COST FACTORS RELATIVE TO THE FIBEROPTIC BACKBONE SYSTEM

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(Note: This paper should be examined in conjunction with the other papers dealing the fiber backbone presented during the 1988 NCTA Technical Sessions. Overall descriptions and technical details covered therein are not repeated in this work.)

Abstract - This paper summarizes the costs involved in constructing a fiberoptic backbone trunk network in a typical suburban cable system. The assumptions and analytic process are included to allow the numbers to be translate into terms appropriate to the company of the reader.

I. Introduction

The purpose of this effort is to perform the cost analyses required to ascertain the economic viability of the fiber backbone venture in the context of typical suburban cable systems. Since this concept has not yet been deployed in an actual operating system, hence lacking the certainties gained from practical experience, all known assumptions and background data impacting the models have been included.

In this effort we have not attempted to include a benefits analysis with its associated discounted cash flow models since this paper is intended for a universal cable industry audience, and there is no universal agreement as to the value of certain cable enhancements. Rather we have shown the cost to install such a system as we propose, and subsum the system enhancements in terms of increased system overhead. How the cable operators utilize that advantage, whether in increased channel capacity, enhanced signal specifications, or greater system reach is a matter of personal choice.

II. Assumptions

In this analysis, we have attempted to qualify each entry in order to remove uncertainty factors from the results. The following list of assumptions represent the minimal number possible, considering the scope and state of readiness of the technology being examined. The assumptions fall into two major catagories:

o Pricing projections on hardware items which are either not yet available in production quantities, or those having rapidly changing or unstable price structures.

o Operational issues relating to the system being modeled, such as number of channels carried, value of those channels, signal quality standards, specifications of some hardware items whichare not yet available in production form, and maintenance and customer service enhancements resulting from the backbone.

Pricing Assumptions

1. The price used on aerial and underground fiber cable is based upon current quotes ATC has on file from qualified vendors. The price of fiber optic cable has a history of a downward trend as production yield and demand increases. It can be safely projected that fiber will be significantly cheaper by the time the backbone is implemented in exisiting divisions. Using today's pricing is a very conservative approach to this issue.

   Current quotes on fiberoptic cable run between 6-1/2 and 7 cents per fiber foot, which includes the cost of sheath, strength member and internal structures, for cables with over a dozen fibers. The cost goes up slightly for cables with fewer fibers to recover the apportioned sheath costs.

2. The conversion node is an AGC equipped feed-forward amplifier station with a fiber detector front end. We have assumed that early production units will be assembled in just that fashion. Therefore, the price of the conversion node has been derived by combining the costs for the amplifier, with the cost of a fully assembled detector package, with an additional factor added for vendor labor, overhead, and profit. As demand increases for this unit, a more cost effective solution will be the design of a custom card, incorporating the detector front end, the gain block, the 75 ohm interface, with associated power supplies, environmental housings, etc. We believe our approach to the price of this unit is very conservative, but benefits us by being highly quantifiable at this

time. Together with some miscellaneous hardware and installation labor, the total unit cost comes to $2,180.00. In the conservative approach used to generate the financials for this paper, there is a one-to-one relationship between the number of laser assemblies at the hub and the number of conversion nodes.

3. The launcher modules in the cable headend area are priced based on current quotes from qualified vendors.

   The Laser transmitters located in the hub are totally self-contained and require typical headend temperature control and 120v60Hz power. The units occupy about three inches of rack space and at present cost $4,000.00 each. In quantity, these units are expected to be reduced in price to about $2,500.00 each. However, for this analysis, we have assumed the current price.

4. All construction costs are as currently quoted by ATC's construction division. ATC currently uses a cost of 50 cents per foot on route milage for construction costs for fiber cable. This is the cost to overlash the fiber cable onto existing plant.

5. We are currently using an assumption of one to one routing. That is, one fiber eminates at the hub and travels to one conversion node. As can be noted from Figure III-1, the average fiber trunk run for, say, the 4 amplifier cascade case, is 4.4 miles. The shortest trunk is 1.13 miles and the longest 8.99. With the power budgets available from today's lasers, we could route such as to hook in series two or more of the closer conversion nodes, perhaps those under 3.0 miles distance from the hub, thus directly saving fiber and laser costs. This kind of design is exactly what a cable operator would do when addressing a specific application. For the purposes of this analysis, we have assumed no finessing of this sort. However, based on the Pinehurst hub, we have estimated that perhaps a per sub savings of 15 to 20% might be realized with optimized routing.

