GUIDE TO PLANT ANALYSIS
INCREASING CHANNEL CAPACITY OF A C.A.T.V. SYSTEM

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ABSTRACT

The major technical considerations of increasing channel capacity are outlined. Priorities are indicated with respect to performance and cost factors, and a guide to decision making is presented. This discussion is limited to the section of the plant between the headend and the subscribers tap port.

INTRODUCTION

The reasons to increase channel carriage of a C.A.T.V. system are well known in the industry. Reasons such as franchise requirements, desire to add revenue-producing programming, or simple modernization of outdated and expensive to maintain plant. To increase capacity, must all the plant be replaced? If not, then what portion should be retained? To find the answers, we must keep in mind two prime considerations: delivery of a reliable quality product, and keeping required investment and operating costs to a minimum. Other important issues are compliance with franchise and FCC regulations, and service to the community.

OBJECTIVES

The most expensive item in a rebuild is cable materials and labor. If existing cable can be used, it will result in significant cost savings. It is also a big advantage to retain existing trunk amplifier locations, so that channel capacity can be increased with a minimum of service interruption to the subscriber. Picture quality, of course, must be maintained at the worst case subscriber. With any type of service upgrade, this is the first consideration. A retrofit is often the most cost-effective way to increase channel carriage while retaining picture quality.

METHOD OF ANALYSIS

To determine if some type of retrofit is practical, it is necessary to take a careful look at the plant. This is best accomplished through separate analysis of four main catagories:

1. Cable Evaluation: type, age, and condition of existing cables need to be examined first because of the large cost impact.

2. Trunk Evaluation: distances, cascades, amplifier spacings - these factors will set the limits on performance.

3. Distribution Evaluation: intimately related to trunk evaluation, this catagory is important because of cost and ease of maintenance.

4. Existing Equipment: often a first priority, usability of existing equipment is best determined after analysis of the previous three items as presented here in logical flow chart form.

CABLE EVALUATION

The first chart (Fig. 1 - Cable Evaluation), will help to answer three main questions:

1. Does existing cable make a retrofit a poor choice?

2. Will existing cable limit usable bandwidth?

3. If cable types and ages are mixed, will some cable need to be replaced?

To evaluate existing cable, first it is necessary to determine the ages, types, and the manufacturers specifications. What is the history of replacement? Each type of cable needs to be looked at separately.

If a significant or increasing percentage of a given type has been replaced, does the type being replaced still comprise a majority of the plant? If so, a rebuild is indicated. If not, replacement of the remainder would be proposed. If the replacement history is spotty and amounts to a low percentage, the type of cable involved should be considered. If this type is outdated (i.e. styrene foam dielectric, corrugated or braided sheath), replacement would be proposed, or if this is the majority of plant, a rebuild would be called for.

If very little or no cable of a given type has been replaced, it is then necessary to look at the age of the cable. Older types, with solid polyethylene or chemically-foamed polyethylene dielectrics, are probably usable to about 35 channel capacity. Cable of medium age, with gas-injected polyethylene or earlier air dielectrics, can typically be used up to about 40 channels. More recent types, such as low-loss versions of gas-injected polyethylene and improved air dielectric cable, will have capacities in excess of 40 channels. If all cable for which replacement has not been proposed is one of these recent types, the cable evaluation is completed. If not, then does the existing cable meet the bandwidth requirements? If not, a rebuild is indicated.

If the needed bandwidth seems attainable with existing cable, this cable should then be tested in the field. To accomplish this, select several long; uninterrupted samples of each age and type to be retained. Each sample is then tested for attenuation and structural return loss across the proposed bandwidth. If the samples show substantially higher loss than the manufacturers specs., then a rebuild may be required. If the samples do not exhibit acceptable return loss across the required bandwidth, then perhaps the proposed bandwidth can be reduced, or if it cannot, a rebuild is indicated. If samples pass both attenuation and return loss testing, the cable evaluation is complete.

