	-	-	-	-	29.50	29.50	29.50	29.50
Variable Equalizer	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75
Feedermaker **	-	-	-	-	8.40	8.40	8.40	8.40
TOTAL	187.75 (1)	267.75 (2)	175.75 (3)	245.75 (4)	225.65 (5)	305.65 (6)	213.65 (7)	283.65 (8)

* This cost is the average of two manual and one automatic unit.
** This cost is the average of four units.
*** The number in these columns show which (addition modules) cost was added to the two-way trunk amplifier station to get the cost for complete two-way.

NOTES: (A) Old catalog price adjusted according to new catalog price change in high-gain amplifier.

(B) Prices listed are for aluminum housings suitable for aerial or pedestial mounting. A cast-iron housing is used for underground. Adjust costs accordingly:

Add $90.00 to series 1 units for cast-iron
Add $65.00 to series 2 and 3 units for cast-iron

Figure 2. Line Extender Amplifier

Frequency Range (MHz)	Gain (dB)	Tilt (dB)	Control	Cost
40 to 240	9	5	Fixed	$ 27.00
				37.00
40 to 245	25	Plug-in	Manual	134.50
				134.50
40 to 260	23	Plug-in	Manual	199.50
40 to 300	25	Plug-in	Manual (one-way)	225.00
"	25	"	AGC (one-way)	245.50
"	25	"	Manual (two-way)	249.50
"	25	"	AGC (two-way)	285.50
			Manual (two-way) with return amplifier	339.00
			AGC (two-way) with return amplifier	375.00

NOTE (1) Housing included in prices suitable for aerial and pedestial mounting cast-iron housing available in all but the first (fixed control) amplifiers. Add $40.00 to prices for cast-iron.

STUDY No. 2

CATV Amplifiers

This write-up lists the amplifiers manufactured by Kaiser. Kaisers' products catalog was used as the source and it does not contain an "amplifier line" use description and breakdown so the information has been deduced from the technical data and specification in the catalog.

A companion study performed on the Jerrold Company amplifiers includes short descriptions of the several units available. Although there are some differences in the design philosophies of the two companies, the units are functionally similar and it is suggested that reference be made to that study for amplifier descriptions.

The Kaiser products are modular in design as are Jerrolds' and the costs in Figures 1 and 2 are for unit combinations that are complete with housing, power pack, and the required amplifier modules. There are three series of amplifiers available from Kaiser.

Figure 1. CATV Trunk Amplifiers

Station	Series 1 54-216 MHz up to 20 Channels	Series 2 50-270 MHz up to 36 Channels	Series 3 54-300 MHz 30 Channels one-way	Series 3 54-300 MHz 30 Channels two-way	Complete two-way 54-300 MHz 30 Channels Return Band 5-30 MHz
Truck Amplifiers	$366.00	$565.00	$616.00	$684.00	$941.00
Truck Amplifiers with AGC	451.00	670.00	763.00	830.00	1088.00
2 - Output MGC Bridging Amplifier Combination	590.00	880.00	860.00	975.00	1232.00
2 - Output AGC Bridging Amplifier Combination	675.00	985.00	1007.00	1121.00	1379.00
4 - Output MGC Bridging Amplifier Combination	636.00	985.00	939.00	1101.00	1357.00
4 - Output AGC Bridging Amplifier Combination	721.00	1090.00	1086.00	1246.00	1504.00
2 - Output Intermediate Bridging Amplifier	496.00	591.00	716.00	830.00	1088.00
4 - Output Intermediate Bridging Amplifier	542.00	696.00	795.00	956.00	1220.00

NOTE: Housings included in the amplifier price are suitable for placing in an underground vault.

Figure 2. Line Extender Amplifier

Frequency Range (MHz)	Gain (dB)	Equalization Range (dB)	Cost
54-216	(No specification sheet)		$130.00
50-270	20	5-15	167.00
50-270	(Same as above with four output customer taps)		190.00
54-300	22	5-18 MGC	347.00
54-300	20	5-18 AGC	426.00
54-300	22	5-18 MGC Less Reverse	386.00
54-300	22	5-18 MGC With Reverse	474.00
54-300	20	5-18 AGC Less Reverse	462.00
54-300	20	5-18 AGC With Reverse	553.00

NOTE: Housings included in the amplifier price are suitable for placing in an underground vault.

OFFICE OF TELECOMMUNICATIONS POLICY
WASHINGTON

February 29, 1972

TO: Jerry Partch
Lockett Wood

FROM: Walt Hinchman

Attached is an information bulletin from Theta-Com for a seminar to be given in Washington, D. C., April 10-13. I would like to suggest that Jerry attend the seminar for the first two days, and Lockett for the full session, if possible. You may send in your registration form direct, but let me know if you are available.

Walt

Walt Hinchman

cc: Bob Lowe
Roger Salamon

THETA-COM

February 18, 1972

Mr. Walter Hinchman
Office of Telecommunications Policy
The White House
Washington, DC 26500

Dear Mr. Hinchman:

We have been conducting a series of technical seminars on multi-channel microwave LDS systems at our plant in Los Angeles. These LDS systems are used for the local distribution of CATV signals. We will be conducting our first such seminar on the East coast in Washington, D. C. from April 10th through April 13th, and would certainly be pleased to have you or any of your associates attend.

Information concerning the seminar is attached. As you will note, there will also be a brief discussion of our new interactive Subscriber Response System.

We look forward to hearing from you and to the possibility of your attendance.

Sincerely yours,

A. H. Sonnenschein

A. H. Sonnenschein
Assistant to the President

AHS:jc

Enclosure - as cited

AML TECHNICAL SCHOOL REGISTRATION

WASHINGTON, D. C.

APRIL 10 - 13, 1972

Name: ______________________________

Title: ______________________________

Company: ______________________________

Mailing address: ______________________________
Street

____
City State Zip

Telephone: ( ) ______________ ______________________________
Area Code Telephone Number

- -

	Yes	No
I plan to attend the complete session	☐	☐
I plan to attend only the 1st two days	☐	☐
I plan to attend the dinner on Tuesday night	☐	☐
I plan to stay at the Quality Motel-Capitol Hill	☐	☐

Note: Make your own hotel-reservations

I intend to arrive at the Hotel on ______________________________

Please specify how you would like your name imprinted on your course completion certificate:

____

____
Signature

- -

Mail to: Mrs. Joan Cochran, Registrar, AML Technical School
Theta-Com of California, 9320 Lincoln Blvd., Los Angeles, CA 90045
Telephone: (213) 641-2100

ETA-COM OF CALIFORNIA
9320 Lincoln Boulevard
Los Angeles, California 90045

INFORMATION BULLETIN

AML TECHNICAL TRAINING SCHOOL

APRIL 10 - 13, 1972

WASHINGTON, D. C.

Basic Subject Matter:

1. Introduction to microwave theory as applied to multi-channel microwave Local Distribution Systems (LDS) [Monday]
2. Systems Engineering and Application Engineering [Tuesday]
3. The integration and composite performance of LDS equipment with conventional CATV systems [Tuesday]
4. Equipment Theory of Operation [Wednesday]
5. Installation and Maintenance [Thursday]

Special Sessions:

1. Brief Progress Report on Subscriber Response System (SRS) [Tues. aft.]
2. Measurement session on AML system to verify following performance parameters:
   a) Synchronous crossmodulation
   b) Signal-to-noise ratio
   c) 2nd order inter-modulation products
   d) 3rd order inter-modulation products
   e) differential phase
   f) differential gain
   g) envelope (group) delay [Thurs. aft.]
3. Reception and Dinner for all attendees [Tues. even.]

Location:

Quality Motel - Capitol Hill
415 New Jersey Avenue, N. W. (near the Capitol)
Washington, D. C. 20001
Telephone (202) 638-1616

Reservations:

1. School: Send special reservation form to Theta-Com
2. Hotel: Contact hotel directly. Hotel reservation forms attached.

Expenses:

1. Theta-Com will supply: all lunches, coffee breaks, reception, dinner banquet, instructional materials, etc.

2. Attendees must take care of: all other meals, hotel room, and their own travel expenses.

Dates:

1. Duration:
Monday morning, April 10, 1972 (classes start promptly at 9:00 A.M., so it is desirable for out of town attendees to arrive on Sunday night) through late Thursday afternoon, April 13, 1972.

2. Partial Attendance:
Attendees who only desire a superficial familiarization may wish to confine their attendance to the first two days only (Monday and Tuesday, April 10 and 11). Your attention is, however, called to the special session scheduled for Thursday afternoon - at which detailed performance measurements will be made on the AML system.

Schedule:

Monday through Thursday: 9 A.M. - 5 P.M.
Reception and Dinner: Tuesday 6 P.M. - 9 P.M.

Contact:

For further information contact:

a) A. H. Sonnenschein
Theta-Com of California
9320 Lincoln Boulevard
Los Angeles, CA 90045
Telephone: (213) 641-2100

or your regional Theta-Com Sales Manager

Northeastern:	Martin J. Moran Willingboro, NJ (609) 871-1660
Southeastern:	Richard P. Walters Atlanta, Georgia (404) 252-6197
Central:	Ferris E. Peery Denver, Colorado (303) 759-4061
Western:	Ben W. Forte Pleasanton, California (415) 462-1353

B11

FAX received 3/1/72
12:00 RW

OFFICE OF TELECOMMUNICATIONS POLICY
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20504

February 28, 1972

To: Paul Polishuk

From: Walt Hinchman

Subject: CATV Demand Study

I am attaching the Sole Source Statement, Statement of Work, and associated material for the CATV Demand Study.

When you have had a look at this material, I would like to discuss with you the best way to get this study accomplished expeditiously.

Walt

Walt

Attachment

SOLE SOURCE STATEMENT

SUBSCRIBER DEMAND FOR CABLE TELEVISION STUDY

for the

OFFICE OF TELECOMMUNICATIONS POLICY

Charles River Associates, Inc., (CRA), is recommended as the contractor to provide the Office of Telecommunications Policy with a study of subscriber demand for cable television. This study will be in sufficient detail to permit OTP to formulate national policy conclusions relating to this aspect of broad-band communications. The study will be used to provide one input to a computer simulation model of the cable television industry. In considering the method of procurement for this study, which is described in detail in the attached work statement, the following important criteria were identified as essential to meet the basic objectives:

1. The work must be done by an organization having extensive experience in performing sophisticated econometric demand studies.

2. The selected organization must have an experienced economic research staff of high caliber.

3. The organization must not be under contract to private groups or organizations in this area, in order to avoid any conflict of interest problems and to ensure maximum impartiality.

4. Due to the urgency of the OTP needs, the staff must be available to begin the study within a brief period of time.

The proposed contractor, CRA, has extensive experience in performing econometric demand studies. These sophisticated studies, and the demonstrated quality of its economic research staff, have gained for CRA general recognition as one of the nation's foremost economic research firms. This is further attested to by its distinguished list of clients which include both private firms and government agencies. The proposed project director, Thomas Domencich, has published extensively in the field of measurement of consumer demand. His work on the urban transportation choice has developed a methodology which is directly applicable to the cable television subscription choice. In particular, the transportation demand study employed data on individual households and as a result, obtained results which were significantly different from those of previous studies which were based on aggregated data. The proposed study will also employ microeconomic data and should also prove to be an advance over previous work which was limited to the study of aggregates.

Gerald Kraft, another senior project member, also has extensive experience in econometric work on consumer demand. He participated with Mr. Domencich on the demand study of urban transportation and has done work on the demand for supersonic transportation, on the demand for intercity travel, and on the demand for personal goods and services in underdeveloped countries.

