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October 15, 1999

Mrs. Blanca S. Bayo, Director
Division of Records and Reporting
Florida Public Service Commission
2540 Shumard Oak Boulevard
Tallahassee, Florida 32399-0850

Re: Docket No. 990649-TP

Dear Mrs. Bayo:

Enclosed for filing in the above-referenced docket are an original and fifteen (15) copies of the surrebuttal testimony of Don J. Wood on behalf of AT&T Communications of the Southern States, Inc. and MCI WorldCom, Inc.

Copies of the foregoing are being served on all parties of record in accordance with the attached Certificate of Service.

Thank you for your assistance with this matter.

Yours truly,

Tracy Hatch

TH:kfj
Enclosures

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CERTIFICATE OF SERVICE
DOCKET 990649-TP

I HEREBY CERTIFY that a true and correct copy of the foregoing was furnished via U.S. Mail to the following parties of record on this 15th day of October, 1999:

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* includes Attachment DJW-2

ORIGINAL

BEFORE THE

FLORIDA PUBLIC SERVICE COMMISSION

DOCKET NO. 990649-TP

SURREBUTTAL TESTIMONY

OF

DON J. WOOD

ON BEHALF OF

AT&T COMMUNICATIONS OF THE SOUTHERN STATES, INC.

AND

MCI WORLDCOM, INC.

October 15, 1999

SURREBUTTAL TESTIMONY OF

DON J. WOOD

ON BEHALF OF

AT&T COMMUNICATIONS OF THE SOUTHERN STATES, INC.

AND

MCI WORLDCOM, INC.

DOCKET NO. 990649-TP

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Don J. Wood. I am employed as a Regional Director of Klick, Kent, and Allen, Inc., an economic and financial consulting firm. My business address is 914 Stream Valley Trail, Alpharetta, Georgia 30022. Klick, Kent & Allen, Inc. is a subsidiary of FTI Consulting, Inc. I provide economic and regulatory analysis of the telecommunications, cable, and related "convergence" industries, with an emphasis on economic policy, development of competitive markets, and cost of service issues.

Q. PLEASE DESCRIBE YOUR BACKGROUND AND EXPERIENCE.

A. I received a BBA in Finance with distinction from Emory University and an MBA with concentrations in Finance and Microeconomics from the College of William and Mary. My telecommunications experience includes employment at both a Regional Bell Operating Company ("RBOC") and an Interexchange Carrier ("IXC").

I was employed in the local exchange industry by BellSouth Services, Inc. in its Pricing and Economics, Service Cost Division. My responsibilities included performing cost analyses of new and existing services, preparing documentation for filings with state regulatory commissions and the Federal Communications Commission ("FCC"), developing methodologies and computer models for use by other analysts, and performing special assembly cost studies. I was also employed in the interexchange industry by MCI Telecommunications Corporation, as Manager of Regulatory Analysis for the Southern Division. In this capacity I was responsible for the development and implementation of regulatory policy for operations in the southern U. S. I then served as a Manager in the Economic Analysis and Regulatory Affairs Organization, where I participated in the development of regulatory policy for national issues.

Q. HAVE YOU PREVIOUSLY PRESENTED TESTIMONY BEFORE STATE REGULATORS?

A. Yes. I have testified on telecommunications issues before the regulatory commissions of twenty-six states, Puerto Rico, and the District of Columbia. I have also presented testimony regarding telecommunications and cost of service issues in state and federal courts and have presented comments to the FCC. A listing of my previous testimony is attached as Attachment DJW-1.

Q. HAVE YOU PREVIOUSLY APPEARED BEFORE THIS COMMISSION?

A. Yes. I have presented testimony on costing issues to this Commission on a number of occasions.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. I have been asked by AT&T and MCI Worldcom to describe in detail (1) the methodology that should be used to determine the relevant costs to be used to establish prices UNEs and combinations of UNEs (*i.e.*, to describe how a cost model should calculate these costs, and why it should do so in the manner described), and (2) the methodology that should be used to determine the appropriate inputs to such a cost model. Proper development of UNE prices is an interactive process that involves an interaction between model methodology and inputs; both must be conceptually correct, accurate, and consistently developed and applied if reliable costs estimates are to be determined and cost-based UNE prices are to result.

My testimony responds to several of the arguments made by the ILEC witnesses in their rebuttal testimony, and is presented in two sections. Section I describes in detail the overarching conceptual basis for my recommendations regarding both the methodology for cost calculation within a model and the method I recommend for developing the proper inputs to such a model. My goal in this section of my testimony, pursuant to my understanding of the Staff's request, is to go beyond the theoretical discussions previously presented in this proceeding by providing tangible illustrations that explain why the concepts described by Mr. Joseph Gillan on behalf of the Florida Competitive Carriers Association and Dr. August Ankum on behalf of AT&T and MCI WorldCom are relevant and appropriate if the experiment in local competition contemplated by the 1996 Act is to result in consumer benefits in Florida.

Section II of my testimony describes, at a "nuts and bolts" level of detail, how a cost model that calculates forward-looking economic costs should (and ultimately, must) operate and how inputs to that model should be developed.

SECTION I: WHY THE CALCULATION OF FORWARD-LOOKING ECONOMIC COSTS MUST BE PERFORMED IN THE MANNER DESCRIBED BY MR. GILLAN AND DR. ANKUM IF THE OBJECTIVES OF THE 1996 ACT ARE TO BE MET.

Q. DOES AN EFFECTIVE APPLICATION OF THE APPROPRIATE CONCEPTUAL FRAMEWORK DEPEND ON A CLEAR AND DETAILED ARTICULATION OF THAT CONCEPTUAL FRAMEWORK?

A. Having been involved in 28 arbitrations between ILECs and potential CLECs, 10 generic cost proceedings, 10 section 271 proceedings, and 6 universal service proceedings to date, I believe that the answer to this question is an emphatic "yes." This is clearly an issue for which the correct "answer" can only follow from a clear articulation of the right "question." Unfortunately, the strategies employed by the ILECs in many of these proceedings have been to pose the salient question in a way that is both muddled and misleading (unintentionally or otherwise).

There is general agreement among the parties here in Florida that some calculation of "economic costs" should form the basis for the prices to be established for UNEs (and combinations of those UNEs). Where the parties diverge is on the question of whether, and to what extent, the characteristics of the ILEC's embedded network and operations should function as constraints when developing these so-called "economic costs." The ILECs attempt, to varying degrees, to include embedded characteristics in the development of these costs (ILECs have often actually sought to include embedded characteristics in the development of the costs that they label as "TELRIC," and then seek an explicit embedded add-on), while the CLECs generally argue (correctly, in my opinion) that embedded characteristics should not -- and cannot if the objectives of the 1996 Act are to be met -- be a part of the relevant cost development process.

Q. BASED ON YOUR EXPERIENCE, HOW SHOULD THE QUESTION BE POSED SO THAT THE CONCEPTUALLY CORRECT ANSWER CAN BE APPLIED IN THE COST STUDIES?

A. I think that the following articulation of the problem may be helpful: For the geographic area being studied, what is the cost that a provider of the functionalities in question would incur going forward, if it had historically operated subject to the constraints of competitive market forces?

Of course, the costs identified should reflect geographic differences in cost, should those differences exist within the area being studied. Cost models (and the process of selecting inputs to those models) which successfully provide an accurate response to the question as I have posed it, would produce cost-based prices for UNEs that would comply with the FCC pricing rules and would allow the objectives of the Act to be achieved.

It is also useful to state, to the extent possible, what is *not* the salient question. This should not be an exercise in the determination of costs and rates that will make the ILECs "whole" in the face of competition, and it is not a method to allow them to recover the costs that would be recoverable under rate of return regulation. In addition, in spite of the red herrings typically offered, properly-developed TELRIC is not an exercise in costing "networks built in a day," or "networks that could never exist." While the process will inevitably require some educated estimation - - by definition, it seeks to calculate what costs would be *if* the ILECs had been operating in a different environment, which clearly must depart from historical, embedded costs - - it is not an exercise in the development of meaningless hypotheticals that the ILECs typically claim it to be. Even the ILEC TELRIC studies reject certain aspects of embedded network configurations and operations. The problem arises from the ILECs' failure to apply this principle uniformly across all network functionality.

Q. CAN YOU POINT OUT FOR THE COMMISSION AND STAFF AN EXAMPLE OF THE TYPE OF CARRIER WHOSE COSTS YOU BELIEVE SHOULD BE EMULATED; I. E. AN EFFICIENT ILEC WHOSE FORWARD-LOOKING COSTS ARE UNCONSTRAINED BY ITS PAST OPERATION AS A REGULATED MONOPOLY AND REFLECT, INSTEAD, THE CONSTRAINTS OF A COMPETITIVE MARKET?

A. No, no one can. By definition, such a carrier does not currently exist. The ILECs have, for most or all of their history, operated as regulated monopolies. As such, their operations have not been subject to the pressures to innovate, to maximize efficiency, and minimize cost that are the hallmarks of competitive markets.

Q. WHY IS IT APPROPRIATE TO HOLD THE ILECS TO A COST STANDARD FOR A CARRIER THAT DOESN'T EXIST?

A. There are three primary reasons. First and foremost, it is the law. Second, and equally important, the application of such a standard is necessary if Florida consumers are to receive benefits from competition for local exchange services. Third, there is no reason why the ILECs could not have innovated, maximized efficiency, and minimized costs as though they were operating in competitive markets. Forcing the UNE rates charged by ILECs to meet this standard now does not constitute the imposition of an unreasonably strict standard, but merely forces them to meet a standard which is the norm for most businesses nationwide. I will explain both of these reasons in detail.

Q. YOU STATED THAT THE APPLICATION OF THE COST STANDARD YOU DESCRIBE IS ESSENTIAL IF COMPETITION FOR LOCAL EXCHANGE SERVICES IN FLORIDA IS TO BE POSSIBLE AND PROVIDE CONSUMER BENEFITS. WHY IS THIS THE CASE?

A. It is my personal view that the "consumer benefit" argument has been overused in these proceedings; clearly all carriers will seek to operate profitably in the local exchange market and will make "consumer benefit" arguments in support of those goals. The linkage between the costing methodology to be applied when establishing rates for UNEs and combinations of UNEs and any ultimate consumer benefit is inescapable, however.

The objective of the federal Act is to generate benefits for consumers by introducing competition into the markets for local exchange services. This goal can only be met if UNEs are made available to competing carriers at prices that will compensate the ILECs *only* for the costs of an efficient carrier. Costs that are artificially inflated to include recovery of embedded costs or other inefficiencies within the ILEC's operations are inconsistent with the competitive market standard. At no point does the federal Act contemplate "rewarding" the incumbent LECs for being inefficient, yet that is exactly what the ILEC pricing proposals for UNEs would do. In addition, the ILEC pricing proposals threaten the development of competition. Potential competitors who are efficient enough to compete with the ILEC if UNEs are priced appropriately may be unable to compete at all if UNEs are priced at higher levels. The speed and success of a CLEC's market entry (and ultimately whether it will enter at all in a given area) will depend on whether a business case can be made to do so. Inflating the price of UNEs above the level of forward-looking economic cost of an efficient competitor -- even slightly -- will have an impact on the speed and scope of competitive local entry.