TRUNK EVALUATION

The second chart (Fig. 2 - Trunk Evaluation) addresses three issues:

1. Are additional hubs required?
2. Can existing trunk cable be used?
3. What are the optimum operating levels?

To evaluate the trunk layout, it is first necessary to determine the service area boundaries. Expected growth areas within the period of the franchise and plant lifetime should be included. Then it is possible to determine the maximum trunkline mileage from existing headend or hubs along potential trunk routes to the extremities of the service area. With this distance in mind, can practical trunks be built to serve these areas and meet the required end of line specifications at the proposed bandwidth? A negative answer to this general question will quickly indicate the need for additional hub sites with attendant high-performance coaxial, fiber optic, or microwave interties. If service area extremities are within potential trunk reach, a map of the existing trunk layout needs to be examined. In many cases it will be necessary to create such a map. The trunk map and information previously determined about cable types will allow the trunk spacing to be determined at the highest existing operating or design frequency. In cases where spacings are difficult to determine, or if determined spacings appear to be erratic, then some field work is required. A technique that answers the spacing question and can also yield a lot of other valuable information is to measure the inputs and outputs at each trunk amplifier in the system. The results of such a study can be used to check the trunk map, indicate bad cable and equipment, and spot bad design and construction. Sometimes it also makes sense to set amplifier output levels as system technicians measure their way out into the trunklines.

Once existing spacings are determined, they can be converted to dB at the highest frequency needed to pass the proposed bandwidth. Now it is possible to examine the option of use of existing trunk amplifier locations. Determine maximum trunk cascade using the trunk layout map. Be sure to include growth areas. Establish the required distribution cascade. Use manufacturers performance specs to optimize equipment operating levels for maximum system reach at existing trunk spacings and required end-of-line performance. Is the worst case trunk cascade within system reach? If not, perhaps lower loss cable can be installed to shorten trunk spacings and improve system reach. The operating levels again need to be optimized to find out if this technique will work. If changing trunk cable is not pracitcal, can trunk cascades be shortened through re-routing or use of "interceptor" trunks? Here again, levels must be optimized at the proposed shorter maximum trunk cascade to determine if this is a viable alternative. If neither of these options alone or in combination will work, then it is necessary to start over again by selecting proposed hub sites and repeating the trunk evaluation. When the final choices have been made, the operating levels can be re-optimized to result in the best performance at the worst case subscriber.

DISTRIBUTION EVALUATION

The third chart (Fig. 3 - Distribution Evaluation) will help to answer three questions:

1. Can line extenders and passives remain in their present locations?
2. Is additional trunking required?
3. Is additional distribution cable required?

To evaluate the distribution section of the plant, first select several trunk amplifiers as samples. Use a sufficient number of samples to represent a cross section of different subscriber densities, trunk depths, design specs/philosophies, and system ages. Redesign each sample at the proposed bandwidth. Use existing line extender and passive locations, changing only levels, gains and tap values. Can sufficient signal be provided to all subscribers? If so, the distribution evaluation is complete. If not, redesign samples using new equipment locations and additional cables if necessary. If the samples can be fed without excessive use of new cable, again the evaluation is complete. If not, can new trunks be built into these areas without creating spacing problems in the "backbone" trunk? If spacing problems come up, return to the trunk evaluation and see if spacing problems can be resolved through use of larger or lower loss cables. When a method of new trunking has been established, the following comparison can be made. Redesign samples using additional distribution cables, and redesign the samples using new trunks. Estimate the cost of each option. If new trunking is cheaper, then it becomes the method of choice. If additional distribution cabling is cheaper, does it result in a complex and hard to maintain layout? If so, new trunks should be used. Analysis of each sample can result in a different conclusion, and the preferred solutions may vary in each situation.

EXISTING EQUIPMENT

At this point, cable has been looked at, design problems have been worked out, and operating levels, spacings, and required equipment performances are known. Now choices can be made regarding replacement, upgrade, and retention of the components of the outside plant.

1. Actives. Trunk amplifiers, bridgers, and line extenders are of principal importance. In general, existing actives are not adequate for increased channel loading. If the gear is of recent vintage, many manufacturers offer replacement plug-in modules with improved performance and higher gain ratings. Modification kits are available in the aftermarket to upgrade performance and increase gain of existing modules. If the highest performance is a must, then feedforeward technology or power doubling amplifiers could be the answer.

2. Passives. The existing splitters and directional couplers must be able to pass the required number of channels. The original manufacturers spec. sheets will indicate the bandwidth of these passives. Directional taps must also be able to pass the required number of channels. Many modern taps are of modular construction, and will allow the tap value to be changed without resplicing. Some manufacturers offer replacement modular plates designed to pass wider bandwidths.