A second factor which contributes to the uniqueness of this proposal is that the data have already been collected and can consequently be made available to the government at only the expense of tabulation. A reasonable estimate of the cost saving involved is $30,000.

A number of other possible candidates were considered to determine their relative capability in the areas of study. Among those were firms that previously had OTP contracts, as well as others who have been unsuccessful bidders on past requests for proposals. The other possible candidates are:

The Urban Institute -- Interest in cable television confined to uses of cable to provide social services and to an advisory role for local governments.

Stanford Research Institute -- Does not have strong econometric group.

Rand Corporation - Relevant personnel are committed to other activities.

A. D. Little - Engaged in similar activities for private clients which creates possible conflict of interest problems. Also lacks strong econometric group.

Statement of Work

Background and Objectives

The Office of Telecommunications Policy (OTP) is interested in developing a model of CATV demand which can be used to address a number of policy issues. To be useful for policy purposes, the model should attempt to provide quantitative measures of the effects on CATV subscriber demand of such variables as the price of CATV, the number, type and reception quality of viewing choices on CATV versus off-the-air alternatives, the effect of price and service variables on the time path of diffusion of CATV, and the effects of socioeconomic variables on CATV subscriber demand.

The objective of this study will be to develop such a model. The study will concentrate on modelling subscriber demand. It would also be extremely useful to model the viewing behavior of TV users, but the data on program viewing for the surveyed households appears to be too limited to support such a model. Thus, this study will concentrate on modelling the relationships between CATV subscriber demand and such policy variables as price and service levels (including program type, quality of reception and number of alternatives) of CATV versus off-the-air alternatives; a range of socioeconomic and demographic variables such as household income, family size and composition (e.g., age), TV set ownership, and so forth; and a number of measures of marketing effort. While the latter two sets of variables are not policy variables per se, they should be incorporated in the model to insure that their influence does not distort the measured effects of the policy variables. In addition, the inclusion of the socioeconomic and demographic variables will be useful for their own sakes in forecasting.

Research Approach

The basic approach in modelling CATV demand will be to develop a stochastic choice model of demand based on data from individual households. The stochastic choice model measures the probability that a specific choice will be made given the alternatives available, the socioeconomic characteristics of the household, and other factors which may affect his decision such as marketing effort. This type of model is particularly appropriate for disaggregated household data because the units of observation are binary (i.e., they either do or do not subscribe to CATV), rather than quantities of households subscribing to CATV as is the case with aggregative data. Experience with disaggregated data indicates that their use considerably improves model estimation.

The dependent variable in the model would be a (zero, one) variable indicating whether or not the household subscribed to CATV. The explanatory variables would fall into three categories.

The first category includes the policy variables: price variables -- including installation, monthly fee, and special terms (e.g., number of free months); and service variables -- for both CATV and off-the-air, the number and type of channels (i.e., U's, V's, independents, networks, ETV's, local CATV origination), the quantity and type of available non-duplicative programming, and the quality of reception.

The second category covers the socioeconomic and demographic variables. These could include measures of family size and composition, household income and occupation, race, age and sex of head of household, TV ownership, average hours of TV watched, measures of the type of city, and so forth.

The third category covers the marketing effort. These variables could include the length of time CATV has been available in the community, the sales and promotional efforts that have been undertaken (i.e., type and number of mailings, promotional budgets, number of salesmen in the field), and the service and maintenance effort (e.g., average length of time to connect, service budget, etc.). The rate of diffusion of CATV subscriptions can also be measured through inclusion of several of the above variables, especially measures of length of time service has been available in the area and previous sales and promotional efforts.

The data for many of the above variables are already available in Berkowitz, Walker and Associates' files from previous household surveys conducted in over 50 market areas. The cross section of market areas provides broad geographic coverage and includes a wide range of city sizes and types. The range of price variation is somewhat limited -- between $3.95 and $6.95 per month, with about half the markets lying between $4.95 and $5.25 per month -- but the variation is increased somewhat by promotional discounts and differences in installation fees. A good range of alternative service levels is available.

The principal variables which are not already available in Berkowitz, Walker and Associates' files include measures of programming content which will be developed from TV Guide; and for some market areas, measures of previous sales and promotional efforts, estimates of which will be obtained from CATV operators.

To estimate the models there are two basic approaches available: least squares estimation of a linear probability model, or maximum likelihood estimation of a non-linear model. Since the model is binary rather than multiple choice, the linear probability model is applicable. Because of its substantially lower computational costs, it will probably receive principal emphasis in the study. However, both approaches will be considered in the course of the study and a choice between them made on the basis of model specification, potential biases, and relative computational costs.

It may be possible to draw inferences about the demand response for Pay-TV from the estimated demand function for CATV subscriptions. The demand for a new alternative can be inferred from comparisons of existing alternatives if the attributes of the existing alternatives can be regarded as generic (rather than specific to the particular alternatives being compared) and if the new alternative can reasonably be described in terms of a combination of the attributes of the existing alternatives. Whether the attributes can be regarded as generic is basically an empirical question. It can be tested by examining the estimated attribute parameters as well as the constant term in the model. We will attempt to structure the CATV model to enable generic parameters to be tested and estimated. To the extent possible, then, the estimation results will be used to examine the demand response for Pay-TV.

Work Statement

To accomplish the objectives of this study in accordance with the methods discussed in the Approach, the following tasks will be undertaken.

1. Literature Review. A review of the literature will be undertaken to examine the methodology employed by previous researchers and to summarize the useful empirical results of existing studies. The objective of this task will not be to provide an exhaustive literature review for its own sake, but rather to add perspective and assist in structuring this study.

2. Model Theory and Specification. A theory of CATV subscription

demand will be developed, based on consumer demand theory as realted to CATV subscription demand. From this, a number of alternative model specifications will be developed. These model specifications will cover the relevant explanatory variables, the mathematical forms of the equations and the stochastic specifications of the models.

3. Data Preparation. The previous task will identify the data requirements for the analysis. This task will cover the preparation of the available relevant data. It will consist of sample selection from the file of household data and preparation of the relevant available household variables for machine accessibility. Also included is preparation of additional variables, as needed, from available published sources (for example, measures of programming content from TV Guide).

4. Parameter Estimation. Once the data are in machine accessible form, alternative models will be estimated statistically. The results will give parameter estimates and the conventional test statistics. The choice of estimation technique will be based on an evaluation of the stochastic properties of the model and expected computational expenses, but we expect that predominant use will be made of the linear probability model estimated by ordinary least squares because of the extremely high costs of non-linear estimation with reasonably large samples.

5. Evaluation and Interpretation of Results. The resulting estimates will be evaluated on the basis of both plausibility of the parameters and the conventional test statistics. Such measures as elasticities and cross-elasticities of variables will be computed to aid in the interpretation of the results.

The results will be interpreted in terms of the effect of each explanatory variable on the demand for CATV subscriptions, and to the extent feasible, on the demand for Pay-TV.

6. Reports. At the completion of the research, a draft report giving the results of the above tasks will be submitted for review by OTP. Within 30 days of receiving OTP's comments on the draft report, a final report will be submitted. In addition, brief progress reports will be submitted monthly during the course of the study.

Five copies of an interim report will be submitted four months after authorization of the contract describing the research results that have been obtained to that date. Within six months of contract acceptance a draft of the final report will be submitted (in five copies) covering the results of all the tasks described above. The final report (20 copies) will be submitted within 30 days of receiving OTP's comments on the draft report. In addition, brief progress reports will be submitted monthly during the course of the study.

7. Financial Arrangements. The contract will be for a fixed price of $65,000. (Details are provided in the enclosed attachments.) Progress payments of 40 percent after 3 months, 40 percent upon submission of the draft report, and the balance upon acceptance of the final report will be made. The duration of the contract will be six months with the work beginning within two weeks of the execution of the contract.

Staff Responsibility

Thomas Domencich will be in charge of Charles River Associates' research efforts and associated with him will be other CRA support staff with backgrounds appropriate for this study. Michael Berkowitz will direct efforts. Professor Daniel McFadden will act as a consultant on the study, assisting on issues of model specification and estimation technique. Mr. Domencich will be overall project director for the study.

Details of Cost Proposal

Office of Telecommunications Policy

Direct Labor		
Senior Research Associate - F -- 340 hours	$5,582	
Senior Research Associate - A -- 150 hours	1,125	
Research Assistants -- 220 hours	825	
TOTAL DIRECT LABOR		$ 7,532
Overhead, General and Administrative Expense		
(At 1971 experienced rate)		13,934
Other Direct Costs		
Data Processing	$4,000	
Travel	1,600	
Long-distance Telephone	300	
Printing and Copying	300	
TOTAL		6,200
Consultants		
D. McFadden, 6 days		1,500
Subcontract		
Michael Berkowitz		30,000
Total Cost		$59,166
Fee		5,834
Total Contract Amount (Fixed Price)		$65,000

THOMAS A. DOMENCICH -- Senior Research Associate

Doctoral	Program in Economics, University of California, Berkeley, 1961-1963.
Doctoral	Program in Business, University of Chicago, 1960-1961.
M.B.A.	Indiana University, 1959.
A.B.	Economics, Ripon College, 1955.

Vice President, Charles River Associates Incorporated. Mr. Domencich has extensive experience in the development of econometric models for use in analyzing public policy issues. He has recently completed a major study for the Federal Highway Administration to develop a methodology for modeling the various choices involved in urban passenger travel behavior using data on individual households. The methodology was tested by estimating stochastic choice models of trip frequency, the time of day of travel, alternative trip destinations and choice of transportation mode, for several trip purposes. In addition, he has applied quantitative estimation techniques to the analysis of markets for numerous nonferrous metals and minerals, the analysis of competition between truck and rail in the intercity freight market, and to an evaluation of a program of transit subsidies. He is currently supervising a major study of interfuel competition in the energy markets. Mr. Domencich has also served as a consultant to the White House staff on revenue sharing, regional economic development, and national transportation policy.

Research Economist, Arthur D. LIttle, Incorporated. Work concentrated on the application of economic and statistical decision theory to investment allocation, and on the development of econometric models to evaluate optimum price and production levels in various markets. Areas of study include maritime shipping, airline traffic, demand for mineral resources, and utilization of natural resources.

Research Assistant in Regional Economics, University of Chicago. Engaged in analysis of trends in population, employment and personal income in the Great Lakes Region. Results were published in *Profile of Michigan*, 1963.

<u>Selected Publications</u>

"Individual Choice MOdels of Urban Passenger Travel Demand, *Highway Research Record*, (forthcoming).

An Analysis of the United States Oil Import Quota, with James C. Burrows (Boston, Massachusetts: Heath Lexington Books, 1970). Portions reprinted in *Contemporary Issues in Economics, Selected Readings*, Richard Eckhaus and Robert Crandall, eds. (Little, Brown and Co., forthcoming).

Free Transit, with Gerald Kraft (Boston, Massachusetts: Heath Lexington Books, 1970). Portions reprinted as "Free Transit," in *Readings in Urban Economics*, edited by Jerome Rothenberg and Matthew Edel (Macmillan, forthcoming).

"Competition Between Truck and Rail in Intercity Freight Transport," with Douglas W. Woods, *Transportation Research Forum*, 1971.

A Model of Urban Passenger Demand in the San Francisco Metropolitan Area, with G. Kraft and Jean-Paul Valette (Boston: Heath-Lexington Books), forthcoming.

Profile of Michigan, Stephen P. Sobotka with T. A. Domencich, The Free Press of Glencoe, 1963.