Equally important for consumers is the fact that even if new entrants can find a way to compete at some level with excessive UNE prices, these inflated "wholesale" rates will inevitably lead to inflated "retail" rates. Short of duplicating the ILEC's ubiquitous local network (the kind of scenario that the federal Act is specifically designed to prevent), competitors will have no choice but to purchase UNEs, both separately and in combination, in order to offer services to consumers. The price paid to the ILEC for these UNEs is a direct cost to competitors that cannot be avoided and must be included in retail rates. While competitive market forces will exert a continuous downward pressure on rates, no market force can push rates below direct cost. As a result, the price floor for retail local exchange services will be artificially high if UNE rates are set above forward-looking economic cost.

For Florida consumers, if UNE rates are set artificially high, two scenarios are possible, both of then rather bleak. First, if competitors do enter the market, they will be offering retail prices that (because of the inflated UNE prices) remain artificially high. Instead of having a "choice" of one provider for their local exchange service, consumers will have a "choice" of several providers offering the same inflated rates, reflecting costs associated with the ILEC's embedded network. Other than the brief moment of satisfaction that some end users may experience as a result of the mere act of switching providers, their only benefit that consumers would receive from competition is the chance to pay the same rate to a different provider. In the second scenario, the ILEC exercises its market position and perpetuates a price squeeze on its competitors, thereby limiting or eliminating their presence and preventing entry by potential competitors. In this case, the only benefit that consumers would receive from this failed attempt at the introduction of competition would be the ability to continue paying the same rate to the same provider (assuming that price caps remain in place that prevent price increases).

While the end result for consumers is effectively the same under either scenario, it is also important to realize that the end result for the ILECs is they will be effectively shielded from competitive market forces and will continue to be able to recover their embedded costs, regardless of how inefficiently they are incurred. The ILECs will win just as surely as consumers will lose.

Q. PURSUANT TO YOUR COST STANDARD, THE ILECS WOULD ONLY BE ABLE TO INCLUDE IN THE PRICES FOR UNES THE LONG-RUN COSTS THAT WOULD BE INCURRED BY AN EFFICIENT CARRIER TO PROVIDE THESE NETWORK FUNCTIONS; *I. E.*, THE COSTS THAT THE ILEC WOULD INCUR ON A FORWARD-LOOKING BASIS IF IT HAD HISTORICALLY OPERATED SUBJECT TO THE CONSTRAINTS OF A COMPETITIVE MARKETPLACE. PRIOR TO THE IMPLEMENTATION OF PRICE REGULATION FOR PRICE CAP ILECS AND UNTIL THE PRESENT FOR ALL OTHERS, THESE COMPANIES HAVE BEEN SUBJECT TO RATE OF RETURN REGULATION BY THIS COMMISSION. WHY WOULD THEIR EMBEDDED COSTS BE HIGHER THAN THE RELEVANT FORWARD-LOOKING COSTS?

A. Because even with close Commission oversight, rate of return regulation does not duplicate the effects of a competitive market. Over time, the regulated company's costs associated with network investments and company operations can be expected to diverge -- potentially significantly -- from the costs that would be experienced by a company providing the same services in a competitive environment.

Properly administered, rate of return regulation applies certain forces to the regulated firm in a way that influences its behavior. The stated objective, of course, is to duplicate -- to the extent possible -- the forces that would be exerted on the firm by a competitive marketplace. While for many years rate of return regulation was considered to be an acceptable surrogate for competitive market forces, there is a general consensus that it does not perfectly duplicate these forces. In reality, there is little debate that rate of return regulation creates incentives for the regulated firm that would not be present in competitive markets, and conversely fails to create some key incentives that competition does create. These differences will, over time, cause the regulated company to operate with a very different base of assets and with a different level of company operations than a similarly positioned competitive company. In short, there are different incentives faced by a firm regulated by rate of return regulation and a firm "regulated" by competitive market forces.

As a result, transition from regulated to effectively competitive environments has resulted in significant price reductions for consumers. Experience bears this out. In *Economic Deregulation and Customer Choice: Lessons for the Electric Utility Industry*, Robert Crandall and Jerry Ellis looked at the experiences of the gas, long-distance telecommunications, airline, trucking, and railroad industries. They found that "[w]ithin 10 years, prices were at least 25 percent lower, and sometimes closer to 50 percent lower. . . consumers gained substantially - - not just because of rate reductions, but also because of improvements in the quality of service. All broad consumer groups shared in the price reductions, though some benefited more than others."

Q. PLEASE DESCRIBE THESE INCENTIVES AND EXPLAIN WHY THEY ARE DIFFERENT.

A. A key question to be addressed by any regulator seeking to establish prices for UNEs (and combinations of those UNEs) is the following: What are the differences between the network investments and level of company operations embedded in the ILECs today and the network investments and level of company operations that would be present if ILEC had historically operated in a competitive environment? The difference represents inefficiencies that should not be borne by new entrants or end users. As described above, the prices charged by the ILEC for UNEs become part of the costs of doing business for competitors. If these UNE rates are inflated (by including embedded costs, for example), competitors will be forced to pay for this inefficiency and pass it along to their customers. Under such a scenario, competitive market forces will be unable to protect consumers and an artificially high price floor will be established for local exchange service rates, if competition develops at all.

I would like to focus on the following key differences between rate of return regulation and competitive market forces as "regulators" of a firm's behavior:

There are significant differences in the availability and use of information. During a general rate case, the Commission and its Staff must rely on information obtained from the regulated company. This information is then used by the Commission in its attempt to duplicate competitive market forces (by disallowing certain costs, for example). An important characteristic of this arrangement is that the regulated company has no inherent interest in limiting costs, but does so only because it is instructed to do so. The Commission must issue those instructions based on the information that it has obtained from the company. In contrast, a company operating in a competitive market faces continuous market pressures for cost reductions, and is highly motivated to reduce costs. Unlike the Commission, which is constrained by the limited information that it has been able to collect, the company and its managers have unlimited access to information regarding the company's operations. As a result, the company will always have a greater *ability* to reduce its costs than a regulator will have. The question of course, is whether it will have the *incentive*. A regulated monopoly will not have such incentives, while a competitive firm will constantly be in a position of acting on such incentives in order to be successful. Over time, even closely regulated companies will have cost structures and levels that are different from those that could be maintained in a competitive environment.

A rate of return regulated company will substitute capital for labor in order to maximize rate base. These incentives for "gold plating" in a rate of return environment are generally understood and well documented. Even if closely regulated, a regulated firm will, over time, develop an asset base that is larger than would exist in a competitive environment. In addition, this aspect of rate of return regulation creates a disincentive for the regulated company to invest in new, lower cost, technology as it becomes available.

Rate of return regulation permits full recovery of prudent investments, even if they are technically obsolete and do not represent the lowest cost technology. This characteristic of rate of return regulation represents a primary source of the difference between the ILEC's embedded costs and the costs that would be incurred by an efficient provider. When operating pursuant to rate of return regulation, a company is permitted to recover a "return on" and "return of" capital for all investments that are considered by the regulator to be prudent when made. In other words, if a regulated company purchases an asset that represents a prudent investment at the time it is made, the company is entitled to the opportunity to recover the cost of the asset over a reasonable depreciation life and to earn a specified return on that investment. This "protection" for the regulated company is obtained as a tradeoff for the limitation applied to the return that it earned on the investment.

Competitive markets are not so generous, however. When a company operating in a competitive environment invests in an asset, it does so at its own risk. There is no guarantee that the company will recover the cost of the asset over the depreciable life that it predicts (a "return of" capital), or that it will have the opportunity to earn a given rate of return (a "return on" capital). This distinction becomes extremely important in an industry, such as telecommunications, in which technological change is occurring rapidly. If a competitive firm invests in an asset today and that asset becomes technically obsolete tomorrow, the competitive firm will not have an opportunity to recover the cost of the asset or to use it to generate a return. Instead, the competitive firm must invest in the new technology in order to be able to offer service to consumers at the lower price or improved quality made possible by the technical innovation (if it does not invest in the new technology, its competitors will; in doing so they will gain a competitive advantage in terms of price and/or quality). A typical scenario is that the firm will "write down" those assets, thereby removing them from its books of account, before they are fully depreciated. In this scenario, the owners of the firm, not the customers, pay for the obsolete asset. Conversely, if a company guesses “right” about new technology, it has an opportunity to gain a significant short-term advantage over its competitors and to earn, in the short-run, significant profits that its competitors do not. This creates the pressure to innovate. Companies that guess right more often than the rest of the market, and who operate efficiently, succeed. Companies that fail in one of these areas are eventually forced out of the market.

In contrast, if a company that is rate of return regulated makes a similar investment, it will continue to have the opportunity to recover the cost of the asset -- plus a reasonable return -- from customers. As long as the acquisition of the asset was prudent at the time it was made, the regulated company will be given the opportunity to recover the cost of the asset over its projected depreciable life and will have no incentive to invest in the new technology or to retire the obsolete technology. Over time, the asset base of the regulated company deviates further and further from the asset base of an efficient competitive provider.

Q. WHY IS THIS DIVERGENCE OF THE ASSET BASE OF A REGULATED MONOPOLY AND A COMPETITIVE FIRM RELEVANT TO AN EVALUATION OF THE APPROPRIATE METHODOLOGY TO BE UTILIZED TO DEVELOP UNE COSTS?

A. The existence of this divergent in the base of assets explains why certain cost models previously presented by the ILECs cannot be used to develop appropriate costs for UNEs. BellSouth's loop cost model, for example, assumes the existing network configuration as a starting point, and makes minor modifications in order to reflect "forward-looking" characteristics. By doing so, the model assumes that, except for these minor modifications, the base of network assets currently being utilized by BellSouth in Florida is that same as the base of assets that it would be using if it had historically been subject to competitive market forces. There is absolutely no basis for such an assumption. To the contrary, for each of the reasons described above there is every reason to assume that the existing, embedded base of assets would *not* be in place if competitive market forces instead of regulatory incentives had controlled the evolution of BellSouth's network.

For this reason, cost studies presented by the ILECs in Phase II cannot use existing network configurations (even with minor adjustments) as a starting point for the development of UNE costs.

Q. IN HIS REBUTTAL TESTIMONY, BELLSOUTH WITNESS VARNER ARGUES THAT BELLSOUTH BELIEVES THAT IT -- OR ANY OTHER COMPANY -- MUST RECOVER THESE EMBEDDED (WHAT HE REFERS TO AS "ACTUAL") COSTS, AND THAT IT IS THEREFORE APPROPRIATE TO INCLUDE THEM IN UNE RATES. DO YOU AGREE?