3. Connectors. Existing connectors must be mechanically sound, and have sufficient shielding to prevent signal leakage. They must also have high enough return loss to reduce reflections. If connectors need to be changed, the additional splicing labor may negate the cost advantages of retaining existing passives and taps, particularly if these devices are of borderline or questionable performance.

4. Powering. Existing power supplies must have adequate current ratings. If selected amplifiers require more power, or if greater numbers of amplifiers will be used, the powering layout should be checked. Replacement or conversion of 30 volt supplies to 60 volts will often eliminate the need for more supplies at new locations.

PERFORMANCE CALCULATIONS

The practical mathematics of performance prediction, although not overly complex, can be difficult for non-engineering personnel in management and technical positions at the system operations level. Fortunately, many electronics manufacturers are happy to provide assistance in operating level selection and determination of end-of-line performance.

SUMMARY

Hopefully this guide will help to sort out the technical and economic issues of channel expansion. Attention to a few simple rules will result in better allocation of financial resources and produce a cable system with dependable performance that will be a good revenue producer for years to come.

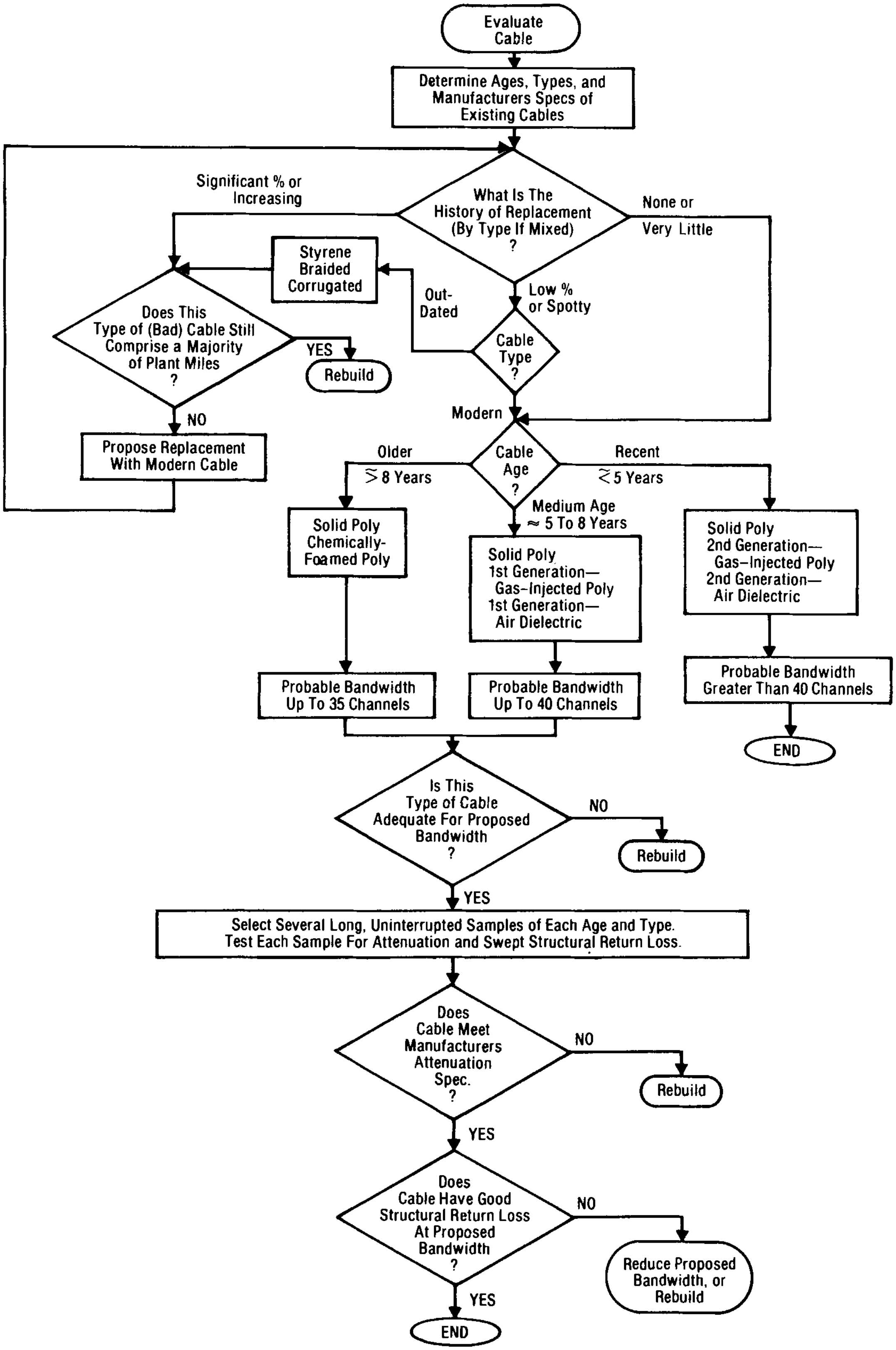

FIGURE I. CABLE EVALUATION

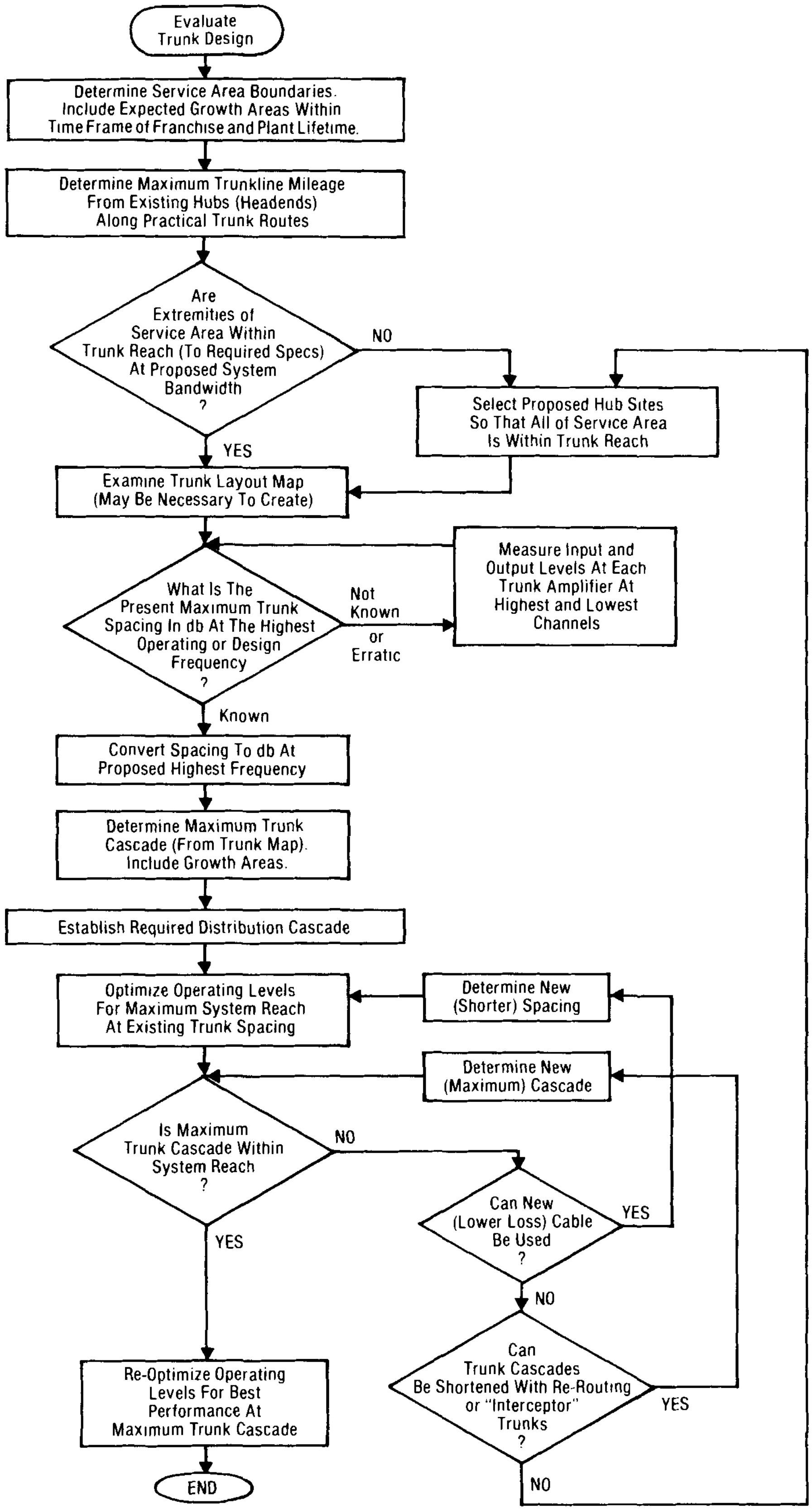

FIGURE 2. **TRUNK EVALUATION**

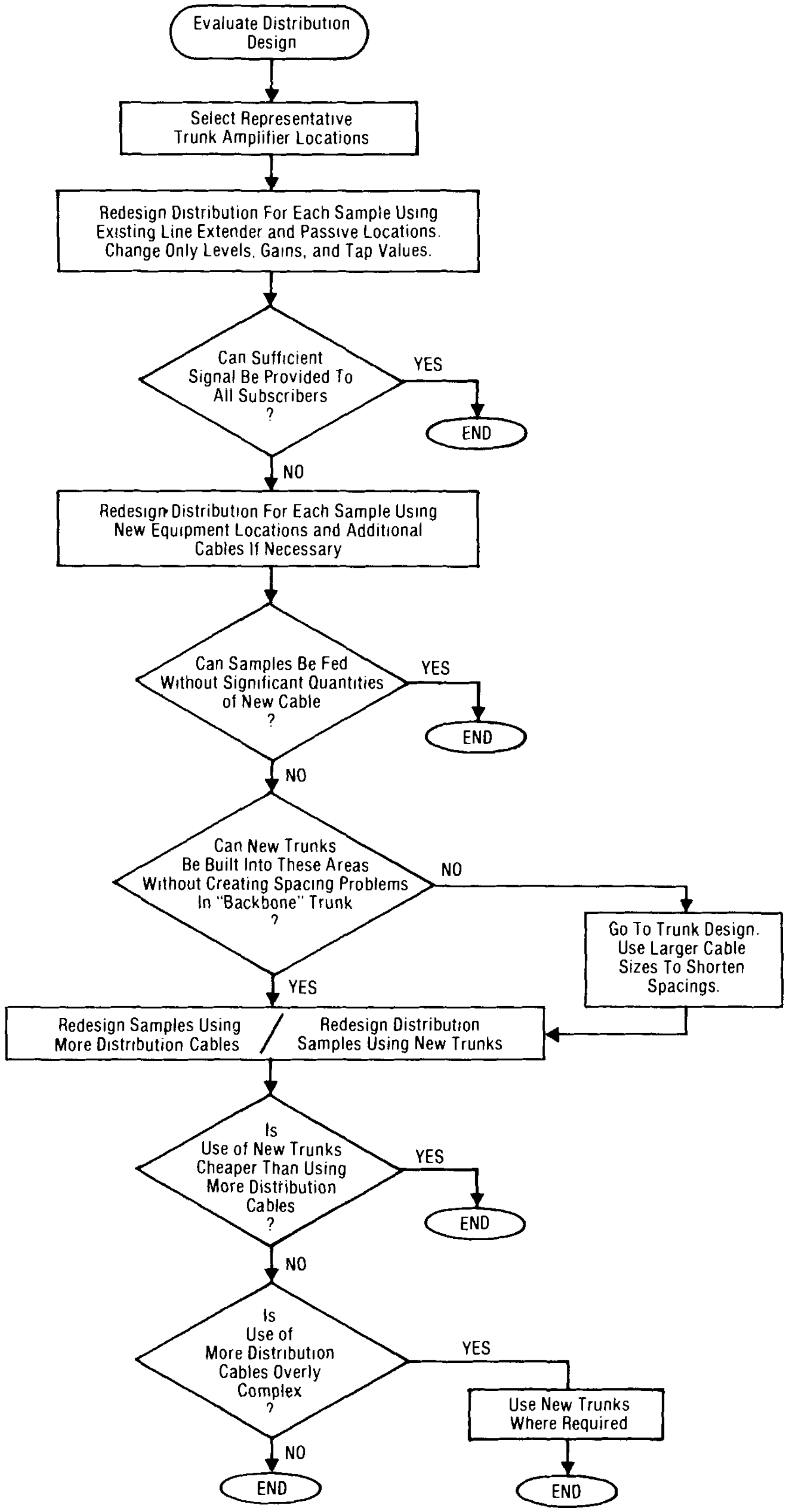

FIGURE 3. DISTRIBUTION EVALUATION