DETAIL OF COST ESTIMATE --
BERKOWITZ, WALKER AND ASSOCIATES

(Subcontract to Charles River Associates
CATV Study)

DIRECT LABOR			
Senior Staff	40 days @ $100		$4,000
Intermediate Staff	25 days @ $75		1,875
Programmers	25 days @ $65		1,625
Junior Staff	70 days @ $30		2,100
TOTAL DIRECT LABOR			$9,600
OVERHEAD @ 100% of Direct Labor			9,600
OUT-OF-POCKET COSTS			
Key Punching	$1,600		
Data Acquisition	$2,000		
Computer Charges	$2,500		
Travel and Communication	$2,000		
			8,100
TOTAL COSTS			$27,300
FEE			2,700
TOTAL FIXED PRICE			$30,000

MICHAEL S. BERKOWITZ

Professional Background

1972	Independent consultant on CATV management and marketing to industry and government.
1971	CATV-Marketing, Incorporated Director of Research & Development - Responsible for market research and economic feasibility studies, management and marketing consultant to government agencies and private industry, and evaluating "in-house" data processing systems and field operations.
1970 - 1971	Federal Communications Commission Office of the Chairman - Planning Staff, industry economist. Responsible for planning and developing Commission research and policy programs. Provided information to the Chairman's office concerning policy issues and major agenda items. Specialized in CATV and broadband communication projects.
1968	Pacific Telephone Company CATV Marketing & Financial Manager & Consultant. Besides normal management functions and responsibilities, acted as company liaison to various CATV/telecommunications regulatory agencies. Developed financial models for comparing company owned and maintained vs. lease back systems.
1966	Bemis Company, Inc. Market Analyst - Responsible for demand, cost and feasiblity studies relating to the convenience food market.

Education

1966 - 1970	Claremont Graduate School & University Center Ph. D. candidate in Business Economics with emphasis on marketing, organization systems theory and economics. Received MBE degree in 1969. Marketing research assistant and NDEA Fellow.
1962 - 1966	University of Minnesota B S Econ. with honors Maurice L Rothschild fellow math major

DANIEL McFADDEN -- Consultant

Professor McFadden is an authority on stochastic choice models of consumer behavior. His paper *The Revealed Preferences of a Government Bureaucracy* extends the classical multinomial logit analysis to enable a substantially wider range of choice situations to be modeled. During his guest professorship at MIT (Spring, 1971) Professor McFadden taught a weekly seminar on individual choice models.

Ph.D. Economics, University of Minnesota, 1962
B.S. Physics, University of Minnesota, 1957

Professor of Economics, University of California, Berkeley, 1968-present. Formerly Assistant and Associate Professor of Economics at Berkeley.

Editor, *Journal of Statistical Physics*, 1968-present
Board Editor, *American Economic Review*, 1971-present
Fellow, Econometric Society
Member, American Statistical Association
Member, Mathematical Association of America
Ford Foundation Behavioral Science Fellow, 1958-1962
Chairman, Econometrics Workshop Committee, Berkeley, 1967-present
Member, Computer Committee, Economics Department, Berkeley, 1967-1969

Unpublished

"Conditional Logit Analysis of Qualitative Data."

"Urban Freeway Routing: An Empirical Analysis of Stochastic Choice Behavior."

Work In Progress

"Random Preference Orderings and Stochastic Choice Behavior."

Selected Publications

The Revealed Preferences of a Government Bureaucracy, Technical Report No. 17, Institute of International Studies, University of California (1968).

"An Optimal Fiscal Policy," in I. Adelman, ed. *The Theory and Design of Economic Development*, 1966, pp. 140-146.

"On Hicksian Stability" in J. N. Wolfe, ed., *Value, Capital, and Growth*, 1969.

"On the Controllability of Decentralized Macroeconomic Systems -- the Assignment Problem" in H. W. Kuhn and G. P. Szego, ed., *Mathematical Systems Theory and Economics*, 1969.

"On the Existence of Optimal Development Plans" in H. Kuhn, ed., *Proceedings of the Princeton Symposium on Mathematical Programming*, 1970.

"Constant Elasticity of Substitution Production Functions" *Review of Economic Studies*, 1963.

"The Evaluation of Development Programs" *Review of Economic Studies*, 1967.

"Manufacturing Production Functions" (Review), JASA, 1967.

"A Simple Remark on the Second Best Pareto Optimality of Market Equilibrium" *Journal of Economic Theory*, 1969.

The Econometric Approach to Production Theory, Daniel McFadden, ed. (forthcoming).

ROBIN C. LANDIS -- Research Associate

Candidate for Ph.D. in Economics, Massachusetts Institute of Technology.
B.A. Yale University, Political Science and Economics, 1966

Research Associate, Charles River Associates Incorporated, engaged in econometric studies of industries. Currently developing an hedonic price model of a heterogeneous producer durable which expresses the price of the good as a function of its operating characteristics.

Research Assistant to Professor Merton J. Peck, Yale University. Engaged in a study of a local industry monopoly in connection with a Federal Trade Commission hearing.

Carnegie Teaching Fellow in Economics, Yale University, conducting lecture and discussion sessions of an introductory course in economics.

Programmer in computer center of Chesapeake and Ohio Railroad Company.

GERALD KRAFT -- Senior Research Associate

Candidate for Ph.D. in Economics, Harvard University
M.S. Harvard University, 1957.
B.A. Wayne University, 1955.

President, Charles River Associates Incorporated. Mr. Kraft has broad experience in the use of economic and statistical techniques in the analysis of public policy issues. His recent work includes an analysis of the demand for a U.S.-built supersonic transport aircraft, a study of the feasibility of federal subsidies for urban public transportation, development of demand models for urban and intercity travel, analysis of the public facilities requirements for industry in regions and local areas, and econometric studies of the markets for commodities in the government stockpile. Mr. Kraft is a panel member of the Maritime Transportation Research Board, National Academy of Science.

Consultant to Harvard University on a study of the demand for personal goods and services in underdeveloped countries.

Research Associate, Regional and Urban Planning Implementation, Incorporated. Supervised a study for the Area Redevelopment Administration using discriminant analysis to determine criteria for the allocation of government funds to promote area development.

Associate, Systems Analysis and Research Corporation. Work included a study of the demand for intercity passenger transportation and a study of the costs of air cargo service in which advanced statistical costing techniques were used extensively.

Principal, United Research Incorporated. Projects included cost/effectiveness analyses of large air traffic control systems and all-weather landing systems; trade-offs between inventory and transportation; and information system design.

Selected Publications

"New Directions for Passenger Demand Analysis and Forecasting," with Martin Wohl, *Transportation Research*, Vol. I, No. 3, 1967.

"Estimation of Urban Passenger Travel Behavior: An Economic Demand Model," with T. A. Domencich and Jean-Paul Valette, *Highway Research Record*, Number 238, 1968.

"The Role of Advertising Costs in the Airline Industry," *Transportation Economics*, National Bureau of Economic Research, 1965.

"The Evaluation of Statistical Costing Techniques as Applied in the Transportation Industry," with John R. Meyer, *Proceedings of the American Economic Association*, May 1961.

Avoidable Costs of Passenger Train Service, with others, Aeronautical Research Foundation, September 1957.

"Economic Aspects of Urban Passenger Transportation," *Highway Research Record*, Number 285, September 1969, pp. 10-19.

Free Transit, with Thomas A. Domencich, (Boston: Heath-Lexington Books, 1970). Portions reprinted as "Free Transit" in Jerome Rothenberg and Matthew Edel, eds., *Readings in Urban Economics*, (New York: Macmillan, forthcoming).

"Free Transit," with Thomas A. Domencich, presented at the Conference on Poverty and Transportation, American Academy of Arts and Sciences, June, 1968.

A Model of Urban Passenger Demand in the San Francisco Metropolitan Area, with Thomas A. Domencich and Jean-Paul Valette, (Boston: Heath-Lexington Books, forthcoming).

"On the Definition of a Depressed Area," with A. R. Willens, J. B. Kaler, and J. R. Meyer, in *Essays in Regional Economics* (preliminary title), ed. Meyer and Kain, (Cambridge: Harvard University Press, forthcoming).

The Role of Transportation in Regional Economic Development, with Jean-Paul Valette and John R. Meyer, (Boston: Heath-Lexington Books, forthcoming).

7910 Woodmont Avenue, Bethesda, Maryland 20014 • Phone (301) 656-2702

RMC INCORPORATED

an affiliate of RESOURCE MANAGEMENT CORPORATION

February 29, 1972

Mr. J. E. Partch
U. S. Department of Commerce
Office of Telecommunication
Institute for Telecommunication Sciences
Boulder, Colorado 80302

Dear Mr. Partch:

As per my telephone conversation with Stan Besen of OTP, I am enclosing a copy of my draft final report on CATV costs.

Your comments about my interim report arrived at the last moment (i.e., today). I have attempted to answer all of your comments except item 4. Clearly, time was at a premium and rather than delay the draft final, I told Stan that item 4 would be included in the final-final.

Specifically:

Item 1: See footnote page 30 and Table 3-7 (cost included in this table).
Item 2: Agree - Figures changed.
Item 3: Agree - Figures 3-2 and Table 3-7 changed.
Item 4: Agree - will do before final.
Item 5: Agree - done.
Item 6: Not sure what you mean.
Item 7: }
Item 8: } Taken care of. See Tables 4-8 and 4-10.
Item 9: Agree - see Appendix A and some assumptions in Chapter 6.

Stan has set up a meeting on 10 March. I plan on briefing OTP on the use of the model framework. Since you will attend, this will give us some time to discuss specifics, especially the development of the computer framework.

Thanks for the kind words in your comments.

Truly yours,

Garrett Weinberg

GW:lsk

Enclosure

OT FORM 10
(1-71)

OFFICE OF TELECOMMUNICATIONS

B13

March 3, 1972

PSD/JEP

CATV Demand Study

Paul Polishuk

I have reviewed the statement of work for the OTP proposed CATV demand study and have the following comments:

1. The study is an analysis of historical data and as such will not help predict the demand for either new non-entertainment services or special interest entertainment which has not been available in the past. It appears that the model would be more accurate and complete than previous attempts (e.g., Rand Report R-875-MF), but it is questionable that this amount of accuracy is useful in an industry model which has no information on demand for other services.

2. It is not clear (see page 1, last paragraph, and page 2, second paragraph) whether the model output will be the probability that a specific choice will be made, or merely a binary yes or no depending on the given demographics. I am sure that this question is merely a problem of semantics.

Jerry Partch
Policy Support Division

FILE COPY

SURNAME	DATE	SURNAME	DATE

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

B14

Date March 8, 1972

Reply to Attn of: ITS/RHE

Subject: A survey of "home terminals" as used for broadband services available through CATV systems.

To: Jerry Partch

The purpose of this memo is to describe for you the approach to be taken in conducting a survey of "home terminals". Home terminals as used here will primarily mean those devices installed or placed in a family residence as a means of interacting with a CATV system to receive broadband services not normally available with a standard TV receiver or with a standard TV receiver and converter.

A brief search of literature shows that most companies engaged in development of "home terminals" are taking a system approach. This seems logical because the devices in the home must respond with the system control and vice versa. At this stage there is not a standard or approved system or approach. The status of these systems seems to be one of development and field testing and "home terminals" are not generally available on the market nor are prices quoted in catalogs or brochures.

The types of services vary but include such items as:

Pay Television
Restricted Television
Opinion Polls
Home Protection
Meter Reading
Accessory Power Control/Timing

Future possibilities which are suggested and require facilities outside the cable system are:

Home shopping
Educational instruction
Reservation services
Stock market transactions, reports
Mail/advertizing
Data bank access

Also most systems include a means for system diagnostics, system controls, etc. which is primarily an inducement to the system operator but is of benefit to the customer in improved system performance and maintenance.