A. No. The perception by certain ILEC employees that a company must recover all of its embedded costs (including the cost of obsolete assets) in order to remain financially viable or to make a "profit" is apparently the result of having operated for too long in a rate of return environment. While operating within the protected environment of rate of return regulation, the ILECs were indeed given the opportunity to recover costs associated with obsolete technology (as described above, the opportunity for such recovery is an inherent characteristic of rate of return regulation and is unrelated to the level of oversight exercised by the Commission and Staff). During this same period of time, companies operating in the competitive world made investments, took their chances, and when necessary invested in new lower cost technologies even when existing assets were not fully depreciated. These obsolete assets were written off the books and in effect paid for by the shareholders, rather than customers, of the company. Those shareholders have often been rewarded with a higher stock price, as Wall Street analysts have interpreted the acquisition of new technology as a sign that operating costs will decrease and earnings will increase.

Q. SINCE THE ILECS OPERATED PURSUANT TO RATE OF RETURN REGULATION EXERCISED BY THIS COMMISSION, SHOULDN'T THEY BE "MADE WHOLE" BY INCLUDING THESE EMBEDDED COSTS IN THE RATES FOR UNES?

A. No. When operating pursuant to rate of return regulation, the ILECs accepted restrictions on their earnings in exchange for the protection offered by this form of regulation (including the recovery of the costs of all embedded assets). By electing to operate under alternative regulation (and therefore to no longer be subject to rate of return regulation), some of the ILECs have gained freedom from the limitations on their earnings, but have also given up the protection afforded it by rate of return regulation. These ILECs should not be permitted to simultaneously receive the benefits of alternative regulation and the protection of rate of return regulation.

Q. THE ILECS OPERATE AS CARRIERS OF LAST RESORT WITHIN THEIR RESPECTIVE OPERATING TERRITORIES. DOESN'T THIS OBLIGATION CAUSE THEIR EMBEDDED BASE OF ASSETS TO BE DIFFERENT (AND LARGER) THAN THAT OF A FIRM OPERATING IN A COMPETITIVE MARKETPLACE?

A. No. The ILEC's carrier of last resort ("COLR") obligation is a distinct and separable issue from the question of whether the assets used to provide service reflect operation under rate of return regulation or the constraints of a competitive marketplace. As COLRs, the ILECs may have served areas (and invested in the network assets to do so) that it would chosen not to serve absent such an obligation. In other words, the ILECs today may be serving high cost areas that they would prefer -- from a business standpoint -- not to serve given the current revenue streams available. The event that revenues generated from services provided to a given area may be insufficient to cover cost is a universal service fund issue. The relevant question, however, is what base of assets would the ILEC be using on a going-forward basis to serve both the high cost and other areas of its operating territory if it had been subject to the constraints of a competitive marketplace and, therefore forced to serve all of these areas as efficiently as possible? It is possible that COLR obligations could be met using a different base of assets depending on whether rate of return regulation or market constraints are applied. While UNE costs should reflect the ILEC's cost of serving any high cost areas created by a COLR obligation (and should be geographically deaveraged to reflect such cost differences), the cost used to establish UNE prices in all areas should reflect the costs of a carrier that has operated pursuant to competitive market forces.

Q. HAS THE COMMISSION (AND STAFF) PREVIOUSLY ADDRESSED THE ISSUES OF EMBEDDED COST RECOVERY IN UNE RATES?

A. Yes. In Order No. PSC-98-0604-FOF-TP, issued April 29, 1998 in Docket Nos. 960757-TP, 960833-TP, and 960846-TP, the Commission concluded that BellSouth's attempt to recover embedded costs through the residual revenue requirement ("RRR") in its proposed rates for UNEs was inappropriate in a forward-looking cost model. (Order at 64). The Commission agrees with AT&T/MCI that by including the RRR in some of its proposed rates, BellSouth appears to desire to be made whole as if it were a rate of return regulated company, while enjoying the benefits of price regulation. (Order at 64). Moreover, the Commission concluded that past COLR investment should not be included.

The question then becomes the following: if it is inappropriate for BellSouth or other ILECs to be "made whole" by permitting the recovery of embedded costs through UNE rates, is it nevertheless appropriate for BellSouth or other ILECs to be made even partially "whole" by permitting UNE rates that are above the level of forward-looking economic costs (yet below the level of complete embedded cost recovery)? It seems clear that the rationale for excluding the total amount of embedded costs from UNE rates would also support the exclusion of any portion of those embedded costs. If BellSouth and other ILECs are permitted to use cost models that carry forward existing network configurations (even as a "starting point") and to include in their studies inputs to those models that reflect historic operating characteristics, the result can only be UNE rates that are -- at best -- "partially embedded." Unfortunately, even such partially embedded costs and cost-based prices will have the same anticompetitive and anticonsumer consequences described previously in my testimony. As I explain in detail in the following section of my testimony, the cost studies performed to develop rates for UNEs and UNE combinations must be limited to long-run, forward-looking economic costs; the costs that would be incurred on a forward-looking basis if the ILECs had historically operated pursuant to competitive market forces. This limit must apply to both the operation of the cost models and to all inputs to forward-looking models.

SECTION II: THE DEVELOPMENT OF COST MODELS AND INPUTS THAT LIMIT COSTS TO THOSE THAT WOULD BE INCURRED ON A FORWARD-LOOKING BASIS IF THE ILECS HAD HISTORICALLY OPERATED PURSUANT TO COMPETITIVE MARKET FORCES.

Q. WHAT SPECIFIC CRITERIA SHOULD THE COMMISSION APPLY WHEN EVALUATING COST MODELS?

A. No cost model -- no matter how sophisticated, detailed, easy to use, or verifiable -- can produce useful results if the underlying methodology is inappropriate for the task at hand. Specifically, a forward-looking economic cost methodology must incorporate the following assumptions:

1) **Investments must be forward-looking and based on a long run assumption.** For this purpose, long run is defined as being a sufficient period of time such that all costs are considered avoidable or variable. Consistent with this assumption, investment assumptions should take into account the geographic and demographic characteristics of the area being studied, but should not be constrained by the characteristics of embedded facilities or equipment.

2) **The costs of operating the company (so-called overhead or shared and common costs) must likewise be forward-looking and based on a long run assumption.** Consistent with this assumption, these costs should be constrained by the tasks that must be performed, but should not be constrained by the historic level of such costs or the methods and practices currently in place.

3) **Forward-looking investment and operating cost assumptions must be consistent.** For example, if investments are calculated assuming installation of state-of-the art equipment, then operating costs should reflect the reduced manpower generally required to operate such equipment.

4) **Investment assumptions and demand assumptions must be properly matched.** If investment sufficient to serve existing demand is studied, then the current demand should be assumed. If investment sufficient to serve a future level of demand is assumed (*i.e.*, investments are sized for growth), then that future level of demand units must be assumed. This principle has significant implications for the selection of the appropriate "fill factors" to be applied in a cost model. A mis-match of investment sized for growth and a current demand assumption will lead to (potentially significantly) overstated

costs.

Of course, even a cost model that applies the appropriate methodology can be otherwise flawed. Any cost model adopted for use by the Commission to develop cost-based prices for UNEs - - and combinations of UNEs - - should possess the following characteristics:

1) **Cost models must produce results that are meaningful in the context of the task at hand.** In order to develop costs to support UNE rates that reflect geographic cost differences or to determine the needed amount of universal service funding, a cost model must be capable of accurately capturing the cost effects of operating in different geographic areas. Similarly, in order to develop costs to support rates for UNEs that will be purchased both separately and in combination, a cost model must be capable of accurately reporting the costs of functions in both isolation and in combination.

2) **Cost models must make the appropriate trade-off between sophistication and complexity.** While a model must be sophisticated enough to develop the cost detail necessary for the task at hand, it should not be more complex than is necessary to do the job.

3) **Cost models must maintain the necessary degree of**

accuracy. They must be populated with accurate inputs and the calculations and algorithms must be based on sound and generally accepted engineering practices.

4) **Cost models must permit review and verification by the Commission and other interested parties.** Models should be open and easy to use and understand. In addition, models should have a history of validation using an open and understandable process.

Q. YOU STATED THAT A COST MODEL MUST BE ABLE TO CALCULATE THE COST OF UNES PROVIDED IN COMBINATION. DO THE COST MODELS PREVIOUSLY SUBMITTED BY THE ILECS MEET THIS REQUIREMENT?

A. No. The rates based on the results of an appropriate model will permit competing carriers to purchase UNEs -- either separately or in combination -- and to pay a rate that will fully and fairly compensate the ILEC without requiring the CLEC to pay for network facilities or equipment that it will not use.

BellSouth's cost models in prior cases, for example, have failed this requirement in several respects. First, BellSouth has not costed even the most essential combinations of network elements. For example, BellSouth has produced a cost for a local loop and a switch line port, but has not produced a study of the cost of a loop connected to a BellSouth switch (as it would be if these UNEs are purchased in combination). Because of the way in which it has conducted its studies of the individual elements, simply adding BellSouth's proposed cost for an unbundled loop to its proposed cost for an unbundled line port will result in a total cost that exceeds the forward-looking costs of providing these elements in combination. Similarly, BellSouth has not developed a cost for a local loop and transport facility (the so-called "extended loop"). BellSouth's failure, to date, to provide the cost of even these most obvious UNE combinations is clear: its cost models are constructed in a way that make it impossible for BellSouth to accurately calculate the cost of UNE combinations.

Second, BellSouth's assumptions that UNEs will only be purchased individually and not in combination has caused it to further overstate the cost of individual UNEs. For example, BellSouth has improperly included an analog interface in its cost for unbundled loops provisioned using Integrated Digital Loop Carrier ("IDLC"), even though those loops terminate directly on a switch without the need for analog conversion.

Third, BellSouth typically has assumed in its studies of nonrecurring costs that the service orders that it is asked to process will be for orders of individual elements purchased separately, and not for combinations of elements. As a result, BellSouth ignores the cost savings that it will experience when processing these orders and overstates these nonrecurring costs.

These shortcomings in the BellSouth models are cited here to be contrasted with the characteristics of an appropriate cost model. Specifically, any cost model produced in Phase II and ultimately used by the Commission should permit calculation of the cost of UNEs purchased *either* separately or in combination, and *accurately* reflect the different costs incurred by the ILEC when such a purchase is made. The pricing of UNE combinations is not a simple matter of summing the rates for individual elements. This capability must extend to both recurring and nonrecurring costs.

Q. WHAT ARE THE MAJOR STEPS THAT A RECURRING COST MODEL MUST TAKE TO CALCULATE THE COST THAT A PROVIDER OF THE FUNCTIONALITIES IN QUESTION WOULD INCUR GOING FORWARD, IF IT HAD HISTORICALLY OPERATED SUBJECT TO THE CONSTRAINTS OF COMPETITIVE MARKET FORCES?

A. In order to develop cost-based UNE prices that conform to sound economic principles, the requirements of the federal Act, and the FCC's pricing rules, a cost model must accomplish the following four tasks:

1) Accurately locate the ILEC switching locations;
2) Accurately locate the customers;
3) Accurately determine the relationship between the customer locations (*i.e.*, determine where groupings of customers exist) and between

these groupings of customer locations and the switching locations;

4) Accurately determine and locate the total level of demand to be modeled; and

5) Design a forward-looking, efficient network that connects the customers to the switching locations, and the switching locations to each other, that is unconstrained by the embedded network design except for the location of switches.

