AN ECONOMIC MODEL OF THE SELECTION PROCESS:

MICROWAVE VERSUS CONVENTIONAL TECHNIQUES IN CATV DISTRIBUTION

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ABSTRACT

When is the use of multi-channel microwave economically attractive? How can the technical trade-offs be converted into dollars? The models used in assessing the parameters of the decision process will be discussed. These include a comparison of alternative methods of signal delivery such as super trunk, separate headends, and multi-channel microwave. Further consideration of the selection process includes estimated signal quality given the alternate distribution methods and the effect of this signal quality on distribution system cost. A method of assessing the viability of the addition of another subscriber area will be discussed.

I INTRODUCTION

On the basis that a cable television system's purpose is to make money for its owners, we can narrow any decision down to an analysis of the financial impact of that decision.

The future profitability of a CATV system can depend heavily on the choice of the type of signal delivery system. Three types of systems will be considered: Super trunk, separate headends and multi-channel microwave. In planning an overall CATV system, the operator has many choices. A choice which appears attractive in the short term, for example, to serve only one community initially, can, in terms of the long term systems viability, be exactly the wrong approach. This is probably most true in small discontiguous systems with several population clusters.

A unique aspect of this analysis will be that the economic impact of the choice of signal delivery system on the distribution system cost is taken into account. Moreover, the need for flexibility of the signal delivery system in allowing the generation of new revenues, either through expansion of the distribution system(s) or the addition of other revenue generating services, is taken into account.

THE ECONOMIC MODEL

Because of the wide range of CATV system configuration possibilities the best possible way to analyze signal delivery systems is with a model which is as generalized as possible. A model, however, is constructed on the basis of a number of assumptions. At the most basic level, for example, linearity is assumed; i.e., two miles of distribution cost twice what one mile costs. The assumptions which were used in constructing this model are discussed below. Signal quality at any subscriber's tap was held constant.

Three methods of signal delivery are considered in the model: 1) Multiple headends, which are attractive where no more than three distribution areas are widely separated and premium TV, imported channels, etc. will not be used. 2) Super trunk, which is most attractive where a single run of ten miles or less serves two or three distribution areas. 3) Multi-channel microwave, which is attractive when three or more distribution areas are to be served, especially if premium TV, imported channels, or system expansion are contemplated.

In the model, only costs which are unique to a particular one of the signal delivery systems have been considered. That is to say, the cost of items which are common to all distribution systems have not been considered. Thus, the cost of subscriber taps and office-related expenses to not appear in this model.

Towards the end of a trunk cascade, line extender cascades have to be kept short-

er and physical spacing between them is shorter due to the lower levels at which they are operating. It then follows that when the signal on the trunk is less degraded, then longer line extender cascades and less trunk can be used. Indeed, as the cross modulation characteristics of the signal source at the distribution center improve, up to a certain point, the signal levels on the trunk can be increased with a resultant increase in the strand distance between the bridgers and the first line extender and between each subsequent line extender. In addition, a longer cascade of line extenders can be used. Thus, in an optimized CATV distribution system design it is possible, with high quality low distortion signals, not only to improve the trunk to feeder ratio but also to improve the cost effectiveness of the feeder by decreasing the cable size and/or decreasing the quantity of electronics required. Figure 1 compares the signal quality at the center of the distribution system using various approaches to signal delivery. Figure 2 represents a distribution area fed by a 10 mile super trunk run. Figure 3 represents a distribution system serving the same area but fed from a centrally located multi-channel microwave receiver. Comparing Figures 2 and 3 the difference in distribution system cost is readily seem. It is clear that the system being fed by the higher quality signal will have a lower initial cost as well as a lower maintenance cost.

SIGNAL QUALITY OF DISTRIBUTION SYSTEM

	S/N	Cross Mod 20 Channels
Super Trunk		
5 Miles	48 dB	-73
10 Miles	45 dB	-67 dB
15 Miles	43 dB	-63 dB
Separate Headend*		
After Combining	60	-90
After Two Trunk Amps	53	-83
Microwave** Multi-Channel		
	53	-72 or
	50	-78 or
	47	-82

* Assuming such quality is available at each site.

** Theta-Com AML - S/N vs Cross mod adjustable with one pad.

Figure 1

In an optimized CATV system the cost of the distribution systems will vary with the quality of the signals available from the signal delivery system at the feed points of the distribution system. In this model it was assumed that distribution systems fed with signals with good signal-to-noise ratios and good cross modulation will cost 20 percent less than a distribution system fed with super trunked signals. It was assumed that two miles of super trunk would cause distribution systems to be 15 percent less than normal cost, four miles, 5 percent less than normal, etc. This percentage is based on Theta-Com's experience in costing distribution systems being fed by a high quality signal from a multi-channel microwave receiver as opposed to a 5 or 10 mile super trunk feeding of a distribution area. With regard to maintenance costs the model assumes a 10 percent differential between the high and low quality fed systems.