Sources of information for this survey will include the open literature and trade magazines, company brochures and direct contact with company representatives. Some of the companies developing systems, some or all of which will be included in this study are:

1.	Cas Manufacturing Co.	TOCOM
2.	Electronics Industries Engineering	CONSERVE I
3.	Theta-Comm Co. (Hughes Aircraft)	SRS
4.	VICOM Manufacturing Co.	QUESET
5.	Rediffusion (London, England)	Dial-a-Program
6.	MITRE (nonprofit-Federal)	TICCIT
7.	AMECO	DISCADE
8.	Sceintific-Atlanta, Inc.	SECURITY-ALERT

The study will be directed toward determining what services can be obtained with a given "home terminal", some basic understanding and description of how the system operates, and some information on how the customer pays and what cost factors he may encounter.

Firm prices for the installations, units, and services may not be available at this time, but attempts will be made to obtain future cost estimates. Even though much of the literature will be system oriented, the study will be conducted keeping in mind the customer who will be using the equipment.

Your comments and suggestions at this time and at any time during the study would be appreciated. The planned completion date for this survey is 5-17-72.

Dick Espeland

Dick Espeland

cc: B. Wieder

OFFICE OF TELECOMMUNICATIONS

March 13, 1972

Mr. Gary Weinberg
RMC Incorporated
7910 Woodmont Avenue
Bethesda, Maryland 20014

Dear Gary,

Here is the list of comments on your final report draft as I promised. The comments are just brief reminders as we discussed the points in more detail at the briefing on Friday.

Page 7, line 5: The loss of signal strength in em propagation in the air is not the same as the loss in a cable.

Page 7, line 21: Channel selectors have only 12 VHF channels, and CATV systems don't use the UHF channels.

Page 10, line 17: Typo error; shelf.

Page 18, table: UHF to VHF converter not required for every channel.

Page 22, line 17: The equipment is not really automatic. It is preset to avoid similar programs.

Page 25, table: Height, not length.

Page 27, line 5: Parabolic antenna is common usage and is used in rest of report.

Page 31: FM discussion should be noted as a typical representation, one of a number of alternatives.

Page 32, figure 3-6: Figure is not clear.

Page 35, footnote: Very questionable assumption.

Page 43, line 4: Word omitted: distribution system.

Page 51, line 14: aluminum vs. copper; dielectric misspelled.

Page 53, footnote: outer conductor.

SURNAME	DATE	SURNAME	DATE

Page 60, line 7: divide spacings into.

Page 66, 68, Tables: 12 or less channels.

Page 69, last line: transmit and receive... VHF baseband signals.

Page 70, line 15: unlimited, depending on location.

Page 99, table: Wage rates based on what area of country? Why stop increase in year six? Wage criteria for maintenance technician is not consistent.

Page 100, 101: Truck maintenance and purchase costs are low. Will be resolved by using leasing costs.

Page 114, 152: Truck purchase costs not consistent.

Page 127, line 17, 18: Cost figures in report show that 0.5 inch Super Foam is always preferred.

Page 128, line 3-5: Identify factors.

Page 130, line 15: Typo: ratio

Page 160: Depreciation discussion might be better placed in body of report, rather than in an example.

If you have any questions on these comments, please call me.

Sincerely,

Jerry Partch
Policy Support Division

cc: Stan Besen, OTP

JP:dd

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
INSTITUTE FOR TELECOMMUNICATION SCIENCES
Boulder, Colorado 80302

B1c

Date: March 14, 1972

Reply to Attn of: ITS/RHE

Subject: A survey of "local origination" equipment as used with CATV systems and cost factors associated with local programming.

To: Jerry Partch

The purpose of this memo is to outline a cost survey of "local origination" equipment used with CATV systems and the operating of this equipment. Local origination (also called "cablecasting") includes all programming that originates with the cable system that distributes it. The material used in local origination is intended to inform, to instruct, and to entertain the subscribers more on a fill-in basis as opposed to a competitive basis with the network programs. The programming includes such material as weather, time and temperature, announcements, films, local news, sports events, civic events and special interest stories.

Most of the equipment used for local origination appears to be available on an "off-the-shelf" or "short delivery time" basis and the price and specifications are available from company catalogs and brochures. Many of the CATV system manufacturers carry some components that are used for "local origination" as do many of the tape recorder, camera, lighting and sound equipment companies.

The brief outline that follows gives my intended approach to making this survey. The concluding paragraphs define the philosophy of this approach.

I. Introduction

II. Types of Programming
- (1) Automatic casting
- (2) Films
- (3) Studio
- (4) Mobile

III. Cost of Equipment
- (1) Automatic casting
- (2) Cameras
- (3) Tape recorders

(4) Lighting and sound
(5) Control panels
(6) Mobile systems

IV. Operating Costs
(1) Supervisors
(2) Crews
(3) Newsmen
(4) Office

V. Levels of Operation

VI. Sources of Revenue

VII. Bibliography of Reference

There are many choices of involvement open to a CATV system operator who wants to transmit "locally originated" material. There is a wide range of equipment costs and operating costs, of quality of production, and of the quality of the material. Therefore, it is believed worthwhile for the users of this report to have some insight into the "business of local origination", consequently sections I and II. Sections III and IV will include as many types of equipments as determined to be useful to local origination. Sections V, VI, and VII will be stressed commensurate with the fruits of the search, but as a minimum there will be some summary of equipment and operating costs, maybe on the basis of types of programming, so that the reader does not have to piece together this information from the sections on equipment costs and operating costs. The study will be conducted keeping in mind that as an end product, the information is to be used as an input to an economic model of CATV systems.

Your comments and suggestions would be appreciated at this time or at any time during the study. The planned completion date for this survey is 5-24-72.

Dick Espeland
Dick Espeland

cc: B. Wieder

OFFICE OF TELECOMMUNICATIONS POLICY
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON, D.C. 20504

March 20, 1972

Mr. Jerry Partch
OTP Support Division
325 S. Broadway
Boulder, Colorado 80302

Dear Jerry:

I have been giving some thought to the uses to which the RMC output might be put and have come to the conclusion that an (hopefully small) additional effort on our part is necessary for the cost data to be useful. For example, we ought to obtain data on the relationship between cable and amplifier type and maintenance expenses and on the relationship between city size and cable miles. The next step is to determine which pieces are missing in the RMC study and to develop some time and cost estimates of how to remedy them. I would appreciate your views on this. Let me hear from you soon.

Sincerely,

Stan

Stan Besen

P.S. Some suggestions of who might do them would also be useful.

U.S. DEPARTMENT OF COMMERCE
Office of Telecommunications
Boulder, Colorado 80302

April 5, 1972

B18

Dr. Stan M. Besen
Office of Telecommunications Policy
Executive Office of the President
Washington, D. C. 20504

Dear Stan:

I am enclosing copies for your files of both Stanford (Comanor-Mitchell) and Rand CATV model programs as we revised them for your use. Both the computer program print-outs and sample runs are included. The programs are written in FORTRAN II.

Sincerely,

Jerry

Jerry Partch

2 Enclosures

SAMPLE RUN -

RAND CATV FINANCIAL MODEL

```
COPY /INPDAT/ TO TELETYPE
  CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION
 24080.       .50  119.30  .09239  15000.
30. 50. 70. 80. 90.100.
50. 50.
 24080.       .50  119.30  .09239  15000.
30. 50. 70. 80. 90.100.
    50. 50.
 24080.       .50  119.30  .09239  15000.
30. 50. 70. 80. 90.100.
    50. 50.
 24080.       .50  119.30  .09239  15000.
30. 50. 70. 80. 90.100.
         50. 50.
 24080.       .50  119.30  .09239  15000.
30. 50. 70. 80. 90.100.
         50. 50.
 24080.       .50  119.30  .09239  15000.
30. 50. 70. 80. 90.100.
         50. 50.
    72.      72.      72.      72.      72.      84.      84.      84.      84.      84.
     12.      12.      12.      12.      12.      18.      18.      18.      18.      18.
     12.      12.      12.      12.      12.      15.      15.      15.      15.      15.
      2.       3.       4.       5.       6.       7.       8.       9.      10.      11.
   7000.      .3               37.     700.      .15                1.   25000.      .[illegible]
   1.01      15.      52.     175.      50.      .5       .15     150.     400.   [illegible]
   4000.     38.     4.50      0.       30.      20.    1000.    1000.   12000.   [illegible]
   1200.     1.08     800.     .05    1500.      .05    3000.              1.      .[illegible]
    .02      .02      .30      .08      .08                       .10
   1.03                                        1.03                       1.03    1.[illegible]
 0
 7
HEADENDS
 100000. 200000. 300000.
ORIG.EQUIP-CENTRAL
 110000.
ORIG.EQUIP-AREAS
         60000.  90000.
ORIG.EQUIP-MOBILE
 25000.          25000.           25000.
HAND-BLDG.
 350000.
FURNITURE - IMPROVE.
 50000.  20000.  30000.
PRE-OPENING EXP.
 80000.
 6
MANAGER                    25000.
ASST.MANAGER               18000.
EXEC.SECRETARY              9000.
CHIEF ENGINEER             22000.
AREA MANAGER               15000.
OFF.MGR.                   10000.
ASST.CHIEF TECH.           12000.
SECRETARY                   7500.
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SERVICE TECHNICIAN      9000.
MAINTENANCE TECH        9000.
BENCH TECHNICIAN        9000.
SERVICE DISP/CHEF       7500.
BOOKKEEPER/CLERK        7000.
PRODUCTION MANAGER       16000.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
MASTER CONTROL STAFF     10000.
 4. 4. 4. 4. 4. 4. 4. 4. 4. 4.
MASTER STUDIO STAFF      10000.
 3. 3. 3. 3. 3. 3. 3. 3. 3. 3.
AREA STUDIO-CNTRL.       9000.
 0. 4.10.10.10.10.10.10.10.10.
MOBILE STUDIO STAFF      10000.
 1. 2. 4. 4. 6. 6. 6. 6. 6. 6.
ADVERTISING MGR.         12000.
 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
ADV.SALES STAFF          10000.
 1. 1. 1. 2. 2. 2. 2. 2. 2. 2.
 6
VEHICLES                2500.
 1.14.26.34.38.40.43.43.43.43.
MOBILE UNITS            5600.
 1. 1. 2. 2. 3. 3. 3. 3. 3. 3.
MICROWAVE
      0.  50000. 100000. 100000. 100000. 100000. 100000. 100000. 100000. 100000.
 ADV.-PROMOTION
 136000. 102000. 102000. 102000. 102000.  34000.  34000.  34000.  34000.  34000.
 INSURANCE
 15000.  20000.  25000.  25000.  25000.  25000.  25000.  25000.  25000.  25000.
 LOCAL ORIG. COSTS
 31200.  62400. 109200. 109200. 109200. 109200. 109200. 109200. 109200. 109200.
 9999

-ERM/



*STOP*

+
-COPY /RANDOUT/ TO TELETYPE


 TABLE 1.  SECTOR GROWTH AND PARAMETERS
 CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION

YEAR:        1       2       3       4       5       6       7       8       9      10

 HOUSEHOLDS IN SECTOR
 1       24080.  24321.  24564.  24810.  25058.  25308.  25561.  25817.  26075.  26336.
 2       24080.  24321.  24564.  24810.  25058.  25308.  25561.  25817.  26075.  26336.
 3       24080.  24321.  24564.  24810.  25058.  25308.  25561.  25817.  26075.  26336.
 4       24080.  24321.  24564.  24810.  25058.  25308.  25561.  25817.  26075.  26336.
 5       24080.  24321.  24564.  24810.  25058.  25308.  25561.  25817.  26075.  26336.
 6       24080.  24321.  24564.  24810.  25058.  25308.  25561.  25817.  26075.  26336.

 GROWTH CURVE (PERCENT OF FINAL PENETRATION)
 1          30.     50.     70.     80.     90.    100.    100.    100.    100.    100.
 2          30.     50.     70.     80.     90.    100.    100.    100.    100.    100.
```

3	30.	50.	70.	80.	90.	100.	100.	100.	100.	100.
4	30.	50.	70.	80.	90.	100.	100.	100.	100.	100.
5	30.	50.	70.	80.	90.	100.	100.	100.	100.	100.
6	30.	50.	70.	80.	90.	100.	100.	100.	100.	100.