The challenge is to perform these four tasks without allowing the ILEC's embedded characteristics to creep into the process.

Q. PLEASE DESCRIBE HOW THIS SHOULD BE ACCOMPLISHED.

A. The first step in developing a TELRIC model as outlined above is dictated by the FCC's First Report and Order. The FCC determined that cost proxy models "should be based on costs that assume that wire centers will be placed at the incumbent LEC's current wire center locations, but that the reconstructed local network will employ the most efficient technology for reasonably foreseeable capacity requirements." (FCC 96-325, 08/08/96, para. 685). Information on current wire center locations can be obtained using the Local Exchange Routing Guide ("LERG").

The second step of accurately locating the customers geographically is a much more difficult process - - not because one is employing a cost proxy model, but because ILECs do not currently possess data on the geographic locations of their customers. Ideally, this information would contain the exact latitude and longitude for each ILEC customer in Florida. Because this information is often not available, all cost proxy models must estimate these locations based on the best data available. Cost models, to date, have used two primary methodologies to develop these customer locations. Both methodologies start with estimates of customer locations by census blocks (a unit defined by the U.S. Bureau of the Census) and then attempt to assign each customer to a geographic location within the census block. The first methodology, called geocoding, assigns latitude and longitude coordinates to actual street addresses. In other words, a program matches addresses of Florida residents to a database that contains information on the roads and streets in Florida. This process most reliably assigns known customer addresses to actual, physical locations. The second methodology does not attempt to identify actual geographic locations for each customer, but instead assigns proxy locations to them. This methodology is most commonly implemented by evenly distributing customers along the road networks in a Census Block. The geocoding methodology is clearly more accurate, because it attempts to accurately capture the dispersion of customers within a census block, rather than simply assuming that those customers are spaced as far away from each other as possible along the road network. Since the geocoding can not currently identify a geographic location for all customers, it needs to be used in conjunction with a surrogate methodology.

Such an approach is consistent with the FCC's tentative conclusion in its May 28, 1999 Further Notice of Proposed Rulemaking that although

> geocode data should be used to locate customers in the federal mechanism, we tentatively conclude that at this time we cannot adopt any particular source of geocode data because interested parties have not had adequate access or time to review such data. We tentatively conclude below that a road surrogate algorithm will be used to locate customers in the federal mechanism until a source of geocode data is selected by the Commission. We reiterate our expectation, however, that we will identify and select a source of accurate and verifiable geocode data in the future for use in the federal mechanism. (FCC 99-120, 05/28/99, para. 25)

The third step - - accurately determining the geographic relationship between individual customer locations, and between groups of customers and the wire centers that serve them - - is critical to the design of a forward-looking TELRIC model. The objective of this step is to group customers into efficient "serving areas" that will allow telecommunications traffic to be concentrated for movement over high-volume feeder plant to the relevant wire center. This process is similar to the process used in any distribution network, such as airline terminals and local highways. This involves using smaller roads, air routes, or distribution cables to reach the end user. Traffic is then aggregated at collection points to allow much higher volumes of traffic to travel together in a more efficient manner to major switching hubs. In local telephone networks, this point of aggregation is at the serving area interface (or feeder distribution interface), the location where the traffic on distribution facilities is aggregated and transported through feeder facilities. The object of this part of the cost modeling process is to create serving areas that are efficient, resulting in the lowest cost design of facilities consistent with engineering requirements.

I agree with the FCC's conclusion that

> a clustering approach, as first proposed by HAI in this proceeding, is superior to a grid-based methodology in modeling customer serving areas accurately and efficiently … The advantage of the clustering approach to creating serving areas is that it can identify natural groupings of customers. That is, because clustering does not impose arbitrary serving area boundaries, customers that are located near each other, or that it makes sense from a technological perspective to serve together, may be served by the same facilities. There are two main engineering constraints that must be accounted for in any

> clustering approach to grouping customers in service areas. Clustering algorithms attempt to group customers on the basis of both a distance constraint, so that no customer is farther from a DLC than is permitted by the maximum distance over which the supported services can be provided on copper wire, and on the basis of the maximum number of customers in a serving area, which depends on the maximum number of lines that can be connected to a DLC remote terminal. (FCC 98-279, 10/28/98, para. 42 & 45)

The fourth step is the process of designing a forward-looking, efficient network that connects the groups of customers to the switches and the switches to each other. This step requires the application of a combination of engineering guidelines and cost-minimization techniques. I believe that the FCC has taken a reasonable approach to solving this problem in selecting the procedure used in the FCC Staff's Hybrid Proxy Cost Model (HCPM). Specifically, the FCC states:

> We conclude that HCPM's outside plant design algorithms best meet the criteria developed in the Universal Service Order, including the requirement that the technology assumed in the model is the "least-cost, most-efficient, and reasonable technology for providing the supported services." We

therefore conclude that the federal mechanism should incorporate HCPM's outside plant design algorithm. (FCC 98-279, 10/28/98, para. 54)

In adopting the HCPM outside plant design algorithms, the FCC incorporated the design objectives of the HCPM, which are:

> (1) to provide a loop design based on sound engineering principles that meets all of the performance criteria specified by the Federal-State Joint Board on Universal Service, or by the user, (2) to allow the model to endogenously determine the appropriate mix of forward-looking technologies to meet this design standard on the basis of cost minimization, and to include explicit optimization routines to approximate the cost minimizing solution, and (3) to accomplish the above in a flexible modular design that can be easily adapted to alternative applications of the model. (The Hybrid Cost Proxy Model Customer Location and Loop Design Modules, December 15, 1998, pages 3-4)

Specifically, the FCC's cost proxy model calculates the cost of connecting the customer to the switch using a variety of methods, and selects the most forward-looking, efficient network to accomplish this goal. For example, the

> HCPM uses an algorithm developed for network planning purposes in both its feeder and distribution segments. This algorithm selects a feeder or distribution routing network by weighing the relative benefits of minimizing total route distance (and therefore structure costs) and minimizing total cable distance (and therefore cable investment and maintenance costs.) HCPM also selects technologies (e.g., fiber vs. copper, aerial vs. buried) on the basis of annual cost factors that account for both operating expenses and capital expenses over the expected life of the technology. (FCC 98-279, 10/28/98, para. 64)

I agree with the FCC that the network and design criteria, as laid out in the HCPM documentation, incorporate the appropriate methodology for use in developing the cost of UNEs. Specifically, the FCC's model ensures that the UNE rates are not based on the embedded characteristics of the ILEC's existing network.

Q. ONCE AN APPROPRIATE MODEL IS IDENTIFIED, HOW SHOULD CONCEPTUALLY CORRECT INPUTS BE DEVELOPED?

A. Inputs must be developed that are consistent with the methodology being applied and with the operation of the cost model into which they are being entered. I have divided the types of inputs that are necessary for the development of UNE costs into several categories: engineering parameters and constraints, material and labor prices, and operating costs. The development of inputs within each category is described separately below.

Q. WHAT ARE THE TYPES OF ENGINEERING PARAMETERS AND CONSTRAINTS THAT MUST BE CONSIDERED AS INPUTS TO A COST MODEL?

A. I will address three such inputs: fill factors, structure mix, and structure sharing. Each is discussed separately.

Q. ONE OF THE METHODOLOGICAL PRINCIPLES YOU DESCRIBED IS THE REQUIREMENT THAT INVESTMENTS BE SIZED CONSISTENTLY WITH THE LEVEL OF DEMAND ASSUMED IN THE STUDY. HOW IS THIS ACCOMPLISHED IN A COST STUDY?

A. Demand assumptions must be made correctly at two points in the cost study process. First, the costs associated with a forward-looking network design (and the operation of that network) must reflect the total demand on the network, including all wholesale and retail services. If this is done correctly, UNE costs and prices will reflect the economies of scale and scope enjoyed by the ILECs as required by the FCC pricing rules. This mechanism is necessary if CLECs are going to be able to enter the market and compete without first duplicating the scale and scope of the existing ILEC operations.

Second, investment and demand assumptions must conceptually match in order for meaningful results to be calculated. The most important mechanism for matching investment and demand assumptions is the correct application of "fill factors," based on assumed usage of "fill" rates for specific investments. Improperly applied fill factors can cause an otherwise properly conducted cost study to generate results that significantly overstate the economic cost of the UNE or service being studied.

Q. WHY ARE FILL FACTOR ASSUMPTIONS SO IMPORTANT?

A. All studies of the costs of either individual components of the telecommunications network or services which comprise combinations of those elements must apply the correct assumptions regarding the treatment of spare capacity placed for future growth. This assumption is most often applied as a fill factor representing the portion of the transmission facility (such as a cable in the distribution portion of the local loop, or fiber in an interoffice facility) or equipment (the remote terminal for a digital loop carrier system or the processor for a local switch, for example) that is expected to be in use.

An important principle that must be applied in all studies, including all studies of economic costs, is the principle of cost causation. Specifically, the study should include all costs, but only those costs, that are *caused* by the decision or requirement to offer the UNE or service being studied (the ILECs apparently endorse, but then do not apply, the principle of cost causation in their cost studies). A forward-looking economic cost study, therefore, will include the costs that would be caused by an efficient provider to offer the UNE or service. Since spare capacity in a facility or piece of equipment is a potentially significant cost to be addressed, it is important that this type of cost be treated in accordance with the principle of cost causation and other economic costing principles.

Q. WHAT ARE THE SOURCES OF SPARE CAPACITY?

A. Spare capacity has several different sources. Each of these types of spare capacity should be treated appropriately in a cost study.

First, some need for spare capacity arises from the need to perform administrative functions. This administrative need includes the need for extra capacity for maintenance and to account for defective facilities (bad pairs in a copper cable, for example). For this reason, the engineer's "target fill" or "fill at relief" -- the fill rate at which new capacity will be installed -- is almost always less than 100%. This form of spare capacity is directly caused by the UNE or service being studied and is properly included in a forward-looking economic cost study.

Second, some spare capacity is created by the fact that investments are lumpy; in other words, it may not be possible to purchase a facility that is exactly sized for the existing need. A need for 550 copper pairs may have to be met with a 600 pair cable, for example. This type of spare capacity is also appropriately included in a forward-looking cost study.

Third, spare capacity may be placed to serve future growth in the network. For example, the ILEC may decide to place sufficient capacity to serve not only all current customers but also all expected future customers in a given geographic area over some planning period. For the reasons outlined below, this type of spare capacity is *not* properly included in a forward-looking economic cost study.

Fourth, there is spare capacity that may exist because of an incumbent company's incentive to over invest when it was subject to rate of return regulation. This type of spare capacity should never be included in any cost study.