<u>Operational Assumptions</u>

1. It is assumed that sufficient power budgets exist with the lasers driving the backbone trunks to deliver signals of appropriate specifications to the conversion node after having traversed 15 Kilometers of passive single mode fiber.

2. It is assumed that the laser/detector pair selected will be capable of transmitting 75 VSB-AM video channels with signal specifications at the back of the detector in the conversion node of:

C/N	55dB
2nd Order	-65dB
CTB	-65dB
Intermod	-65dB

3. It is assumed that the lasers will be located in an environmentally controlled area with protected and conditioned power, such as a cable headend, and that the conversion node will meet all of the same specifications for environment, lightning surges, power fluctuations, etc., as currently met by typical active coaxial plant equipment.

III. The Analytic Process

When attempting to qualify technically and financially a new system element, there are two basic approaches to modeling, neither of which are perfect. The first approach selects portions of actual existing and operating cable plants and injects the new item into that environment and examines the results. This approach has the advantage that considerable high-confidence data is available on the existing system. The downside risk, is that there may be unobvious factors in that system selected which make it unlike most other systems, therefore limiting the general applicability of the model.

The second technique is to build on paper a generic cable system which incorporates all design elements typically found in operating divisions. The advantage to this approach is that the base model is completely controllable by the analysis team, and all system factors impacting the outcome can be easily included. The problem with this approach, is that there is no way of qualifying the generic model against the real world, since no such system exists. This also means that the results may have limited applicability against actual systems.

In general,experience has taught us that technique one is far superior when attempting to develop numbers on a new and singular system item, and that technique two may be better when doing comparisons between two or more items having the same functionality. Since in this effort, we are trying to determine the financial viability of a new, singular architectual element for cable systems, the first method appears to be more appropriate. It was the sense of the team assembled to assist in this effort that the model should be derived from actual ATC plant.

For the purposes of this analysis we have chosen a portion of the Orlando, Florida cable system as being representative of typical suburban plant. Specifically, we have chosen to convert the entire Pinehurst node to the backbone architecture. This hub is currently fed via AML microwave and delivers 36 channels of video over 375 miles of 270 MHz plant. There are a total of 10,000 subscribers served by this distribution node.

AMPLIFIERS IN CASCADE	NO. OF CONV. NODES REQ'D.	NO. OF AMPS REMOVED	TOTAL FIBER FOOTAGE REQ'D	FIBER TRUNK ROUTE MILES
2	61	135	1,309,250	44
3	41	102	922,000	45
4	29	69	679,000	51

FIGURE III-1. System Model Summary

Table III-1. summarizes the important factors relating to the system model, indexed according to our assumptions of 2,3, or 4 amplifiers in cascade beyond the optical conversion node. Please note the following items relative to that table. The number of amplifiers removed includes those trunk units bypassed by the fiber, plus the station replaced by the conversion node itself. Also, the fiber footage numbers refer to the total lineal feet of fiber required. There may be up to 24 fibers in a single sheath when it leaves the headend. The number of fibers per sheath will be optimized according to the design.

Figures III-2,3, and 4 show the node locations and fiber routing for the three cascade instances mentioned above.