CONSTRUCTION PHASING (PERCENT CONSTRUCTED IN END OF YEAR)

1	50.	100.	100.	100.	100.	100.	100.	100.	100.	100.
2	0.	50.	100.	100.	100.	100.	100.	100.	100.	100.
3	0.	50.	100.	100.	100.	100.	100.	100.	100.	100.
4	0.	0.	50.	100.	100.	100.	100.	100.	100.	100.
5	0.	0.	50.	100.	100.	100.	100.	100.	100.	100.
6	0.	0.	50.	100.	100.	100.	100.	100.	100.	100.

SECTOR	FINAL PENETRATION	HOMES PER MILE	PERCENT UNDERGROUND	COST PER MI. UNDERGROUND
1	50.	119.30	9.2	15000.
2	50.	119.30	9.2	15000.
3	50.	119.30	9.2	15000.
4	50.	119.30	9.2	15000.
5	50.	119.30	9.2	15000.
6	50.	119.30	9.2	15000.

TABLE 2. SYSTEM GROWTH AND REVENUE
CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION

YEAR:	1	2	3	4	5	6	7	8	9	10	TOTAL
HOUSEHOLDS IN FRANCHISE AREA											
	144480.	145925.	147384.	148858.	150346.	151850.	153368.	154902.	156451.	158016.	
REVENUE PER SUBSCRIBER:											
FIRST OUTLET (YEARLY)	72.00	72.00	72.00	72.00	72.00	84.00	84.00	84.00	84.00	84.00	
SECOND OUTLET (YEARLY)	12.00	12.00	12.00	12.00	12.00	18.00	18.00	18.00	18.00	18.00	
INSTALLATION	12.00	12.00	12.00	12.00	12.00	15.00	15.00	15.00	15.00	15.00	
OTHER (YEARLY)	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	
SUBSCRIBERS:											
INCREASE	1806.	6694.	14149.	16200.	12677.	9733.	7369.	5617.	2603.	768.	
AVERAGE	451.	5153.	15575.	30749.	45187.	56392.	64943.	71436.	75546.	77232.	
ENDING	1806.	8500.	22649.	38849.	51526.	61259.	68627.	74244.	76847.	77616.	
PENETRATION	1.2	5.8	15.4	26.1	34.3	40.3	44.7	47.9	49.1	49.1	

($1000)

REVENUE

FIRST OUTLET	32.5	371.0	1121.4	2213.9	3253.[illegible]	4737.0	5455.2	6000.6	6345.9	6487.5	3601[illegible].3
SECOND OUTLET	1.6	13.6	56.1	110.7	162.7	304.5	350.7	385.8	407.9	417.1	2215.6
INSTALLATION	21.7	83.6	195.1	235.2	222.1	261.9	248.4	238.7	206.1	184.4	1897.0
OTHER PER SUB REV	.9	15.5	62.3	153.7	271.1	394.7	519.5	642.9	755.5	849.5	3665.7
TOTAL	56.7	488.6	1424.8	2713.5	3909.3	5698.1	6573.8	7267.9	7715.4	7938.5	43736.7

TABLE 3. PAYROLL
CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION
($1000)

SALARY

YEAR:1	1	2	3	4	5	6	7	8	9	10	TOTAL
MANAGER	25.0	25.0	26.[illegible]	28.1	29.9	31.7	33.6	35.6	37.8	40.1	42.6	330.9
ASST. MANAGER	18.0	18.0	19.1	20.3	21.5	22.8	24.2	25.7	27.2	28.9	30.6	239.3
EXEC. SECRETARY	9.0	9.0	9.5	10.1	10.7	11.4	12.1	12.8	13.6	14.4	15.3	119.1
CHIEF ENGINEER	22.0	22.0	23.3	24.8	26.3	27.9	29.6	31.4	33.3	35.3	37.5	291.2
AREA MANAGER	15.0	15.0	47.7	101.3	107.5	114.0	121.0	128.3	136.1	144.4	153.2	1068.6
OFFICE MANAGER	10.0	10.0	31.8	67.5	71.6	76.0	80.6	85.5	90.8	96.3	102.1	712.4
AREA CHIEF TECH.	12.0	12.0	38.2	81.0	86.0	91.2	96.8	102.7	108.9	115.5	122.6	854.8
AREA SECRETARY	7.5	7.5	23.9	50.6	53.7	57.0	60.5	64.2	68.1	72.2	76.6	534.3
SVC. TECH.	9.0	.0	9.5	30.4	75.2	102.6	157.2	231.0	245.0	260.0	275.8	1386.8
MAINT. TECH.	9.0	9.0	28.6	70.9	96.7	102.6	108.9	115.5	122.5	130.0	137.9	922.6
BENCH TECH.	9.0	9.0	19.1	30.4	43.0	45.6	48.4	51.3	54.5	57.8	61.3	420.3
SVC. DISPATCHER	7.5	7.5	8.0	16.9	35.8	47.5	60.5	74.9	90.8	96.3	102.1	540.2

BOOKKEEPER.	7.0	7.0	14.9	31.5	66.9	106.4	141.1	169.7	190.6	213.4	238.3	[illegible]
PRODUCTION MANAGER	16.0	16.0	17.0	18.0	19.1	20.3	21.5	22.9	24.2	25.7	27.2	[illegible]
MASTER CONTROL STAFF	10.0	30.0	42.4	45.0	47.8	50.7	53.8	57.0	60.5	64.2	68.1	[illegible]
MASTER STUDIO STAFF	10.0	20.0	31.8	33.9	35.8	38.0	40.3	42.9	45.4	48.1	51.1	[illegible]
AREA STUDIO-CNTRL.	9.0	.0	38.2	101.3	107.5	114.0	121.0	128.3	136.1	144.4	153.2	[illegible]
MOBILE STUDIO STAFF	10.0	20.0	21.2	45.0	47.8	76.0	80.6	85.5	90.8	96.3	102.1	[illegible]
ADVERTISING MGR.	12.0	12.0	12.7	13.5	14.3	15.2	16.1	17.1	18.2	19.3	20.4	[illegible]
ADV.SALES STAFF	10.0	.0	10.6	11.3	23.9	25.3	26.9	28.5	30.3	32.1	34.0	[illegible]
TOTAL	249.0	474.2	831.9	1020.9	1176.2	1334.5	1510.6	1624.5	1734.7	1852.2	[illegible]	

TABLE 4. OPERATING EXPENSES
CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION
($1000)

YEAR:	1	2	3	4	5	6	7	8	9	10	TOTAL
PAYROLL	249.0	474.2	831.8	1020.9	1176.2	1334.5	1510.6	1624.5	1734.7	1852.2	[illegible]
FRINGE BENEFITS	37.3	71.1	124.8	153.1	176.4	200.2	226.6	243.7	260.2	277.8	[illegible]
VEHICLE O + M + DEPR.	15.0	36.0	69.0	92.9	106.9	115.9	128.4	132.2	136.2	140.3	[illegible]
MOBILE UNIT O + M	5.6	5.8	11.9	12.2	18.9	19.5	20.1	20.7	21.3	21.9	[illegible]
POLE RENTAL	15.7	65.2	152.6	211.6	220.1	229.0	238.2	247.8	257.8	268.2	[illegible]
DUCT RENTAL	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
LINE MAINT.	3.0	12.6	29.5	40.9	42.6	44.9	49.1	56.7	66.8	77.6	[illegible]
POWER	3.0	[illegible]	26.0	33.8	35.1	36.5	37.9	39.3	40.8	42.4	[illegible]

	1	2	3	4	5	6	7	8	9	10	TOTAL
LARGE AREA CENTER	.0	24.7	63.7	65.6	67.5	69.6	71.6	73.8	76.0	78.3	590.
TELEPHONE	4.8	7.4	11.5	11.8	12.2	12.5	12.9	13.3	13.7	14.1	114.1
BILLING	.5	5.7	17.9	36.3	54.9	70.6	83.7	94.9	103.4	108.8	576.7
DUES + SUBSCRIPTIONS	.8	1.1	1.7	2.6	3.4	4.2	4.9	5.4	5.8	6.1	35.[illegible]
TRAVEL + ENTERTAINMENT	1.5	1.9	2.4	3.3	4.2	5.0	5.7	6.2	6.7	7.0	43.[illegible]
PROF. SERVICES	3.0	3.6	4.8	6.6	8.5	10.0	11.3	12.5	13.4	14.0	87.[illegible]
PROPERTY TAX	87.5	251.1	541.6	731.5	775.3	813.2	846.7	876.7	900.0	919.1	6742.[illegible]
FRANCHISE TAX	1.1	9.8	28.5	54.3	78.2	114.0	131.5	145.4	154.3	158.8	875.7
BAD DEBTS	1.1	9.8	28.5	54.3	78.2	114.0	131.5	145.4	154.3	158.8	875.7
FCC FEE	.1	1.5	4.7	9.2	13.6	16.9	19.5	21.4	22.7	23.2	132.9
SELLING COST	21.7	83.6	185.1	23 .2	222.1	261.9	248.4	233.7	206.1	184.4	1887.0
MICROWAVE	.0	51.5	106.1	109.3	112.6	115.9	119.4	123.0	126.7	130.5	994.9
ADV.-PROMOTION	36.0	105.1	108.2	111.5	114.8	39.4	40.6	41.8	43.1	44.4	784.9
INSURANCE	15.0	20.6	26.5	27.3	28.1	29.0	29.9	30.7	31.7	32.6	271.4
LOCAL ORIG. COSTS	31.2	64.3	115.9	119.3	122.9	126.6	130.4	134.3	138.3	142.5	1125.7
TOTAL	633.1	1318.0	2492.3	3143.5	3472.7	3783.2	4098.6	4328.4	4513.9	4702.9	32486.6

TABLE 5. CAPITAL EXPENDITURES
PHASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION
($1000)

YEAR:	1	2	3	4	5	6	7	8	9	10	TOTAL
DIST ABOVE GROUND	41.2	2007.7	3497.0	2229.9	89.2	92.8	96.6	100.5	104.5	108.7	8963.1
BELOW GROUND	38.9	427.2	762.9	486.4	19.5	20.2	21.1	21.9	22.8	23.7	1956.2

	1	2	3	4	5	6	7	8	9	10	TOTAL
POLE ARRANGEMENT	64.1	200.9	319.7	223.0	9.9	9.3	9.7	10.0	10.4	10.9	[illegible]
DROPS ABOVE GROUND	60.6	237.6	539.6	699.5	637.1	552.0	472.1	406.9	284.6	205.5	[illegible]
BELOW GROUND	8.7	34.0	77.2	93.5	91.1	79.0	67.5	58.2	40.7	29.4	[illegible]
EQUIP. INVENTORY	16.0	50.2	87.4	55.7	2.2	2.3	2.4	2.5	2.6	2.7	224.0
TOOLS + TEST EQUIP.	4.6	14.3	25.0	15.9	.6	.7	.7	.7	.7	.8	64.1
HEADENDS	.0	206.0	318.3	.0	.0	.0	.0	.0	.0	.0	524.3
ORIG.EQUIP-CENTRAL	210.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	210.0
ORIG.EQUIP-AREAS	.0	61.8	95.5	.0	.0	.0	.0	.0	.0	.0	157.3
ORIG.EQUIP-MOBILE	25.0	.0	26.5	.0	28.1	.0	.0	.0	.0	.0	79.7
HAND-BLDG.	350.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	350.0
FURNITURE - IMPROVE.	50.0	20.6	31.8	.0	.0	.0	.0	.0	.0	.0	102.4
RE-OPENING EXP.	180.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	180.0
TOTAL	1750.	3271.	5811.	3798.	877.	756.	670.	601.	466.	382.	18382.
CUMULATIVE	1750.	5021.	10832.	14630.	15507.	16263.	16933.	17534.	18000.	18382.	