Of the four sources of spare capacity, it is the treatment of spare capacity placed for future growth that has proven to be primarily at issue. The ILECs generally seek to include the first three types of spare capacity in their cost studies (administrative, lumpy investment, and future growth) and may include some portion of the fourth. In contrast, the fill factors used in a properly performed forward-looking economic cost study include only the first two types (administrative and lumpy investment). This difference in the treatment of spare capacity placed for future growth represents a significant portion of the difference in cost results reported in prior CLEC and ILEC cost studies. By applying the fill factors that they have used in their studies, the ILECs are in effect requiring new entrants to pay for the ILEC's investment needed to serve both current and future customers. The practical effects of this approach have serious implications: the ILEC's costs to serve customers in the future will be paid for by its current competitors, the ILEC will be able to double recover its costs, and a significant barrier to entry will be created.

Q. PLEASE EXPLAIN HOW AN ILEC'S USE OF THE WRONG FILL FACTORS WILL HAVE THESE FAR REACHING EFFECTS.

A. The cost causation principle described above is a requirement for efficiency: the costs attributed to any given customer should be no higher than that customer actually causes. While an ILEC may elect to place facilities or equipment today in order to accommodate growth that may occur in the future, today's customers should not have to pay for costs that are *caused* by tomorrow's customers. UNE rates set at the level of the results of the ILEC's studies would have exactly this consequence.

This specific case of shifting costs from one set of customers to another (from future customers to current customers) is conceptually no different than any other improper shifting of costs between customers. For example, if the ILEC wants to offer broadband services, it may invest in the facilities to do so. The costs of these broadband facilities, of course, are *caused* by the customers of broadband services and should be recovered in the rates charged to them. It would clearly be inappropriate to shift those costs to other customers (purchasers of narrowband Plain Old Telephone Service, for example). It is likewise inappropriate to shift costs *caused* by future customers to current customers: future customers, like broadband customers, should pay for the costs that they cause.

In order to avoid this shifting of costs, it is important that spare capacity placed for future growth be treated correctly. It is *not* appropriate (and in fact is conceptually meaningless) to look at the total size of plant in place today (including capacity to serve both existing and future customers) and only the current level of demand in order to calculate the level of "fill" to be used in a cost study, yet this "apples to oranges" calculation is exactly what the ILECs have used in their cost studies. In order to perform this calculation on an "apples to apples" basis, it is necessary to calculate the level of fill by matching the size of the necessary facilities to serve current demand with current demand, or the size of the facilities placed to serve both current and future demand with the expected level of future demand.

Stated mathematically, the two options for correctly calculating fill are as follows (for illustrative purposes, these formulas are stated in terms of lines -- as they would be used when calculating the fill factor for a cable used in the loop or interoffice network. Other units, such as the units of processor capacity of a switch, would be used where appropriate):

1) Fill Rate = Current Working Lines / Total Lines Placed to Serve Current Demand, *or*

2) Fill Rate = Projection of Future Working Lines / Total Lines Placed to Serve Current and Future Demand

This second alternative is consistent with the requirement set forth by the FCC in the paragraph often cited by ILEC witnesses. Specifically, paragraph 682 of the FCC Order requires fill to be based on a "*reasonable projection* of actual fill." When applying its flawed methodology, the ILECs conveniently forget that the phrase "reasonable projection" was included in the FCC language for a good reason. As a result, the ILECs calculate fill according to the following flawed formula:

Fill Rate (BST) = Current Working Lines / Total Lines Placed to Serve Current and Future Demand

This is not a trivial oversight. By mixing and matching elements of two mutually exclusive options, the ILECs have reduced (often significantly) the level of the calculated fill. By underestimating the numerator, the ILECs' incorrect formula yields a lower percentage fill factor. Even small changes in the fill factor applied can have a significant impact on the cost calculated. For example, consider a facility costing $1000 to acquire and place ($1000 EF&I investment) having 100 units of capacity. With a fill rate of 85%, the calculated investment per unit for the facility will be $11.76. If the fill factor is lowered to 70%, the investment per unit increases to $14.28. As a result of using this flawed approach, the ILECs have significantly overstated the cost of providing UNEs.

Rates based on the results of the ILEC studies would also be discriminatory and therefore in direct violation of section 252 (d) (1) of the federal Act. In effect, the ILEC would be offering itself terms that are more favorable than those offered to its competitors. Under the ILEC methodology, new entrants would pay for the spare capacity to serve future customers, but never get to use this capacity that they have paid for. In contrast, the ILEC would have access to this spare capacity for future use, even though it had been paid for by its competitors. An example makes this problem clear: Assume that a competitor pays $20 per month to the ILEC for an unbundled loop, based on a cost study that used a fill factor based on the flawed formula described above. If the ILEC is using a fill factor that includes spare capacity for future use, the competitor is paying for the line being used and all or part of an additional line (if the ILEC is using a distribution fill factor that is significantly less than 50%, it is very possible that the rate paid by the competitor is recovering the cost of two full lines). Now assume that the end user customer wishes to purchase an additional line from the ILEC's competitor. The competitor would have to pay the ILEC an additional $20 to do so (thereby potentially paying for the cost of four lines).

No correction would be made for the fact that the competitor is now using some of the previously spare facilities *for which it has already paid*. In contrast, the ILEC could offer the second line for a very low price, because the competitor will have paid for the second line in the rate it paid for the first. Such an arrangement is discriminatory (the ILEC receives the second line at a cost that is much lower than the cost to an entrant) and creates the opportunity for a price squeeze.

In addition to gaining the ability to charge excessive and discriminatory rates, the error made by the ILECs when calculating fill factors also will permit them to recover their costs multiple times. If the spare capacity for growth and current demand are both used when calculating the fill factor to be used in the cost study (the ILEC's "apples and oranges" methodology), the costs of this spare capacity will be recovered in the rates charged to current customers (including both competitors and end users). When new customers enter the area and the expected demand growth takes place, the ILEC will use the previously spare capacity in order to serve those customers (that is why it was originally placed, after all). These future customers (or an ILEC competitor serving these new customers) will be paying the ILEC full rates for facilities for which the ILEC has already been fully compensated by current customers -- a classic case of double recovery.

In order to avoid this problem, the Commission must reject the flawed costing methodology that causes it: the ILEC's incorrect calculation of fill rates (and subsequent application of these flawed fill factors in their cost studies). The Commission should ensure that any costs that it uses to establish rates for UNEs (or for any other purpose) be determined by cost studies that properly mix investment and demand assumptions. In order to accomplish this, fill rates must be calculated using one of the two acceptable formulas described above and not with the ILEC formula that attempts to force together two mutually exclusive assumptions.

Q. CAN YOU PROVIDE AN EXAMPLE OF HOW THE COST MODELS PREVIOUSLY SUBMITTED BY THE ILECS INCORRECTLY MATCH INVESTMENTS AND DEMAND?

A. Yes. BellSouth, for example, is quite up front about the calculation error that it has made in previous studies. In a Georgia proceeding in Docket No. 7061-U, BellSouth witness Wayne Gray made it clear, for example, that BellSouth had calculated fill as described above: by considering capacity placed to serve both present and future customers juxtaposed with the demand of only current customers. Mr. Gray explained that BellSouth places facilities with spare capacity for future growth, yet calculates the fill factors used in its cost studies by simply dividing total capacity by existing demand. BellSouth witness Caldwell also stated in that proceeding that the current "average utilization level" was used in the previous BellSouth cost studies.

The contradictions in Mr. Gray's testimony reflect the contradictions inherent in BellSouth's fill factor calculation. For example, Mr. Gray correctly points out that all telecommunications plant should be placed "in a manner which minimizes the cost of doing so, whether you are talking about the actual cost of placing the plant, or the cost of carrying the spare capacity." There is certainly no disagreement on this point; the capacity that should be installed is a function of both placement costs and the costs of carrying additional capacity. All firms that must make significant capital investments face the same dilemma and must make the same calculation: there are costs associated with coming back and installing additional plant, but there are also capital costs associated with carrying extra capacity as an asset that does not currently produce revenue but which is expected to do so in the future. Specifically, the calculation to determine the efficient level of spare capacity to be placed compares the present value of the cost per unit over the life of the asset with the level of spare capacity in place with the cost of placing the plant to serve today's capacity without regard to growth and reinforcing that plant at exhaust (i.e. when the objective fill level, or fill at relief, has been reached).

After correctly identifying the tradeoff of costs associated with each scenario and the need for BellSouth to choose the approach with the lowest total cost (that is, the scenario with the lowest total of the stream of costs to be incurred over the life of the asset discounted back to the present; in other words, the scenario with the lowest cost expressed on a present value basis), Mr. Gray recommends that cost studies be performed with BellSouth's measure of what he calls "actual" fill: the mismatch of investment to meet current and future demand with current demand units. *The effect of the BellSouth calculation is to shift 100% of the carrying costs associated with spare capacity to its end user customers and competitors.* The tradeoff described so well by Mr. Gray in his testimony *will not exist* if the fill factors he recommends are used: it is impossible for BellSouth to compare the cost of two scenarios if the costs of one of the scenarios has been transferred to its customers and competitors. As a result -- if Mr. Gray's proposed fill factors are used in cost studies -- BellSouth (and any other ILEC) can minimize cost over time (the objective stated by Mr. Gray) by placing excess capacity and having others pay for it.

In fact, the ILEC would gain two distinct benefits under this proposal. First, as described above, the ILEC would gain the capacity necessary to serve future customers while having it paid for by its competitors (through UNE rates) and end user customers (through retail service rates). Second, the ILEC could place more capacity now than it projects to be needed to accommodate growth, and it could do so risk free. While companies operating in competitive markets must consider the risk that they will overdeploy capacity and ultimately pay carrying costs on capacity that never produces revenue, the ILEC would face no such risk. It could deploy capacity equal to twice, or ten times, or one hundred times its projected need, and the effect would be that its (inappropriately calculated) fill factors would fall, the per unit costs calculated by its cost studies would increase by a corresponding amount, and rates for UNEs and retail services would likewise increase. *The ILECs will be in a position to bet their competitors' and customers' money that a given level of capacity will be used in the future, while never putting a penny of their own at risk.* In summary, both the testimony of BellSouth witness Gray and the ILEC position regarding the calculation of appropriate fill factors contain an inherent contradiction that will result in significant benefits to the ILECs but significant peril for its competitors and other customers.

The Commission should ensure that the ILEC cost studies submitted in Phase II do not contain this fundamental error.

Q. HOW SHOULD INPUTS REGARDING THE STRUCTURE MIX BE DEVELOPED?

A. Telecommunications facilities can be placed on (or in) three general categories of structures: poles (aerial facilities), conduit (underground facilities), or directly in a trench (buried). Depending on the geographic characteristics and line density of the area being served, an efficient ILEC would probably use a mixture of these types of structures. Since the structure type assumption has a direct impact on the cost calculated, it is important to accurately determine the structure mix that would be in place on a going-forward basis, without the assumptions being constrained by the existing structure mix in an ILEC's embedded network.