Plant maintenance costs, when viewed over a ten year period, can have as significant an effect on profitability as the initial cost of the plant. Maintenance costs, therefore, must be included in any examination of the economic impact of a specific course of action. Inasmuch as capital expenditures occur in one or two years, while the maintenance expenses are incurred over a period of time, the cost of maintenance must be brought to its present value. In the model all maintenance expenses are inflated at 4 percent a year and brought to present value by discounting them in accordance with the interest rate entered into the model.

The cost of maintaining a microwave system, whether multi-channel, or single channel has been assumed to be $3,000 per year. This estimate is based on Theta-Com's evaluation of the labor and material cost necessary to maintain AML microwave equipment. The assumption that the maintenance for one or two channels of single channel microwave equipment would be comparable is based on the fact that broadband microwave is only marginally more complex than microwave equipment which is capable of carrying only one channel.

The cost of maintaining a distribution system has been adjusted depending on the number of active devices in the system. Thus, in the model it has been assumed that an optimized CATV system being fed with high quality low distortion signals will use fewer electronics and that the maintenance will be about 10 percent less than it would ordinarily be expected to be.

Headend maintenance in the model has been assumed to be $1000 per headend/yr. Headend costs were assumed to be $26,000 plus $2,600 per channel for a headend with no origination except for a time and weather channel. Where a centrally originated program material, such as premium television, was considered it was assumed that material available at one site would be microwaved by single channel microwave to the other headends. The turnkey cost of the microwave equipment to perform this task is definable in the model by the user. It was assumed that headends would be $7,500 and two amplifiers away from the center of the distribution system.

Super trunk costs were assumed to be directly proportional to the number of miles of super trunk required to interconnect the distribution areas. Super trunk maintenance was assumed to be just as expensive as distribution system maintenance, on a per mile basis.

As a simplifying assumption land acquisition cost for separate headends, super trunk pole rental, and microwave mounting structure rental, were assumed to balance out. They are therefore not included in this analysis.

Multi-channel microwave costs used are those which Theta-Com uses to budgetarily estimate the turnkey cost of a given microwave system. The transmitter, and headend serving it, were assumed to be located independently of the distribution areas. If they were adjoining a distribution area then the multi-channel microwave would be $15,000 less. The cost for LDS using single channel transmitters and single channel receivers has not been considered, but like other factors in the model which are not specifically variable by data entry, this can be modified in the program itself.

The model is shown as Appendix A. It is written in basic and has been run several hundred times on a Wang 1200 Mini Computer. A sample input and output is shown as Figure 4. The inputs are underlined.

ADDITION OF A DISTRIBUTION AREA

After the model has analyzed the comparative cost of the three methods of signal delivery the marginal cost of a new service area can be seen by entering "yes" in response to the appropriate question. Anytime in this model that the number of years of maintenance is equal to zero, the model output will display plant cost per subscriber. The plant cost per subscriber will indicate the viability of the additional distribution area being considered. See Figure 5

CALCULATED RESULTS

In order to compare the results of this model with previous comparisons of the cost of the signal delivery systems alone, three, four and five distribution area systems with 6 total miles of distribution plant were evaluated. The model was run in order to develop a number of points that indicate the comparative advantage or disadvantage of the various signal delivery systems. Figures 6, 7 and 8 show the system cost with three, four and five distribution areas.

The assumptions used in running this system in the model were that super trunk costs $7,000 or $9,000/mile, that the "standard" distribution system costs $5,500/mile and that aerial maintenance costs $350/mile/year. Interest was assumed to be 12 percent and the single channel microwave was assumed to be $15,000 at the transmit site and $18,000 at each sub-headend.

A study of these graphs will show that multi-channel microwave can often be more cost effective than separate headends or super trunking. Multi-channel microwave is often more cost effective than any other signal delivery system, even in system configurations where microwave might ordinarily not have been considered.

ADDITIONAL CONSIDERATIONS

There are a number of factors contributing to the economic selection of a signal delivery system which have not been dealt with in the model.

1. Significant extra cost in using one signal delivery system in a given situation due to large physical obstructions to super trunking, inadequacies of off-air signals at a headend site, and a microwave path obstruction.

2. Cost of separate headends due not take into account the lower subscriber

penetration resulting from a lack of non-broadcast material available at the separate headends, or conversely, the expense of bringing more than one channel of microwave from a central site to the headends. The cost of just one imported channel at $400 per month at one site over a ten year period is $58,000, at present value.