TABLE 6. INCOME STATEMENT
CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION
($1000)

YEAR:	1	2	3	4	5	6	7	8	9	10	TOTAL
REVENUE	56.7	488.6	1424.8	2713.5	3909.3	5698.1	6573.8	7267.9	7715.4	7938.5	43786.7
LESS OPR. EXPENSE	633.1	1318.0	2492.3	3143.5	3472.7	3783.2	4098.6	4328.4	4513.9	4702.9	32486.6
OPERATING INCOME	-576.4	-829.4	-1067.[illegible]	-430.0	436.6	1915.0	2475.2	2939.6	3201.5	3235.6	[illegible]
LESS INTEREST 8.0 PERCENT	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

CASH FLOW

	1	2	3	4	5	6	7	8	9	10	TOTAL
	-576.4	-829.4	-1067.5	-430.0	436.6	1915.0	2475.2	2939.6	3201.5	3235.	11300.1
CUMULATIVE	-576.4	-140[illegible]	-2473.3	-290[illegible]	-2466.7	-551.7	1923.5	4863.1	8064.5	11300.1	
LESS DEPRECIATION 11 YR. STR. LINE	116.7	334.[illegible]	722.1	975.[illegible]	1033.8	1084.2	1128.9	1169.9	1200.0	1225.5	8990.1
PRETAX INCOME	-693.1	-1164.1	-1789.6	-1405.3	-597.2	830.8	1346.3	1770.6	2001.5	2010.1	231[illegible]
CUMULATIVE	-693.1	-1857.2	-3646.8	-5052.1	-5649.3	-4818.5	-3472.2	-1701.6	299.9	2310.0	
LESS INC. TAX	.0	.0	.0	.0	.0	.0	.0	.0	137.5	958.4	1095.[illegible]
NET INCOME	-693.1	-1164.1	-1789.6	-1405.3	-597.2	830.8	1346.3	1770.6	1864.0	1051.8	1214.2
CUMULATIVE	-693.1	-1857.2	-3646.8	-5052.1	-5649.3	-4818.5	-3472.2	-1701.6	162.4	1214.2	
LESS DIVIDENDS	.0	.0	.0	.0	.0	1040.4	1760.3	2301.6	2576.7	1892.8	9571.8
RETAINED EARNINGS	-693.1	-1164.1	-1789.6	-1405.3	-597.2	-209.6	-414.0	-531.0	-712.6	-841.0	-8357.6
CUMULATIVE	-693.1	-1857.2	-3646.8	-5052.1	-5649.3	-5858.9	-6273.0	-6804.0	-7516.6	-8357.6	

TABLE 7. SOURCES AND USES OF FUNDS
CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION
($1000)

YEAR:	1	2	3	4	5	6	7	8	9	10	TOTAL
SOURCES:											
OPERATING INCOME	-576.4	-829.4	-1067.5	-430.0	436.6	1915.0	2475.2	2939.6	3201.5	3235.6	11300.1
EQUITY FUNDS	2305.4	4080.1	6859.3	4279.0	509.6	.0	.0	.0	.0	.0	18033.3
CUMULATIVE	2305.	6385.	13245.	17524.	18033.	18033.	18033.	18033.	18033.	18033.	
LOANS	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
CUMULATIVE	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
TOTAL	1729.0	3250.7	5791.8	3849.0	946.2	1915.0	2475.2	2939.6	3201.5	3235.6	29333.4
USES:											
INC. IN WORKING CAP.	-21.1	-20.2	-19.1	51.0	69.3	118.3	44.9	37.1	21.0	2.7	283.8
CAPITAL EXPENDITURES	1750.1	3271.0	5810.3	3798.0	876.8	756.3	670.0	600.8	466.4	331.7	18382.0

	1	2	3	4	5	6	7	8	9	10	TOTAL
INTEREST	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
INCOME TAX	.0	.0	.0	.0	.0	.0	.0	.0	137.5	958.4	1095.[illegible]
DIVIDENDS	.0	.0	.0	.0	.0	1040.4	1760.3	2301.6	2576.7	1892.0	9571.[illegible]
TOTAL	729.0	3250.7	5791.8	3949.0	946.2	1915.0	2475.2	2939.5	3201.5	3235.6	29333.4

DEBT/EQUITY RATIO: .00

OPERATING EXPENSES TO REVENUES RATIO

1	2	3	4	5	6	7	8	9	10	TOTAL
11.16	2.70	1.75	1.16	.89	.66	.62	.60	.59	.59	.74

TABLE 9. BALANCE SHEET
CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION
($1000)

YEAR:	1	2	3	4	5	6	7	8	9	10	TOTAL
ASSETS:											
CASH	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	
RECEIVABLES	4.5	39.1	114.0	217.1	312.7	455.9	525.9	581.4	617.2	635.1	
TOTAL CURRENT	29.5	64.1	139.0	242.1	337.7	480.9	550.9	606.4	642.2	660.1	
PLANT + EQUIPMENT	1750.	5021.	10932.	14630.	15507.	16263.	16933.	17534.	18000.	18382.	
ACCUMULATED DEPR.	116.7	451.4	1173.5	2143.9	3182.6	4266.3	5395.7	6564.6	7764.6	8990.1	
TOTAL	1663.	4634.	9797.	12723.	12662.	12477.	12088.	11576.	10878.	10052.	
LIABILITIES:											
PAYABLES	50.6	105.4	199.4	251.5	277.8	302.7	327.9	346.3	361.1	376.2	
LOANS	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	
TOTAL	50.6	105.4	199.4	251.5	277.8	302.7	327.9	346.3	361.1	376.2	
PAID IN EQUITY	2305.	6385.	13245.	17524.	18033.	18033.	18033.	18033.	18033.	18033.	
RETAINED EARNINGS	-693.	-1857.	-3647.	-5052.	-5649.	-5859.	-6273.	-6804.	-7517.	-8358.	

NET WORTH

1612. 4528. 9598. 12472. 12334. 12174. 11760. 11229. 10517. 9676.

LIABILITIES+NET WORTH

1663. 4634. 9797. 12723. 12662. 12477. 12098. 11576. 10878. 10052.

TABLE 9. INTERNAL RATES OF RETURN
CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION

SALE PRICE AFTER 10 YEARS:

7 TIMES OPERATING INCOME	300 TIMES NUMBER OF SUBSCRIBERS	
$ 23000. THOUSAND		
PRIVATE RATE OF RETURN		
9.1	9.5	9.3

DIVIDENDS AND SALE PRICE OF DEBT-FREE SYSTEM AS RETURN ON EQUITY CAPITAL

TABLE 6. INCOME STATEMENT
CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION
($1000)

YEAR:	1	2	3	4	5	6	7	8	9	10	TOTAL
REVENUE	56.7	488.6	1424.8	2713.5	3909.3	5698.1	6573.8	7267.9	7715.4	7938.5	[illegible]
LESS OPR. EXPENSE	633.1	1318.0	2492.3	3143.5	3472.7	3783.2	4098.6	4328.4	4513.9	4702.9	[illegible]
OPERATING INCOME	-576.4	-829.4	-1067.5	-430.0	436.6	1915.0	2475.2	2939.6	3201.5	3235.6	[illegible]
LESS INTEREST 8.0 PERCENT	.0	.0	.0	302.2	668.7	762.9	762.9	762.9	762.9	762.9	[illegible]
CASH FLOW	-576.4	-829.4	-1067.5	-732.1	-232.1	1152.1	1712.2	2176.6	2438.6	2472.6	[illegible]
CUMULATIVE	576.4	-1405.8	-2473.3	-3205.4	-3437.5	-2285.5	-573.2	1603.4	4042.0	6514.6	
LESS DEPRECIATION 11 YR. STR. LINE	116.7	334.7	722.1	975.3	1033.8	1084.2	1128.9	1168.9	1200.0	1225.5	[illegible]
PRETAX INCOME	93.1	-1164.1	-1789.6	-1707.5	-126[illegible].9	67.9	583.4	1007.7	1238.5	1247.2	[illegible]
CUMULATIVE	-693.1	-1857.2	-3646.8	-5354.3	-6620.2	-6552.3	-5968.9	-4961.2	-3722.7	-2475.5	

	1	2	3	4	5	6	7	8	9	10	TOTAL
LESS INC.TAX	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
NET INCOME	-693.1	-1164.1	-1789.6	-1707.5	-1265.9	67.9	583.4	1007.7	1238.5	1247.2	-2475.5
CUMULATIVE	-693.1	-1857.2	-3646.8	-5354.3	-6620.2	-6552.3	-5968.9	-4961.2	-3722.7	-2475.5	
LESS DIVIDENDS	.0	.0	.0	.0	.0	277.5	997.4	1538.7	1951.2	2088.2	6853.0
RETAINED EARNINGS	-693.1	-1164.1	-1789.6	-1707.5	-1265.9	-209.6	-414.0	-531.0	-712.6	-841.0	-9328.5
CUMULATIVE	-693.1	-1857.2	-3646.8	-5354.3	-6620.2	-6829.8	-7243.8	-7774.8	-8487.5	-9328.5	

TABLE 7. SOURCES AND USES OF FUNDS
CASE 1, 12 INCORPORATED CITIES, 50 PERCENT PENETRATION
($1000)

YEAR:	1	2	3	4	5	6	7	8	9	10	TOTAL
SOURCES:											
OPERATING INCOME	-576.4	-829.4	-1067.5	-430.0	436.6	1915.0	2475.2	2939.6	3201.5	3235.6	11300.1
EQUITY FUNDS	2305.4	4080.1	3082.0	.0	.0	.0	.0	.0	.0	.0	9467.5
CUMULATIVE	2305.	6385.	9467.	9467.	9467.	9467.	9467.	9467.	9467.	9467.	
LOANS	.0	.0	3777.3	4581.2	1178.2	.0	.0	.0	.0	.0	9536.7
CUMULATIVE	.0	.0	3777.3	8358.4	9536.7	9536.7	9536.7	9536.7	9536.7	9536.7	
TOTAL	1729.0	3250.7	5791.8	4151.2	1614.8	1915.0	2475.2	2939.6	3201.5	3235.6	30304.3
USES:											
INC. IN WORKING CAP.	-21.1	-20.2	-19.1	51.0	69.3	118.3	44.8	37.1	21.0	2.7	283.8
CAPITAL EXPENDITURES	1750.1	3271.0	5810.9	3798.0	876.8	756.3	670.0	600.8	466.4	391.7	18392.0
INTEREST	.0	.0	.0	302.2	668.7	762.9	762.9	762.9	762.9	762.9	4785.5
INCOME TAX	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
DIVIDENDS	.0	.0	.0	.0	.0	277.5	997.4	1538.7	1951.2	2088.2	6853.0
TOTAL	1729.0	3250.7	5791.8	4151.2	1614.8	1915.0	2475.2	2939.6	3201.5	3235.6	30304.3