The ILECs have argued that the forward-looking structure mix should be based on the existing structure mix, modified only by future plans for changes to this mix. Such a process improperly carries forward embedded characteristics and is inconsistent with the scorched node approach required by the FCC pricing rules. The correct approach recognizes that, over time, a carrier subject to competitive market forces may change the type of structure on a given route in order to take advantages of changes in the relative cost of structure types and to remain efficient. A carrier operating pursuant to rate of return regulation (and under pricing regulation if no effective competition is present) will face no real incentive to modify the structure type for a given facility. As a result, as with other network characteristics the structure mix of a regulated company and the structure mix of a company operating within the constraints imposed by competitive market forces are likely to diverge over time. For this reason, it is inappropriate to determine an efficient forward-looking structure mix by beginning with the embedded structure mix of the ILECs, even if an attempt is made to modify these embedded characteristics to make them forward-looking.

Q. HOW SHOULD STRUCTURE SHARING ASSUMPTIONS BE DEVELOPED?

A. Structure sharing assumptions are necessary to reflect the fact that providers of services other than telecommunications utilize similar (and sometimes identical) structures for the placement of their facilities. ILECs have, over time, engaged in a limited amount of sharing of these structures with other providers. The poles running along Capital Circle, for example, contain power, telephone, and at some points cable television facilities. There is little debate that sharing of structures occurs, and that it results in lower costs for each service provider sharing the structure.

The ILECs typically argue that forward-looking structure sharing percentages should be equal to – or only slightly different from – the existing percentages. As I understand it, the justification for this assertion has two parts: (1) the ILECs have engaged in structure sharing in the past, therefore the Commission should assume that they did so to the greatest extent possible, and (2) changing the structure sharing assumptions within a "scorched node" scenario inherently assumes that the networks of other service providers (power and cable companies, for example) are also being "scorched" as part of the exercise. Both of these justifications miss the point. First, there is absolutely no evidence or other basis for an assumption that the amount of structure sharing done in the past represents the maximum amount of sharing that was possible. As described in Section 1 of my testimony, a company operating pursuant to rate of return regulation would have had incentives to maximize rate base by placing its own structures, and little incentive to forego those assets in order to save money. As a result, there is no basis for an assumption that the historic level of structure sharing represents the amount of sharing that would have been undertaken by a company operating subject to competitive market forces. Second, a "scorched node" assumption does not mean that a network will be built overnight. As described in Section 1, the proper application of this assumption requires that a cost model (and the inputs to that model) accurately reflect the forward-looking costs of a company that has historically been subject to competitive market forces. A study of how the ILECs would have sought to share structures over time if they had been motivated to do so does not require a cost model to "scorch the power company." It does, however, require that costs be developed independently of the structure sharing percentages in the ILEC's embedded network.

Q. WHAT IS THE PROPER METHODOLOGY FOR DETERMINING THE MATERIAL AND LABOR PRICES THAT ARE USED TO DETERMINE THE COST OF UNES?

A. A fundamental assumption that must be applied in UNE cost studies performed pursuant to sound economics and the FCC rules is that the costs of material and labor used and inputs must reflect the full scale and scope of the ILEC's operations. The inputs must consider the ILEC's purchasing power that is created by the large scale of its projects and ongoing operations. It is clear that the ILECs receive discounts (many of them substantial) when acquiring material and labor.

The components that make up material and labor input assumptions are list prices, delivery costs, and purchasing discounts for material and work times time and wage rates for the labor component. These five elements are combined to develop the engineered, furnished, and installed (EF&I) cost of an asset. There are generally four methods that have been advocated for determining EF&I costs:

(1) Rely on expert opinion, and hire (presumably experienced) subject matter experts to estimate costs.

(2) Solicit bids from vendors and contractors and compile the information in order to develop accurate estimates.

(3) Survey competitive companies that have performed similar work.

(4) Review the ILEC's booked costs, and draw inferences to current and forward-looking costs based on this past experience.

Any process ultimately used to develop reliable and accurate forward-looking material and labor costs is likely to require some combination of the first three approaches. Subject matter experts, vendor bids, and competitive company reviews can and should all play a role in a comprehensive effort. The ILEC booked costs, however, do not provide an objective starting point for this effort.

Q. HOW SHOULD THE COST OF CAPITAL BE DETERMINED?

A. The cost of capital represents the annual rate of return expected by investors and debtors for providing the funding of the company's assets. The appropriate cost of capital input for a given cost study depends uniquely on the financial risk associated with the cost object of the study. It is essential, therefore, to determine a cost of capital input for UNEs that reflects the monopoly nature of UNE availability.

In order to determine the specific cost of capital appropriate for a study of the forward-looking economic costs of UNEs, the risk relationship between an ILEC's local exchange business and its other telecommunications ventures must be understood. The local exchange business is clearly less risky than the ILEC's other ventures. The provisioning of UNEs (i. e., acting as a wholesale provider of essential network functions) carries even less risk: the ILEC may lose a retail local exchange customer but remain the provider of the underlying facilities. The level of interest in this and related proceeding indicates that the financial risk associated with the assets used by the ILECs to provide UNEs is likely to prove very low.

Financial theory has long recognized the need to capture the characteristics of project-specific risk. An analysis of the desirability of an investment should include a consideration of a discount rate that is specific to the risks associated with that investment. Risks associated with other ILEC ventures are not a part of the cost of providing UNEs, and should not impact the development of the inputs for capital costs used in a UNE study.

Q. HOW SHOULD THE ECONOMIC LIVES OF ASSETS BE DETERMINED?

A. The economic cost of a UNE is a direct function of the underlying asset's economic life. Rapid improvements and innovations, as well as the decreasing price levels that characterize many technology-intensive industries, add a level of complexity to the accurate prediction of an asset's useful life.

Both competition and technological innovation may cause the economic life of a given asset to deviate from the useful life predicted at the time the asset was acquired. As described in Section 1 of my testimony, competitive market forces tend to cause economic lives to be shorter than expected, and companies operating in competitive markets have no choice but to remain efficient. Depending on the asset being considered, however, technological innovation may increase or decrease the economic life. Since the impact of technological change is certain to be specific to specific types of assets, it is necessary to perform an economic life analysis at this level of disaggregation. General observations are simply not sufficient.

A superficial examination of the issue suggests that competition and technological innovation shorten economic lives. A closer examination reveals that there are instances in which companies are able to enhance current infrastructure through technological innovation, thereby extending the economic lives of the underlying assets beyond their originally expected life. A competitive market provides incentives for incumbent market players to invest in updating current technologies. For example, ILECs have been able to increase the capacity (and useful life) of copper facilities, first through the use of loop carrier systems and later through the use of equipment that makes digital subscriber lines possible utilizing short copper loops. Rather than shorten economic lives, in these instances competition and technological innovation have extended it.

Because of this dynamic, the only satisfactory methodology is to assess economic lives for each type of asset. As an alternative for this analysis, the Commission should consider economic lives adopted in the three-way meetings with the FCC.

Q. HOW SHOULD SALVAGE VALUES BE DETERMINED?

A. Like the economic life, the salvage value of an asset may vary depending on the types of technological advances and whether those innovations increase or decrease the life of the asset.

Q. WHAT IS THE PROPER WAY TO DEVELOP ANNUAL OPERATING

EXPENSES WHEN CALCULATING THE COST OF UNES?

A. There are three primary components of annual operating expenses: operations, maintenance and repairs, and administrative functions. Attempting to calculate these expenses for an ILEC operating in a competitive market can be difficult for the reasons described in Section 1: the existing operations of the ILECs (and the corresponding costs) are a direct function of having historically operated in a monopoly environment. We simply have no direct method of determining what the operations of an ILEC would look like if it had historically been subject to competitive market forces.

The most appropriate way to develop these expenses would be to develop, from the ground up, an operating plan that would provide sufficient personnel and resources to operate a forward-looking network sufficient to provide the UNEs being studied. Like a determination of the characteristics of a forward-looking network necessary to serve a given geographic area, such a bottom-up determination of operating costs is the only means of determining the costs that a competitive company would incur.

Because of the magnitude of such a project, most developers of inputs to cost studies have settled for a decidedly second-best alternative for most categories of operating costs. Most parties submitting cost studies have opted to use adjustments to historical operating expenses as a proxy for forward-looking level of operating expenses that would be sustainable in a competitive market.

There are two alternatives for the application of this second best alternative of modifying historical operating expenses in order to estimate forward-looking operating expenses. The first methodology involves calculating expense-to-investment ratios. This methodology assumes that forward-looking efficient operating expenses will fluctuate based on the amount of assets required to provide the capability being studied. This methodology implicitly allows operating expenses to fluctuate with the sophistication of the equipment and with the number of lines. In other words, the more sophisticated equipment will, all other things being equal, cost more, therefore increasing investment and the operating expenses. Also, the more lines, the greater quantity of equipment will be required, increasing investment and the operating expenses. Under this approach, the total magnitude of operating expenses is reduced as the total cost of the investments needed to provide the capability being studied is reduced.

The second methodology computes operating expenses based on the number of lines. However, because the study contemplates (as it must) the full scale and scope of the incumbent's operations, the embedded total magnitude of operating costs will be assumed to continue on a going-forward basis unless the per-line operating expenses are reduced by some amount. Such reduction must be grounded in cost-savings and efficiency gains resulting from the more efficient network. Obviously, this methodology requires a much more in-depth analysis of the current architecture and technology compared with the forward-looking architecture and technology. The use of a subject matter expert (or group of subject matter experts) will be required in making these judgments.

The most effective approach is to use a combination of these two approaches, with the expense-to-investment or expense-to-line ratio approach being applied depending on the specific operations cost being evaluated. Some operations functions, such as network operations and billing, are best represented on a per-line basis. These expenses are directly related to the number of lines (and by extension the subscribers) that comprise the network. Other operations costs, such as maintenance and repair expenses, are best represented by an expense-to-investment ratio.

In summary, operations costs, like all forward-looking costs, should be developed using a bottom-up approach. Specifically, the cost study should attempt to determine the operations costs that would be required to efficiently operate the network necessary to provide the functionalities being studied. As a second alternative, it is possible to estimate forward-looking levels of operations costs based on the application of expense-to-investment and expense-to-line ratios.

Q. CAN YOU PROVIDE AN EXAMPLE OF THE TYPE OF DOCUMENTATION THAT SHOULD ACCOMPANY THE INPUTS A

PARTY IS PROPOSING FOR UNES?

A. Yes. Attachment DJW-2 is the HAI Model Inputs Portfolio ("HIP") that illustrates, for each input, the type of methodology that should be followed in developing the inputs that are used to calculate the cost of UNEs. This document also shows the minimum level of supporting documentation that should be required for any input being considered for use in a cost study for UNEs.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

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EDUCATION

Emory University, Atlanta, Ga.
BBA in Finance, with Distinction.

College of William and Mary, Williamsburg, Va.
MBA, with concentration in Finance and Microeconomics.