3. Signal delivery system flexibility in the addition of new distribution areas, or expansion of existing areas.

4. Speed of installation for earliest subscriber revenues.

GENERALIZED CONCLUSIONS

Running this model several hundred times has resulted in some generalized conclusions which were not previously apparent. Multi-channel microwave is economically viable in most cases where it might be considered, providing that distribution areas being served have not been built or will be rebuilt shortly and that the system design will take advantage of the high quality low-distortion signals. One basic exception is the case where a single super trunk run of 10 miles or less in length can serve several distribution areas, provided it is assumed that no expansion in the number of distribution areas is required.

SUMMARY

The CATV operators' primary goal is to manage profitable systems. In order to generate as much profit as possible it is necessary to evaluate the signal delivery system's impact on total system cost. The model shown in Attachment A will provide a means of analyzing the cost implications of various signal delivery systems. If some of the assumptions in the model do not agree with your experience then the program can be adjusted accordingly. For the majority of the cases considered in this paper multi-channel microwave is the most economical approach.

APPENDIX A

```
10 Input "Number of Channels", C
20 Input "Interest in Percent", Il:Il=
   Il/100
30 Input "Super Trunk Cost", Sl
40 Input "Dist Cost--Conventional", Dl
50 D2=Dl*.8
60 Input "Aerial Maintenance", D3
70 S3=D3
80 Input "Super Trunk Miles" S
90 Input "Distribution Miles", D
100 Input "No Of Systems", N
110 Input "Pay TV MW TX", Pl
120 Input "Pay TV MW RX", P2
130 M9-0
140 Input "Number of Subscribers", S8
150 Input "Number of Years of Mainte-
    nance", M8
160 Print, "-Super Trunk -"
170 Print, "Basic", "Premium TV"
180 Hl=C*2600+25000:A=Hl
190 If M9>0 Then 210
200 Goto 220
210 Print "Headend", "0":P=0:A=0:Goto 250
220 Print "Headend", Hl
230 E=1000
240 Gosub 480
250 Print "He Maint", P
260 A=A+P
270 S4=Sl*S
280 Print "Super Trunk", S4
290 A=A+S4
300 E=S3*S
310 Gosub 480
320 Print "St Maint", P
330 A=A+P
340 D4=Dl*D:S5=S/N:If S5  5 Then 360
350 D4=D4+(.75+(S5x.05)):D4=Int(D4)
360 Print "Dist Syst", D4:A=A+D4
370 E=D3*D
380 Gosub 480
390 Print "Dist Maintenance", P
400 A=A+P
410 Print "Total", "0", A
420 A8=A/S8
430 A8=Int (A8)
440 If M8>0 Then 460
450 Print "$/Sub", A8, "0", A8
460 Stop
470 Goto 580
480 If M8  0 Then 500
490 P=0: Return
500 P=0
510 For T=1 to 11
520 If T=M8+1 Then 570
530 P=P+(E/(1+I↑T))
540 E=E*1.04
550 Next T
560 Goto 510
570 P=Int (P): Return
580 Print, "-Separate Headends-"
```