DEBT/EQUITY RATIO: 1.0

OPERATING EXPENSES TO REVENUE RATIO

11.16	2.70	1.75	1.16	.89	.66	.62	.60	.59	.59	.74

TABLE 8. BALANCE SHEET
CASE 1, 12 INCORPORATED CITIES, 10 PERCENT PENETRATION
($1000)

YEAR:	1	2	3	4	5	6	7	8	9	10	TOTAL
ASSETS:											
CASH	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	
RECEIVABLES	4.5	39.1	114.0	217.1	312.7	455.9	525.9	591.4	617.2	635.1	
TOTAL CURRENT	29.5	64.1	139.0	242.1	337.7	480.9	550.9	606.4	642.2	660.1	
PLANT + EQUIPMENT	1750.	5021.	10832.	14630.	15507.	16263.	16933.	17534.	18000.	18382.	
ACCUMULATED DEPR.	116.7	451.4	1173.5	2148.9	3182.6	4266.8	5395.7	6564.6	7764.6	8990.1	
TOTAL	1663.	4634.	9797.	12723.	12662.	12477.	12088.	11576.	10878.	10052.	
LIABILITIES:											
PAYABLES	50.6	105.4	199.4	251.5	277.8	302.7	327.9	346.3	361.1	376.2	
LOANS	.0	.0	3777.3	8358.4	9536.7	9536.7	9536.7	9536.7	9536.7	9536.7	
TOTAL	50.6	105.4	3976.7	8609.9	9814.5	9839.3	9864.6	9882.9	9897.8	9912.9	
PAID IN EQUITY	2305.	6385.	9467.	9467.	9467.	9467.	9467.	9467.	9467.	9467.	
RETAINED EARNINGS	-693.	-1857.	-3647.	-5354.	-6620.	-6830.	-7244.	-7775.	-8497.	-9328.	
NET WORTH	1612.	4528.	5821.	4113.	2847.	2638.	2224.	1693.	980.	139.	
LIABILITIES+NET WORTH	1663.	4634.	9797.	12723.	12662.	12477.	12088.	11576.	10878.	10052.	

TABLE 9. INTERNAL RATES OF RETURN
CASE 1, 12 INCORPORATED CITIES, 30 PERCENT PENETRATION

SALE PRICE AFTER 10 YEARS:
TIMES OPERATING INCOME   300 TIMES NUMBER OF SUBSCRIBERS
$ 23000. THOUSAND

PRIVATE RATE OF RETURN

	10.6	11.0	10.8

DIVIDENDS AND SALE PRICE OF DEBT-FREE SYSTEM AS RETURN ON EQUITY CAPITAL

SAMPLE RUN -

COMANOR-MITCHELL

CATV FINANCIAL MODEL

```
-CATV

NOV 16,1971 VERSION OF CABLE TV WITH LINKED INPUT AND OUTPUT
VALUES FOR MILESU, ASYMP, AND AINTRAT ARE NOW GIVEN AS WHOLE NUMBERS,
EXAMPLE 10% IS INPUT AS 10.  TOTAL OPERATING EXPENSES (TABLE 3 OF
MITCHELL) ARE GIVEN IN TABLE 4.

DO YOU NEED AN EXPLANATION OF THE INPUT?

YES
 THIS PROGRAM WILL ASK FOR THE FOLLOWING PARAMETERS.

 ITITLE= TITLE OF RUN.
 TOP100=1. IF FIRM IS IN ONE OF THE TOP 100 MARKETS: 0. IF NOT.
 CHAN20=1. IF FIRM HAS 20 CHANNEL  CAPABILITY: 0. IF NOT.
 ICHANMI= THE NUMBER OF MICROWAVE CHANNELS.
 RATE1= THE MONTHLY RATE FOR THE FIRST OUTLET.
 RATE2= THE MONTHLY RATE FOR THE SECOND OUTLET.
 RATEH= THE ONE TIME CONNECTION RATE.
 COSTU= THE UNDERGROUND CABLE COST PER MILE.
 MILESU= THE PERCENT OF MILES OF UNDERGROUND CABLE.
 DERAT= THE DEBT EQUITY RATIO.

 ASYMP= THE ASYMPTOTIC PENETRATION.
 SIZE= THE TOTAL NUMBER OF HOMES SERVED IN YEAR 10.
 HOUSE= THE HOMES PER MILE (DENSITY).
 NEWS=1. IF A NEWS CHANNEL IS PROVIDED: 0. IF NOT.
 TIME=1. IF A TIME, WEATHER CHANNEL IS PROVIDED: 0. IF NOT.
 SW= THE NUMBER OF CHANNEL SWITCHERS.
 HOPS= THE NUMBER OF HOPS PER MICROWAVE CHANNEL.
 CASMIN= THE MINIMUM CASH BALANCE REQUIRED.
 AINTRAT= THE INTEREST RATE PAID ON BORROWED FUNDS.
 INETOLD= THE NUMBER OF NETWORK STATIONS AVAILABLE WITHOUT CABLE.

 INDOLD= THE NUMBER OF INDEPENDENT STATIONS AVAILABLE WITHOUT CABLE.
 IEDOLD= THE NUMBER OF EDUCATIONAL STATIONS AVAILABLE WITHOUT CABLE.
 INETNEW= THE NUMBER OF NETWORK STATIONS AVAILABLE WITH CABLE.
 INDNEW= THE NUMBER OF INDEPENDENT STATIONS AVAILABLE WITH CABLE.
 IEDNEW= THE NUMBER OF EDUCATIONAL STATIONS AVAILABLE WITH CABLE.
 IOWNMI=1 IF MICROWAVE EQUIPMENT IS OWNED: 0 IF RENTED.
 INEWREG=1 FOR PROPOSED REGULATIONS: 0 FOR CURRENT.
 ITOP50=1 IF FIRM IS IN ONE OF THE TOP 50 MARKETS: 0 IF NOT.
 IDUAL=1 FOR DUAL CABLE 20 CHANNEL CAPABILITY: 0 FOR CONVERTER.
 IMINORG=1 FOR MINIMUM COST ORIGINATION SYSTEM: 0 FOR STANDARD.

 ADIN= ANNUAL ADVERTISING REVENUES IN DOLLARS/SUBSCRIBER.


 ALL VARIABLES THAT BEGIN WITH AN "I" SHOULD BE INTEGERS (NO DECIMALS)
  AND BE FOLLOWED BY A COMMA ON INPUT.
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ALL OTHER VARIABLES SHOULD BE INPUT WITH A DECIMAL.

ALL VARIABLES HAVE BEEN GIVEN A 2 DIGIT REFERENCE NUMBER TO REFER TO WHEN CHANGING THEM. AFTER TYPING THE REFERENCE NUMBER, GIVE THE VALUE OF THE CHANGED PARAMETER. THEN GIVE ANOTHER REFERENCE NUMBER UNTIL YOU ARE FINISHED CHANGING. A REFERENCE NUMBER OF 00 WILL TERMINATE CHANGES.

ALL QUESTION ANSWERS OR VARIABLE VALUES MUST TERMINATE WITH A CARRIAGE RETURN.
ONE (OR MORE) "CONTROL A('S)" MAY BE USED TO CHANGE A CHARACTER(S) AT THE TIME OF INPUT BEFORE THE CARRIAGE RETURN.

```
1[illegible] ITITLE=(NAME)SAMPLE RUN-OLD REGULATIONS
1[illegible] TOP100=(X.)0.
12 CHAN20=(X.)0.
2[illegible] ICHANMI=(N,)4,
1[illegible] RATE1=(X.)5.
14 RATE2=(X.)1.
15 RATEH=(X.)0.
1[illegible] COSTU=(X.)15000.
1[illegible] MILESU=(X.)10.
18 DERAT=(X.)1.
1[illegible] ASYMP=(X.)73.
2[illegible] SIZE=(X.)3500.
21 HOUSE=(X.)80.
2[illegible] NEWS=(X.)0.
2[illegible] TIME=(X.)0.
24 SW=(X.)1.
25 HOPS=(X.)1.
2[illegible] CASMIN=(X.)25000.
2[illegible] AINTRAT=(X.)10.
30 INETOLD=(N,)2,
3[illegible] INDOLD=(N,)0,
3[illegible] IEDOLD=(N,)0,
33 INETNEW=(N,)6,
3[illegible] INDNEW=(N,)5,
3[illegible] IEDNEW=(N,)1,
36 IOWNMI=(N,)1,
37 INEWREG=(N,)0,
3[illegible] ITOP50=(N,)0,
3[illegible] IDUAL=(N,)0,
40 IMINORG=(N,)0,
2[illegible] ADIN=(X.)6.6
D[illegible] YOU WANT TO CHANGE ANY OF THE PARAMETERS?

N[illegible]
I[illegible]PUT FINISHED. WAIT FOR PROGRAM TO ASK ABOUT OUTPUT.