CURRENT EMPLOYMENT

Don J. Wood is a Regional Director in the firm of Klick, Kent, and Allen/FTI Consulting, Inc. He provides economic and regulatory analysis services in telecommunications, cable, and related "convergence" industries, specializing in economic policy related to the development of competitive markets and cost of service issues. Mr. Wood was a founding partner of the firm of Wood & Wood, and has been employed in a management capacity at a major Local Exchange Company and an Interexchange Carrier. In each capacity he has been directly involved in both the development and implementation of regulatory policy. The subject matter of his testimony has ranged from broad policy issues to detailed cost analysis. Mr. Wood has presented testimony before the administrative regulatory bodies of twenty-five states, the District of Columbia, and Puerto Rico. He has also presented testimony in State and Federal courts and has prepared comments for filing with the Federal Communications Commission.

PREVIOUS INDUSTRY EMPLOYMENT

Wood & Wood
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TESTIMONY - STATE REGULATORY COMMISSIONS:

Alabama Public Service Commission

Docket No. 19356, Phase III: Alabama Public Service Commission vs. All Telephone Companies Operating in Alabama, and Docket 21455: AT&T Communications of the South Central States, Inc., Applicant, Application for a Certificate of Public Convenience and Necessity to Provide Limited IntraLATA Telecommunications Service in the State of Alabama.

Docket No. 20895: In Re: Petition for Approval to Introduce Business Line Termination for MCI's 800 Service.

Docket No. 21071: In Re: Petition by South Central Bell for Introduction of Bidirectional Measured Service.

Docket No. 21067: In Re: Petition by South Central Bell to Offer Dial Back-Up Service and 2400 BPS Central Office Data Set for Use with PulseLink Public Packet Switching Network Service.

Docket No. 21378: In Re: Petition by South Central Bell for Approval of Tariff Revisions to Restructure ESSX and Digital ESSX Service.

Docket No. 21865: In Re: Petition by South Central Bell for Approval of Tariff Revisions to Introduce Network Services to be Offered as a Part of Open Network Architecture.

Docket No. 25703: In Re: In the Matter of the Interconnection Agreement Between AT&T Communications of the South Central States, Inc. and BellSouth Telecommunications, Inc., Pursuant to 47 U.S.C. § 252.

Docket No. 25704: In Re: Petition by AT&T Communications of the South Central States, Inc. for Arbitration of Certain Terms and Conditions of a Proposed Agreement with GTE South Incorporated and CONTEL of the South, Inc. Concerning Interconnection and Resale under the Telecommunications Act of 1996.

Docket No. 25835: In Re: Petition for Approval of a Statement of Generally Available Terms and Conditions Pursuant to §252(f) of the Telecommunications Act of 1996 and Notification of Intention to File a §271 Petition for In-Region InterLATA Authority with the Federal Communications Commission Pursuant to the Telecommunications Act of 1996.

Docket No. 26029: In Re: Generic Proceeding - Consideration of TELRIC Studies.

Docket No. 25980: Implementation of the Universal Support Requirements of Section 254 of the Telecommunications Act of 1996.

Arkansas Public Service Commission

Docket No. 92-337-R: In the Matter of the Application for a Rule Limiting Collocation for Special Access to Virtual or Physical Collocation at the Option of the Local Exchange Carrier.

Public Utilities Commission of the State of Colorado

Docket No. 96A-345T: In the Matter of the Interconnection Contract Negotiations Between AT&T Communications of the Mountain States, Inc., and US West Communications, Inc., Pursuant to 47 U.S.C. Section 252. Docket No. 96A-366T: In the Matter of the Petition of MCIMetro Access Transmission Services, Inc., for Arbitration Pursuant to 47 U.S.C. § 252(b) of the Telecommunications Act of 1996 to Establish an Interconnection Agreement with US West Communications, Inc. (consolidated).

Docket No. 96S-257T: In Re: The Investigation and Suspension of Tariff Sheets Filed by US West Communications, Inc., with Advice Letter No. 2608 Regarding Proposed Rate Changes.

Docket No. 98F-146T: Colorado Payphone Association, Complainant, v. US West Communications, Inc., Respondent.

State of Connecticut, Department of Utility Control

Docket 91-12-19: DPUC Review of Intrastate Telecommunications Services Open to Competition (Comments).

Docket No. 94-07-02: Development of the Assumptions, Tests, Analysis, and Review to Govern Telecommunications Service Reclassifications in Light of the Eight Criteria Set Forth in Section 6 of Public Act 94-83 (Comments).

Delaware Public Service Commission

Docket No. 93-31T: In the Matter of the Application of The Diamond State Telephone Company for Establishment of Rules and Rates for the Provision of IntelliLinQ-PRI and IntelliLinQ-BRI.

Docket No. 41: In the Matter of the Development of Regulations for the Implementation of the Telecommunications Technology Investment Act.

Florida Public Service Commission

Docket No. 881257-TL: In Re: Proposed Tariff by Southern Bell to Introduce New Features for Digital ESSX Service, and to Provide Structural Changes for both ESSX Service and Digital ESSX Service.

Docket No. 880812-TP: In Re: Investigation into Equal Access Exchange Areas (EAEAs), Toll Monopoly Areas (TMAs), 1+ Restriction to the Local Exchange Companies (LECs), and Elimination of the Access Discount.

Docket No. 890183-TL: In Re: Generic Investigation into the Operations of Alternate Access Vendors.

Docket No. 870347-TI: In Re: Petition of AT&T Communications of the Southern States for Commission Forbearance from Earnings Regulation and Waiver of Rule 25-4.495(1) and 25-24.480 (1) (b), F.A.C., for a trial period.

Docket No. 900708-TL: In Re: Investigation of Methodology to Account for Access Charges in Local Exchange Company (LEC) Toll Pricing.

Docket No. 900633-TL: In Re: Development of Local Exchange Company Cost of Service Study Methodology.

Docket No. 910757-TP: In Re: Investigation into the Regulatory Safeguards Required to Prevent Cross-Subsidization by Telephone Companies.

Docket No. 920260-TL: In Re: Petition of Southern Bell Telephone and Telegraph Company for Rate Stabilization, Implementation Orders, and Other Relief.

Docket No. 950985-TP: In Re: Resolution of Petitions to establish 1995 rates, terms, and conditions for interconnection involving local exchange companies and alternative local exchange companies pursuant to Section 364.162, Florida Statutes.

Docket No. 960846-TP: In Re: Petition by MCI Telecommunications Corporation and MCI Metro Access Transmission Services, Inc. for Arbitration of Certain Terms and Conditions of a proposed agreement with BellSouth Telecommunications, Inc. Concerning Interconnection and Resale Under the Telecommunications Act of 1996 and Docket No. 960833-TP: In Re: Petition by AT&T Communications of the Southern States, Inc. for Arbitration of Certain Terms and Conditions of a Proposed Agreement with BellSouth Telecommunications, Inc. Concerning Interconnection and Resale Under the Telecommunications Act of 1996 (consolidated).

Docket No. 960847-TP and 960980-TP: In Re: Petition by AT&T Communications of the Southern States, Inc., MCI Telecommunications Corporation, MCI Metro Access Transmission Service, Inc., for Arbitration of Certain Terms and Conditions of a Proposed Agreement with GTE Florida Incorporated Inc. Concerning Interconnection and Resale Under the Telecommunications Act of 1996 (consolidated).

Docket No. 961230-TP: In Re: Petition by MCI Telecommunications Corporation for Arbitration with United Telephone Company of Florida and Central Telephone Company of Florida Concerning Interconnection Rates, Terms, and Conditions, Pursuant to the Federal Telecommunications Act of 1996.

Docket No. 960786-TL: In Re: Consideration of BellSouth Telecommunications, Inc.'s Entry Into InterLATA Services Pursuant to Section 271 of the Federal Telecommunications Act of 1996.

Docket Nos. 960833-TP, 960846-TP, 960757-TP, and 971140-TP: Investigation to develop permanent rates for certain unbundled network elements.

Docket No. 980696-TP: In Re: Determination of the cost of basic local telecommunications service, pursuant to Section 364.025 Florida Statutes

Georgia Public Service Commission

Docket No. 3882-U: In Re: Investigation into Incentive Telephone Regulation in Georgia.

Docket No. 3883-U: In Re: Investigation into the Level and Structure of Intrastate Access Charges.

Docket No. 3921-U: In Re: Compliance and Implementation of Senate Bill 524.

Docket No. 3905-U: In Re: Southern Bell Rule Nisi.

Docket No. 3995-U: In Re: IntraLATA Toll Competition.

Docket No. 4018-U: In Re: Review of Open Network Architecture (ONA) (Comments).

Docket No. 5258-U: In Re: Petition of BellSouth Telecommunications for Consideration and Approval of its "Georgians FIRST" (Price Caps) Proposal.

Docket No. 5825-U: In Re: The Creation of a Universal Access Fund as Required by the Telecommunications Competition and Development Act of 1995.

Docket No. 6801-U: In Re: Interconnection Negotiations Between BellSouth Telecommunications, Inc. and AT&T Communications of the Southern States, Inc., Pursuant to Sections 251-252 and 271 of the Telecommunications Act of 1996.

Docket No. 6865-U: In Re: Petition by MCI for Arbitration of Certain Terms and Conditions of Proposed Agreement with BellSouth Telecommunications, Inc. Concerning Interconnection and Resale Under the Telecommunications Act of 1996.

Docket No. 7253-U: In Re: BellSouth Telecommunications, Inc.'s Statement of Generally Available Terms and Conditions Under Section 252 (f) of the Telecommunications Act of 1996.

Docket No. 7061-U: In Re: Review of Cost Studies and Methodologies for Interconnection and Unbundling of BellSouth Telecommunications Services.

Docket No. 10692-U: In Re: Generic Proceeding to Establish Long-Term Pricing Policies for Unbundled Network Elements.

Iowa Utilities Board

Docket No. RPU-95-10.

Docket No. RPU-95-11.

Kentucky Public Service Commission

Administrative Case No. 10321: In the Matter of the Tariff Filing of South Central Bell Telephone Company to Establish and Offer Pulselink Service.

Administrative Case No. 323: In the Matter of An Inquiry into IntraLATA Toll Competition, An Appropriate Compensation Scheme for Completion of IntraLATA Calls by Interexchange Carriers, and

WATS Jurisdictionality.

- Phase IA: Determination of whether intraLATA toll competition is in the public interest.
- Phase IB: Determination of a method of implementing intraLATA competition.
- Rehearing on issue of Imputation.

Administrative Case No. 90-256, Phase II: In the Matter of A Review of the Rates and Charges and Incentive Regulation Plan of South Central Bell Telephone Company.

Administrative Case No. 336: In the Matter of an Investigation into the Elimination of Switched Access Service Discounts and Adoption of Time of Day Switch Access Service Rates.

Administrative Case No. 91-250: In the Matter of South Central Bell Telephone Company's Proposed Area Calling Service Tariff.

Administrative Case No. 96-431: In Re: Petition by MCI for Arbitration of Certain Terms and Conditions of a Proposed Agreement with BellSouth Telecommunications, Inc. Concerning Interconnection and Resale Under the Telecommunications Act of 1996.

Administrative Case No. 96-478: In Re: The Petition by AT&T Communications of the South Central States, Inc. for Arbitration of Certain Terms and Conditions of a Proposed Agreement with GTE South Incorporated Concerning Interconnection and Resale Under the Telecommunications Act of 1996.