APPENDIX A - Continued

```
590 H4=H1*N
600 Print, "Basic", "Premium TV"
610 A=14
620 P4=P1+(P2*N)
630 If M9>0 Then 650
640 Goto 660
650 P4=P2
660 Print "Headends", H4, P4
670 E=N*1000
680 Gosub 480
690 H3=P:A=A+H3
700 E=3000
710 Gosub 480
720 P3=P
730 Print "He Maint", H3, P3
740 1=7,500*N: Print "Headend Runs", 1
750 E=S3*N: Gosub 480
760 Print "He Run Main", P
770 A=A+1+P
780 D4=D2*D:A=A+D4
790 Print "Dist Syst", D4
800 E=.9*D3*D
810 Gosub 480
820 A=A+P
830 Print "Dist Maint", P
840 P5=P3+P4
850 X=A+P5
860 Print "Total", A, P5, X
870 A8=A/S8:P8=P5/S8:X8=X/S8
880 A8=Int (A8):P8=Int(P8):X8=Int(X8)
890 If M8>0 Then 910
900 Print "$/Sub", A8, P8, X8
910 Stop
920 Print, "-Microwave Dist-"
930 If M9=0 Then 950
940 H1=0
950 Print "Headend, H1
960 E=1000:Gosub 480
970 If M9=0 Then 990
980 P=0
990 A=H1+P
1000 Print "He Maintenance", P:M1=C*
     2200+(N*14580)
1010 If C<7 Then 1050
1020 If C<15 Then 1060
1030 If C<23 Then 1070
1040 If C<30 Then 1080
1050 M1=M1+32605:Goto 1090
1060 M1=M1+48385:Goto 1090
1070 M1=M1+65855:Goto 1090
1080 M1=M1+78435:Goto 1090
1090 If M9>0 Then 1110
1100 Goto 1120
1110 Print "Microwave", M9, "0": M1=M9:
     Goto 1130
1120 Print "Microwave", M1, "3200"
1130 A=A+M1
1140 E=3000: Gosub 480
1150 If M9=0 Then 1170
1160 E=500:Gosub 480
1170 Print "MW Main", P
1180 A=A+P
1190 D4=D2*D
1200 Print "Dist Syst", D4
1210 E+.9*D3*D:Gosub 480
1220 Print "Dist Main", P
1230 A=A+P+D4
1240 If M9>0 Then 1260
1250 P8=3200:Goto 1270
1260 X=A:P8=0:Print "Total", A, "0",
     X:Goto 1290
1270 X=A=3200
1280 Print "Total", A, "3200", X
1290 A8=A/S8:P8=P8/S8:X8=X/S8
1300 A8=Int (A8):P8=Int (P8): X8=Int
     (X8)
1310 If M8>0 Then 1330
1320 Print "$/Sub", A8, P8, X8
1330 Stop
1340 Input "Do You Want To Add A Distri-
     bution Area", A$
1350 If A$ >"No" Then 1370
1360 Gosub 160
1370 Input "Super Trunk Miles", S
1380 Input "Distribution Miles", D
1390 Input "Number of Years of Mainte-
     nance", M8
1400 Input "Number of Additional Subs",
     S8
1410 N=1:M9=14580
1420 Gosub 160
```

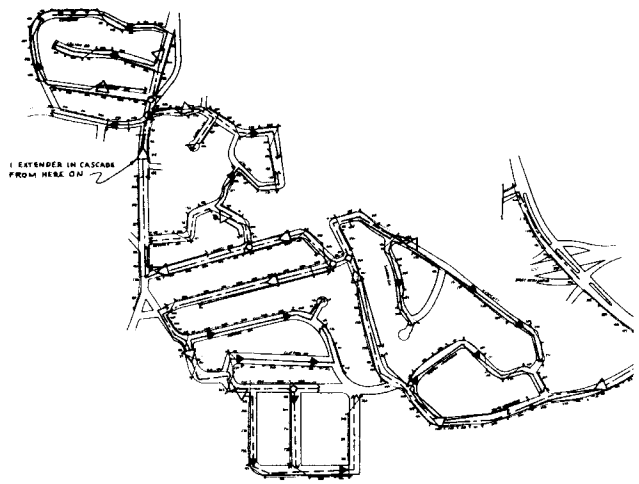


FIGURE 2

DISTRIBUTION SYSTEM FED BY 10 MILES OF SUPER TRUNK
Active Equipment: 13 Trunk Stations
18 Line Extenders

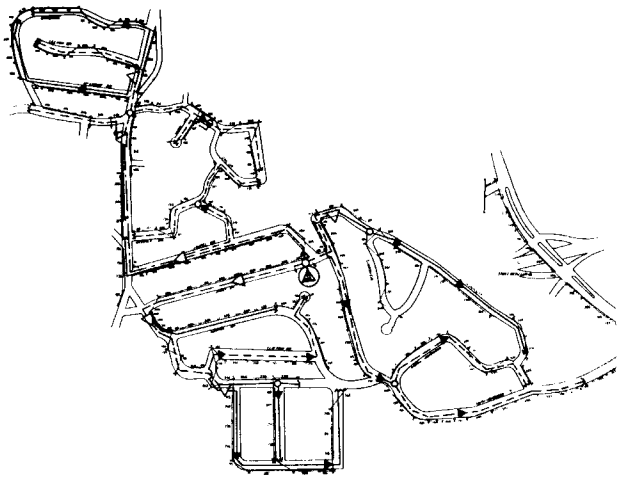


FIGURE 3

DISTRIBUTION SYSTEM CENTER FED WITH LOW DISTORTION SIGNALS
Active Equipment: 7 Trunk Stations
15 Line Extenders

FIGURE 4 SAMPLE INPUT AND OUTPUT PRINT-OUTS OF THE ECONOMIC MODEL

```
Run
Number of Channels? 6
Interest In Percent? 12
Super Trunk Cost? $9,000
Dist Cost--Conventional? $5,500
Aerial Maintenance? 350
Super Trunk Miles? 30
Distribution Miles? 100
No Of Systems? 4
Pay TV MW TX? 15000
Pay TV MW RX? 8000
Number Of Subscribers? 4500
Number Of Years Of Maintenance? 10
```