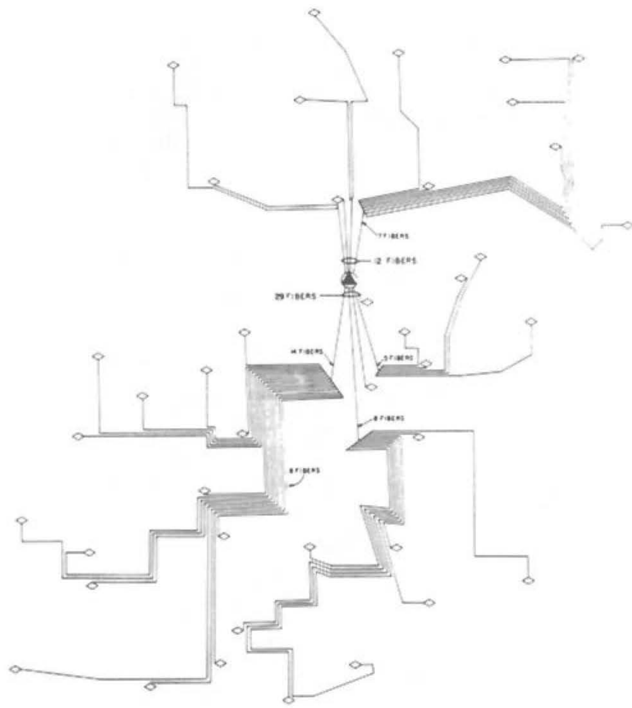

FIGURE III-3. Node Location and Fiber Routing for Three Amplifiers in Cascade

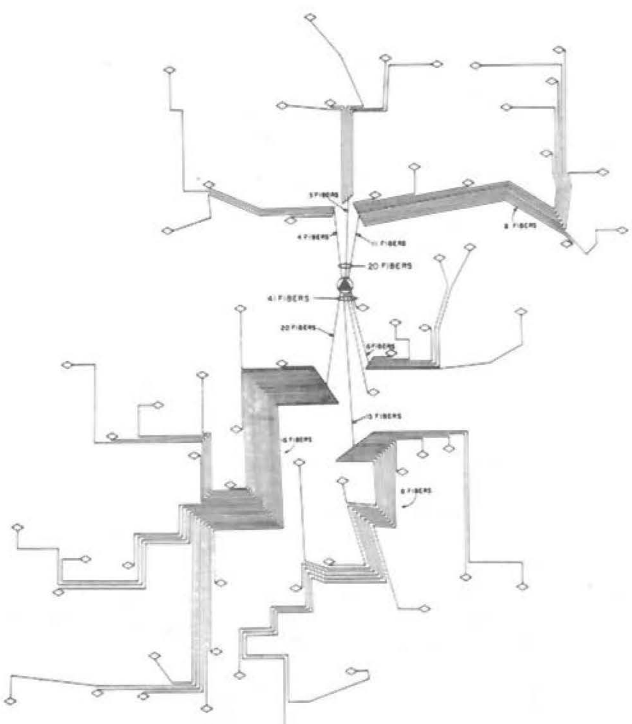

FIGURE III-2. Node Location and Fiber Routing for Two Amplifiers in Cascade

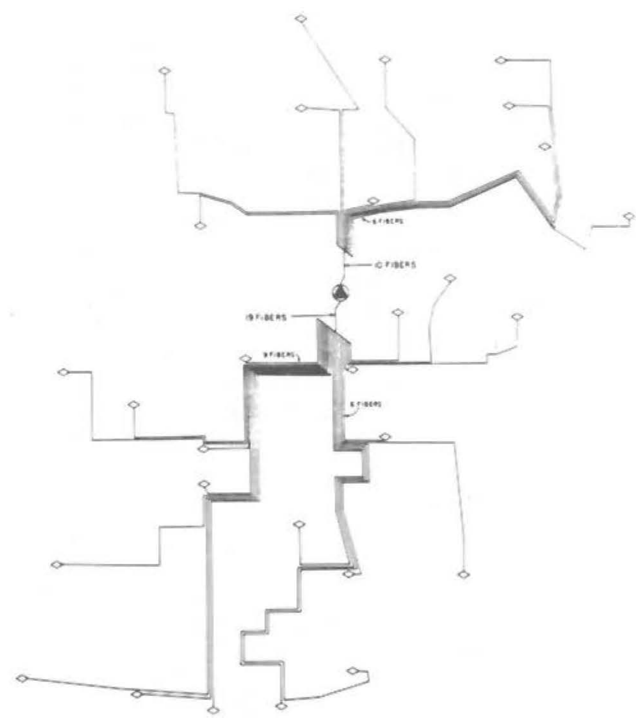

FIGURE III-4. Node Location and Fiber Routing for Four Amplifiers in Cascade

COST ITEM	COST PER UNIT	NUMBER OF UNITS 2 AMP CASCADE	TOTAL COST 2 AMP CASCADE	NUMBER OF UNITS 3 AMP CASCADE	TOTAL COST 3 AMP CASCADE	NUMBER OF UNITS 4 AMP CASCADE	TOTAL COST 4 AMP CASCADE
HEADEND COSTS							
LASER XMITTERS	4,000.00						
MISC. HARDWARE	Included						
LABOR	Included						
TOTAL PER TRUNK	4,000.00	61	244,000.00	41	164,000.00	29	116,000.00
CONVERSION NODES							
STATION COST	2,000.00						
MISC. HARDWARE	30.00						
LABOR	160.00						
TOTAL NODE	2,180.00	61	132,980.00	41	89,380.00	29	63,220.00
FIBER TRUNKING							
CABLE COST	.07 /fiber foot	1,309,250	91,647.50	922,000	63,540.00	679,000	47,530.00
MISC. HARDWARE	Included						
CONST. LABOR	.50/route foot.	230,736	115,368.00	239,184	119,592.00	268,752	134,376.00
TOTAL COST			583,995.50		436,512.00		361,126.00
COST/FIBER NODE			9,573.70		10,646.63		12,456.62
COST/TRUNK MILE			13,363.74		9,636.03		7,094.81
COST/SUBSCRIBER			58.40		43.65		36.11

FIGURE IV-1. Fiberoptic Backbone Cost Summary

IV. SUMMARY OF RESULTS

Figure IV-1 summarizes the costs for the fiber backbone for each of the three cases, 2,3, and 4 amplifiers in cascade beyond the conversion node.

This does not include the cost of rearranging the coaxial plant beyond the conversion node, nor wrecking out the replaced trunk, if desired. The distribution rearrangement depends on the decision of the cable operator as to how the gained system overhead is utilized and is not a function of this exercise. It is our feeling that wrecking out the replaced trunk is not useful, since the bypassed trunk may be utilized for other purposes or as backup to the fiber. Also, wrecking out the trunk adds needless expense to the project.

Once again, it must be noted that the costs in each instance represents a worse case number. Our understanding, based on this admittedly small, but very typical, sample, indicates that the costs can be reduced by 15 to 20% by using optimum routing and daisy-chaining conversion nodes on those fiber runs of less than 3 miles. The bottom line is that in the four amplifier cascade instance, it appears that the per subscriber cost will be closer to $30.00 than the indicated $36.11.

V. CONCLUSIONS