D[illegible] YOU WANT TO KNOW WHICH TABLES ARE AVAILABLE?
YES
T[illegible]BLE 1 GIVES INPUT PARAMETERS.
T[illegible]BLE 2 GIVES SUBSCRIBER GROWTH.
TABLE 3 GIVES REVENUES.
T[illegible]BLE 4 GIVES INCOME AND CASH FLOW.
T[illegible]BLE 5 GIVES SOURCES OF FUNDS.
TABLE 6 GIVES USES OF FUNDS.
TABLE 7 GIVES RATE OF RETURN.
T[illegible]BLE 8 GIVES CAPITAL EXPENDITURES.
T[illegible]BLE 0 TERMINATES THE OUTPUT AND ASKS FOR NEW INPUT.
TABLE 9 TERMINATES THE OUTPUT AND THE PROGRAM.
```

SAMPLE RUN-OLD REGULATIONS

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

1

CURRENT FCC REGULATIONS
MARKET TYPE: OUTSIDE TOP 100
SYSTEM SIZE IN 10TH YEAR = 3500. SUBSCRIBERS
TOTAL HOMES PASSED = 4943., TOTAL MILES CABLE = 61.8, 80. HOMES/MILE
6.2 (10%) MILES OF UNDERGROUND CABLE AT $ 15000. PER MILE
1.00 APPROXIMATE DEBT/EQUITY RATIO .100 INTEREST RATE ON DEBT

SIGNALS OFF AIR	CABLE SIGNALS
2 NETWORKS	6 NETWORKS
[illegible] INDEPENDENTS	5 INDEPENDENTS
[illegible] EDUCATIONAL	1 EDUCATIONAL
[illegible] TOTAL	12 TOTAL
	4 TOTAL MICROWAVE

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

1

SUBSCRIBER GROWTH

YEAR	INCREASE	AVERAGE	ENDING	PENETRATION
1	902.	451.	902.	.18
2	722.	1263.	1624.	.33
3	902.	2075.	2526.	.51
4	433.	2742.	2959.	.60
5	216.	3067.	3175.	.64
6	108.	3229.	3284.	.66
7	108.	3338.	3392.	.69
8	36.	3410.	3428.	.69
9	36.	3446.	3464.	.70
10	36.	3482.	3500.	.71

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

3

REVENUES

YEAR	1ST OUTLET	2ND OUTLET	ADVERTISING	TOTAL
1	27062.	812.	0.	27874.
2	75773.	2273.	0.	78046.
3	124485.	3735.	0.	128219.
4	164536.	4936.	0.	169472.
5	184021.	5521.	0.	189541.
6	193763.	5813.	0.	199576.
7	200258.	6008.	0.	206265.
8	204588.	6138.	0.	210725.
9	206753.	6203.	0.	212955.
10	208918.	6268.	0.	215185.
TOTAL	1590155.	47705.	0.	1637859.

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

(9)

4

INCOME AND CASH FLOW

YEAR	REVENUE	-OPERATING EXPENSES	OPERATING INC(LOSS)	-INTEREST	-DEPRECIATION	PRETAX INC(LOSS)
1	27874.	75095.	-47221.	0.	45819.	-93040.
2	78046.	75951.	2096.	23869.	47968.	-69741.
3	128219.	94809.	33410.	29195.	50753.	-45539.
4	169472.	98791.	70682.	30459.	52577.	-12354.
5	189541.	104742.	84800.	28260.	53889.	2651.
6	199576.	108277.	91299.	23917.	[illegible]	12482.
7	206265.	110256.	96009.	13139.	55845.	21975.
8	210725.	110678.	100047.	11354.	56563.	32131.
9	212955.	110929.	102026.	3202.	57286.	41538.
10	215185.	111181.	104004.	0.	58017.	45988.
TOTAL	1637859.	1000709.	637151.	167446.	533614.	-63909.

YEAR	INCOME TAX	NET INCOME
1	0.	-93040.
2	0.	-69741.
3	0.	-45539.
4	0.	-12354.
5	0.	2651.
6	0.	12482.
7	0.	21975.
8	0.	32131.
9	0.	41538.
10	0.	45988.
TOTAL	0.	-63909.

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

5

SOURCES OF FUNDS

YEAR	BEG CASH BAL	EQUITY FUNDS	LOANS	REVENUE COLLECTED	TOTAL
1		291724.	238683.	27874.	558281.
2	25000.		43270.	78046.	146316.
3	25000.		22634.	128219.	175853.
4	25000.		0.	169472.	194472.
5	25000.		0.	189541.	214541.
6	25000.		0.	199576.	224576.
7	25000.		0.	206265.	231265.
8	25000.		0.	210725.	235725.
9	25000.		0.	212955.	237955.
10	84563.		0.	215185.	299748.

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

6

USES OF FUNDS

YEAR	CAP EXPD	OP EXP	INT PAY	INC TAX	LOAN RET	TOTAL
1	458196.	75095.	0.	0.	0.	533291.
2	21497.	75951.	23869.	0.	0.	121316.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	18240.	[illegible]	[illegible]	0.	[illegible]	169472.
5	13105.	[illegible]	[illegible]	0.	[illegible]	189541.
6	10103.	[illegible]	22917.	0.	57277.	[illegible]
7	9468.	[illegible]	[illegible]	0.	[illegible]	206265.
8	7177.	[illegible]	[illegible]	0.	[illegible]	210725.
9	7237.	[illegible]	3202.	0.	32024.	153393.
10	7304.	1111 1.	0.	0.	0.	118485.
TOTAL	580167.	1000709.	167416.	0.	[illegible]	

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

7

RATE OF RETURN

INCLUDING POLE RENT		EXCLUDING POLE RENT
8.91%	- ASSUMING 10 YEAR LIFE -	10.50%
9.95%	- ASSUMING 12 YEAR LIFE -	11.65%
10.99%	- ASSUMING 15 YEAR LIFE -	12.67%

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

8

CAPITAL EXPENDITURES

ONE TIME EXPENDITURES

HEADEND	30500.
MICROWAVE	40000.
DIST. ABOVE GROUND	222426.
DIST. BELOW GROUND	92678.
POLE ARRANGEMENT	16682.
TOWER	10000.
BUILDING	3000.
INVENTORY	7704.
TOOLS AND TEST EQ.	5553.
FURN AND LSHOLD IMP.	10250.
PUB. SERV. CHANNELS	0.
TWO WAY CAPABILITY	0.
SUBTOTAL	438792.

YEARLY EXPENDITURES

YEAR	DROPS	SIGNAL UPGRAD	20 CHAN CAP	ORIG EQUIP	TOTAL
1	19394.	0.	0.	0.	458186.
2	21497.	0.	0.	0.	21497.
3	27849.	0.	0.	0.	27849.
4	18240.	0.	0.	0.	18240.
5	13105.	0.	0.	0.	13105.
6	10103.	0.	0.	0.	10103.
7	9468.	0.	0.	0.	9468.
8	7177.	0.	0.	0.	7177.
9	7237.	0.	0.	0.	7237.
10	7304.	0.	0.	0.	7304.
TOTAL	141375.	0.	0.	0.	580167.

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

DO YOU WANT ALL NEW INPUT?

NO

WHAT IS THE REFERENCE NUMBER OF THE FIRST CHANGE?

?

10

SAMPLE RUN- NEW REGULATIONS

37

00

INPUT FINISHED. WAIT FOR PROGRAM TO ASK ABOUT OUTPUT.

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

1

```
PROPOSED FCC REGULATIONS
MARKET TYPE: OUTSIDE TOP 100
SYSTEM SIZE IN 10TH YEAR =   3500. SUBSCRIBERS
STANDARD ORIGINATION, ADVERTISING REVENUE = $ 6600. PER 1000 SUBSCRIBERS
TOTAL HOMES PASSED =   4943., TOTAL MILES CABLE =  61.8,  80. HOMES/MILE
   6.2 ( 10%)  MILES OF UNDERGROUND CABLE AT $  15000.   PER MILE
  1.00  APPROXIMATE DEBT/EQUITY RATIO       .100 INTEREST RATE ON NOTES

 SIGNALS OFF  AIR                 CABLE SIGNALS
 2 NETWORKS                        6 NETWORKS
 0 INDEPENDENTS                    5 INDEPENDENTS
 0 EDUCATIONAL                     1 EDUCATIONAL
 2 TOTAL                          12 TOTAL
                                   4 TOTAL MICROWAVE
```

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

2

SUBSCRIBER GROWTH

YEAR	INCREASE	AVERAGE	ENDING	PENETRATION
1	902.	451.	902.	.18
2	722.	1263.	1624.	.33
3	902.	2075.	2526.	.51
4	433.	2742.	2959.	.60
5	216.	3067.	3175.	.64
6	108.	3229.	3284.	.66
7	108.	3338.	3392.	.69
8	36.	3410.	3428.	.69
9	36.	3446.	3464.	.70
10	36.	3482.	3500.	.71

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

3

REVENUES

YEAR 1ST OUTLET 2ND OUTLET ADVERTISING TOTAL

[illegible]

7

1	27062.	912.	2977.	30851.
2	75773.	2273.	8335.	86381.
3	12448[illegible].	3735.	13693.	141912.
4	164536.	4936.	18099.	187571.
5	184021.	5521.	20242.	209784.
6	193763.	5813.	21314.	220890.
7	200258.	6008.	22028.	228294.
8	204588.	6138.	22505.	233230.
9	206753.	6203.	22743.	235698.
10	208918.	6268.	22981.	238166.
TOTAL	1590155.	47705.	174917.	1812776.

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

4

INCOME AND CASH FLOW

YEAR	REVENUE	-OPERATING EXPENSES	OPERATING INC(LOSS)	INTEREST	-DEPRECIATION	PRETAX INC(LOSS)
1	30851.	129880.	-99030.	0.	57189.	-156219.
2	86381.	133890.	-47508.	20878.	61143.	-129529.
3	141912.	156700.	-14788.	31670.	66183.	-112641.
4	187571.	164176.	23396.	41356.	69090.	-87050.
5	209784.	172006.	37778.	46059.	70942.	-79223.
6	220890.	176550.	44339.	48738.	72223.	-76622.
7	228294.	179154.	49140.	50459.	73440.	-74759.
8	233230.	179973.	53257.	51809.	74248.	-72799.
9	235698.	180432.	55266.	52472.	75062.	-72268.
10	238166.	180893.	57273.	53006.	75882.	-71615.
TOTAL	1812776.	1653654.	159123.	396446.	695402.	-932726.

YEAR	INCOME TAX	NET INCOME
1	0.	-156219.
2	0.	-129529.
3	0.	-112641.
4	0.	-87050.
5	0.	-79223.
6	0.	-76622.
7	0.	-74759.
8	0.	-72799.
9	0.	-72268.
10	0.	-71615.
TOTAL	0.	-932726.

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

5

SOURCES OF FUNDS

YEAR	BEG CASH BAL	EQUITY FUNDS	LOANS	REVENUE COLLECTED	TOTAL
1		487147.	208777.	30851.	726775.
2	25000.		107924.	86381.	219306.
3	25000.		96859.	141912.	263771.
4	25000.		47025.	187571.	259597.
5	25000.		[illegible]	[illegible]	[illegible]

[illegible]	25000.	[illegible]	[illegible]	[illegible]
6	25000.	17208.	220890.	263098.
7	25000.	121417.	228294.	374711.
8	25000.	103489.	233230.	361719.
9	25000.	52370.	235698.	313068.
10	25000.	30738.	238166.	293904.

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

9

USES OF FUNDS

YEAR	CAP EXPD	OP EXP	INT PAY	INC TAX	LOAN RET	TOTAL
1	571895.	129880.	0.	0.	0.	701775.
2	39538.	133990.	20872.	0.	0.	194400.
3	50401.	156700.	31670.	0.	0.	238771.
4	29065.	164176.	41356.	0.	0.	234597.
5	18517.	172006.	46059.	0.	0.	236582.
6	12809.	176550.	48738.	0.	0.	238098.
7	12174.	179154.	50459.	0.	107924.	349711.
8	8079.	179973.	51809.	0.	96859.	336719.
9	8139.	180432.	52472.	0.	47025.	288068.
10	8207.	180893.	53006.	0.	26798.	268904.
TOTAL	758823.	1653654.	396446.	0.	278607.	

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

7

RATE OF RETURN

INCLUDING POLE RENT		EXCLUDING POLE RENT
.30%	- ASSUMING 10 YEAR LIFE -	1.38%
1.41%	- ASSUMING 12 YEAR LIFE -	2.50%
2.47%	- ASSUMING 15 YEAR LIFE -	3.56%

WHAT IS THE NUMBER OF THE TABLE YOU WANT?

8

CAPITAL EXPENDITURES

ONE TIME EXPENDITURES

HEADEND	30500.
MICROWAVE	40000.
DIST. ABOVE GROUND	222426.
DIST. BELOW GROUND	92678.
POLE ARRANGEMENT	16682.
TOWER	10000.
BUILDING	3000.
INVENTORY	7704.
TOOLS AND TEST EQ.	5553.
FURN AND LSHOLD IMP.	10250.
PUB. SERV. CHANNELS	23500.
TWO WAY CAPABILITY	11121.
SUBTOTAL	473413.

YEARLY EXPENDITURES

YEAR	DROPS	SIGNAL UPGRAD	20 CHAN CAP	ORIG EQUIP	TOTAL

1	1[illegible]4.	0.	41[illegible]7.	38000.	571[illegible]5.
2	[illegible]7.	0.	1[illegible]41.	0.	3953[illegible].
	27[illegible].	0.	22552.	0.	50401.
4	1[illegible]240.	0.	10[illegible].	0.	29065.
	13105.	0.	5412.	0.	1851[illegible].
6	10103.	0.	2706.	0.	12809.
7	94[illegible].	0.	2706.	0.	12174.
8	7177.	0.	902.	0.	8079.
9	7237.	0.	902.	0.	8139.
10	7304.	0.	902.	0.	8207.
TO[illegible]	141375.	0.	10603[illegible].	38000.	75[illegible]23.

W[illegible] IS THE N[illegible]R OF THE TABLE YOU WANT?

9

[illegible]

+