	-Super Trunk- Basic	Premium TV	
Headend	40600		
He Maint	11882		
Super Trunk	270000		
St Maint	124761		
Dist Syst	550000		
Dist Maintenance	415872		
total	1413115	0	1413115

Stop
Continue

	-Separate Headends- Basic	Premium TV	
Headends	162400	47000	
He Maint	47528	35646	
Headend Runs	30000		
He Run Main	16634		
Dist Syst	440000		
Dist Maint	374285		
Total	1070847	82646	1153493

Stop
Continue

	-Microwave Dist-		
Headend	40600		
He Maintenance	11882		
Microwave	104125	3200	
MW Main	35646		
Dist Syst	440000		
Dist Main	374285		
Total	1006538	3200	1009738

Stop

FIGURE 5 SAMPLE INPUTS AND OUTPUTS FOR AN ADDITIONAL DISTRIBUTION AREA

```
Continue
Do You Want To Add A Distribution Area? yes
Super Trunk Miles? 8
Distribution Miles? 20
Number Of Years of Maintenance? 0
Number Of Additional Subs? 1000
```

	-Super Trunk- Basic	Premium TV	
Headend	0		
He Maint	0		
Super Trunk	72000		
St Maint	0		
Dist Syst	110000		
Dist Maintenance	0		
Total	182000	0	182000
$/Sub	182	0	182

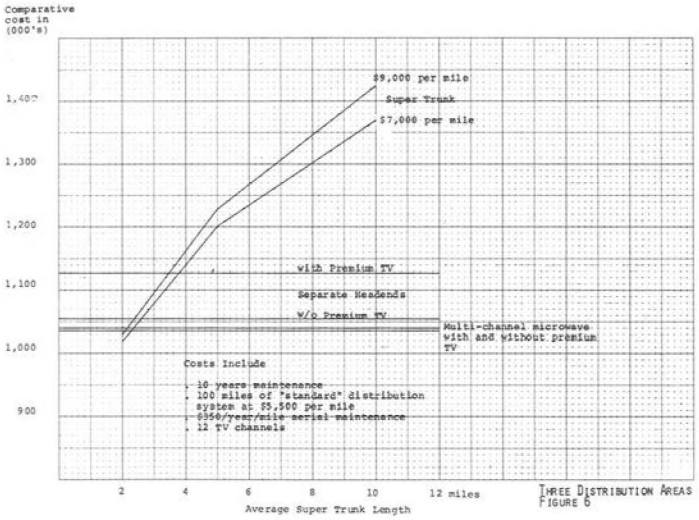
Stop
Continue

	-Separate Headends- Basic	Premium TV	
Headends	40600	8000	
He Maint	0	0	
Headend Runs	7500		
He Run Main	0		
Dist Syst	88000		
Dist Maint	0		
Total	136100	8000	144100
$/Sub	136	8	144

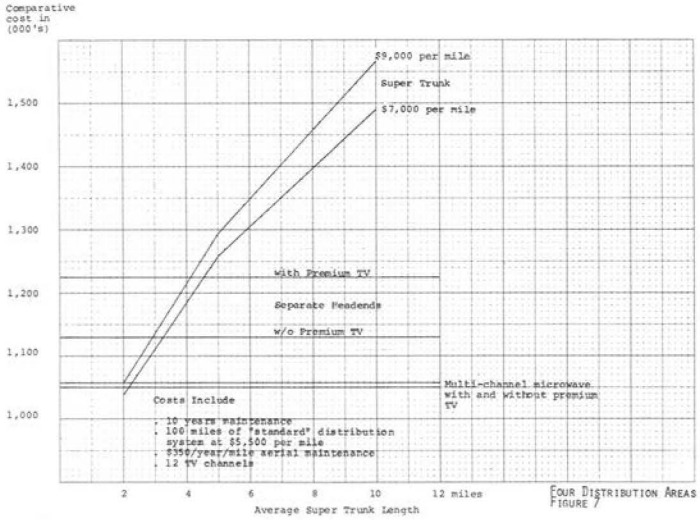
Stop
Continue

	-Microwave Dist-		
Headend	0		
He Maintenance	0		
Microwave	14580	0	
MW Main	0		
Dist Syst	88000		
Dist Main	0		
total	102580	0	102580
$/Sub	102	0	102

Stop



THREE DISTRIBUTION AREAS
FIGURE 6



FOUR DISTRIBUTION AREAS
FIGURE 7