In conclusion, the value of this kind of plant upgrade cannot be ascertained in a global fashion, but each operator must assess its value on a case by case basis. Some value must be assigned to the increased system overhead in order to examine the benefits through the usual discounted cash flow and internal rate of return models.

From the ATC standpoint, we are reasonably convinced that the $30.00 approximate investment required to add this capability to our systems is well justified when considering the results. ATC will expend the gained overhead in a different manner in each of its systems, based on need. However, a factor we are well advised to keep in mind is the need to provide increased signal quality to the subscriber home. This is to address three cable industry problems, one long standing, the other two not yet having reached reality.

- o A long term need to enhance signal quality in order to increase our penetration numbers and to reduce churn.

- o Some uncertainty regarding the quality of signal required to accomodate HDTV, when it arrives in full force in the next few years.

- o The need to enhance quality in order to be in a more competetive position should our competition continue with their plans to run high-quality digital video into the home of the future.

It is not anticipated that these three factors will require all of the gained overhead, but should be figured into the equation by any prudent operator.

Finally, there are many within ATC who believe that fiber will certainly become a franchising issue in the next few years, and an unwillingness or lack of history in using fiber in this manner will put the system operator in a disadvantaged position.

So what kind of an investment are we anticipating if the whole cable industry should decide to adopt the fiber backbone into all systems. With approximately 712,000 miles of plant in the United States serving some 38,800,000 subscribers, and using the 4 amplifier cascade option as the most cost effective, a total investment of just under $1.2 Billion is indicated, based on the $30.00 per subscriber number. This represents the installation of just over 100,000 route miles of fiber trunking, with a varying number of fibers per trunk, as required.

This task has primarily resided in the Engineering and Technology Department at the ATC Corporate offices. It consists of an approximate three month effort beginning in January, 1988. The list of contributors in Engineering and Technology include, alphabetically, Claude Baggett, Jim Chiddix, Mavis Dooley, Barb Lukens, Dave Pangrac, Perry Rogan, George Salvador, Raleigh Stelle, and Jay Vaughan.