Administrative Case No. 96-482: In Re: The Interconnection Agreement Negotiations Between AT&T Communications of the South Central States, Inc. and BellSouth Telecommunications, Inc., Pursuant to 47 U.S.C. § 252.

Administrative Case No. 360: In the Matter of: An Inquiry Into Universal Service and Funding Issues.

Administrative Case No. 96-608: In the Matter of: Investigation Concerning the Provision of InterLATA Services by BellSouth Telecommunications, Inc. Pursuant to the Telecommunications Act of 1996.

Louisiana Public Service Commission

Docket No. 17970: In Re: Investigation of the Revenue Requirements, Rate Structures, Charges, Services, Rate of Return, and Construction Program of AT&T Communications of the South Central States, Inc., in its Louisiana Operations.

Docket No. U-17949: In the Matter of an Investigation of the Revenue Requirements, Rate Structures, Charges, Services, Rate of Return, and Construction Program of South Central Bell Telephone Company, Its Louisiana Intrastate Operations, The Appropriate Level of Access Charges, and All Matters Relevant to the Rates and Service Rendered by the Company.

- Subdocket A (SCB Earnings Phase)

- Subdocket B (Generic Competition Phase)

Docket No. 18913-U: In Re: South Central Bell's Request for Approval of Tariff Revisions to Restructure ESSX and Digital ESSX Service.

Docket No. U-18851: In Re: Petition for Elimination of Disparity in Access Tariff Rates.

Docket No. U-22022: In Re: Review and Consideration of BellSouth Telecommunications, Inc.'s TSLRIC and LRIC Cost Studies Submitted Pursuant to Sections 901(C) and 1001(E) of the Regulations for Competition in the Local Telecommunications Market as Adopted by General Order Dated March 15, 1996 in Order to Determine the Cost of Interconnection Services and Unbundled Network Components to Establish Reasonable, Non-Discriminatory, Cost Based Tariffed Rates and Docket No. U-22093: In Re: Review and Consideration of BellSouth Telecommunications, Inc.'s Tariff Filing of April 1, 1996, Filed Pursuant to Section 901 and 1001 of the Regulations for Competition in the Local Telecommunications Market Which Tariff Introduces Interconnection and Unbundled Services and Establishes the Rates, Terms and Conditions for Such Service Offerings (consolidated).

Docket No. U-22145: In the Matter of Interconnection Agreement Negotiations Between AT&T Communications of the South Central States, Inc. and BellSouth Telecommunications, Inc., Pursuant to 47 U.S.C. § 252.

Docket No. U-22252: In Re: Consideration and Review of BST's Preapplication Compliance with Section 271 of the Telecommunications Act of 1996, including but not limited to the fourteen requirements set forth in Section 271 (c) (2) (b) in order to verify compliance with section 271 and provide a recommendation to the FCC regarding BST's application to provide interLATA services originating in-region.

Docket No. U-20883 Subdocket A: In Re: Submission of the Louisiana Public Service Commission's Forward Looking Cost Study to the FCC for Purposes of Calculating Federal Universal Service Support.

Public Service Commission of Maryland

Case 8584, Phase II: In the Matter of the Application of MFS Intelenet of Maryland, Inc. for Authority to Provide and Resell Local Exchange and Intrastate Telecommunications Services in Areas Served by C&P Telephone Company of Maryland.

Case 8715: In the Matter of the Inquiry into Alternative Forms of Regulating Telephone Companies.

Case 8731: In the Matter of the Petitions for Approval of Agreements and Arbitration of Unresolved Issues Arising Under Section 252 of the Telecommunications Act of 1996.

Mississippi Public Service Commission

Docket No. U-5086: In Re: MCI Telecommunications Corporation's Metered Use Service Option D (Prism I) and Option E (Prism II).

Docket No. U-5112: In Re: MCI Telecommunications Corporation's Metered Use Option H (800 Service).

Docket No. U-5318: In Re: Petition of MCI for Approval of MCI's Provision of Service to a Specific Commercial Banking Customers for Intrastate Interexchange Telecommunications Service.

Docket 89-UN-5453: In Re: Notice and Application of South Central Bell Telephone Company for Adoption and Implementation of a Rate Stabilization Plan for its Mississippi Operations.

Docket No. 90-UA-0280: In Re: Order of the Mississippi Public Service Commission Initiating Hearings Concerning (1) IntraLATA Competition in the Telecommunications Industry and (2) Payment of Compensation by Interexchange Carriers and Resellers to Local Exchange Companies in Addition to Access Charges.

Docket No. 92-UA-0227: In Re: Order Implementing IntraLATA Competition.

Docket No. 96-AD-0559: In Re: In the Matter of the Interconnection Agreement Negotiations Between AT&T Communications of the South Central States, Inc. and BellSouth Telecommunications, Inc., Pursuant to 47 U.S.C. § 252.

Docket No. 98-AD-035: Universal Service.

Docket No. 97-AD-544: In Re: Generic Proceeding to Establish Permanent Prices for BellSouth Interconnection and Unbundled Network Elements.

Nebraska Public Service Commission

Docket No. C-1385: In the Matter of a Petition for Arbitration of an Interconnection Agreement Between AT&T Communications of the Midwest, Inc., and US West Communications, Inc.

New York Public Service Commission

Case No. 28425: Proceeding on Motion of the Commission as to the Impact of the Modification of Final Judgement and the Federal Communications Commission's Docket 78-72 on the Provision of Toll Service in New York State.

North Carolina Public Utilities Commission

Docket No. P-100, Sub 72: In the Matter of the Petition of AT&T to Amend Commission Rules Governing Regulation of Interexchange Carriers (Comments).

Docket No. P-141, Sub 19: In the Matter of the Application of MCI Telecommunications Corporation to Provide InterLATA Facilities-Based Telecommunications Services (Comments).

Docket No. P-55, Sub 1013: In the Matter of Application of BellSouth Telecommunications, Inc. for, and Election of, Price Regulation.

Docket Nos. P-7, Sub 825 and P-10, Sub 479: In the Matter of Petition of Carolina Telephone and

Telegraph and Central Telephone Company for Approval of a Price Regulation Plan Pursuant to G.S. 62-133.5.

Docket No. P-19, Sub 277: In the Matter of Application of GTE South Incorporated for and Election of, Price Regulation.

Docket No. P-141, Sub 29: In the Matter of: Petition of MCI Telecommunications Corporation for Arbitration of Interconnection with BellSouth Telecommunications, Inc., Petition of AT&T Communications of the Southern States, Inc. for Arbitration of Interconnection with BellSouth Telecommunications, Inc. (consolidated).

Docket No. P-141, Sub 30: In the Matter of: Petition of MCI Telecommunications Corporation for Arbitration of Interconnection with General Telephone Company of North Carolina, Inc., Petition of AT&T Communications of the Southern States, Inc. for Arbitration of Interconnection with General Telephone Company of North Carolina, Inc. (consolidated).

Docket No. P-100, Sub 133b: Re: In the Matter of Establishment of Universal Support Mechanisms Pursuant to Section 254 of the Telecommunications Act of 1996.

Docket No. P-100, Sub 133d: Re: Proceeding to Determine Permanent Pricing for Unbundled Network Elements.

Docket No. P-100, Sub 84b: Re: In the Matter of Petition of North Carolina Payphone Association for Review of Local Exchange Company Tariffs for Basic Payphone Services (Comments).

Public Utilities Commission of Ohio

Case No. 93-487-TP-ALT: In the Matter of the Application of The Ohio Bell Telephone Company for Approval of an Alternative Form of Regulation.

Oklahoma Corporation Commission

Cause No. PUD 01448: In the Matter of the Application for an Order Limiting Collocation for Special Access to Virtual or Physical Collocation at the Option of the Local Exchange Carrier.

Public Utility Commission of Oregon

Docket No. UT 119: In the Matter of an Investigation into Tariffs Filed by US West Communications, Inc., United Telephone of the Northwest, Pacific Telecom, Inc., and GTE Northwest, Inc. in Accordance with ORS 759.185(4).

Docket No. ARB 3: In the Matter of the Petition of AT&T Communications of the Pacific Northwest, Inc., for Arbitration of Interconnection Rates, Terms, and Conditions Pursuant to 47 U.S.C. § 252(b) of the Telecommunications Act of 1996. Docket No. ARB 6: In the Matter of the Petition of MCIMetro Access Transmission Services, Inc. for Arbitration of Interconnection Rates, Terms, and Conditions Pursuant to 47 U.S.C. § 252(b) of the Telecommunications Act of 1996 (consolidated).

Docket No. ARB 9: In the Matter of the Petition of an Interconnection Agreement Between MCIMetro Access Transportation Services, Inc. and GTE Northwest Incorporated, Pursuant to 47 U.S.C. Section 252

Pennsylvania Public Utilities Commission

Docket No. I-00910010: In Re: Generic Investigation into the Current Provision of InterLATA Toll Service.

Docket No. P-00930715: In Re: The Bell Telephone Company of Pennsylvania's Petition and Plan for Alternative Form of Regulation under Chapter 30.

Docket No. R-00943008: In Re: Pennsylvania Public Utility Commission v. Bell Atlantic-Pennsylvania, Inc. (Investigation of Proposed Promotional Offerings Tariff).

Docket No. M-00940587: In Re: Investigation pursuant to Section 3005 of the Public Utility Code, 66 Pa. C. S. §3005, and the Commission's Opinion and Order at Docket No. P-930715, to establish standards and safeguards for competitive services, with particular emphasis in the areas of cost allocations, cost studies, unbundling, and imputation, and to consider generic issues for future rulemaking.

South Carolina Public Service Commission

Docket No. 90-626-C: In Re: Generic Proceeding to Consider Intrastate Incentive Regulation.

Docket No. 90-321-C: In Re: Petition of Southern Bell Telephone and Telegraph Company for Revisions to its Access Service Tariff Nos. E2 and E16.

Docket No. 88-472-C: In Re: Petition of AT&T of the Southern States, Inc., Requesting the Commission to Initiate an Investigation Concerning the Level and Structure of Intrastate Carrier Common Line (CCL) Access Charges.

Docket No. 92-163-C: In Re: Position of Certain Participating South Carolina Local Exchange Companies for Approval of an Expanded Area Calling (EAC) Plan.

Docket No. 92-182-C: In Re: Application of MCI Telecommunications Corporation, AT&T Communications of the Southern States, Inc., and Sprint Communications Company, L.P., to Provide IntraLATA Telecommunications Services.

Docket No. 95-720-C: In Re: Application of BellSouth Telecommunications, Inc. d/b/a Southern Bell Telephone and Telegraph Company for Approval of an Alternative Regulation Plan.

Docket No. 96-358-C: In Re: Interconnection Agreement Negotiations Between AT&T Communications of the Southern States, Inc. and BellSouth Telecommunications, Inc., Pursuant to 47 U.S.C. § 252.

Docket No. 96-375-C: In Re: Interconnection Agreement Negotiations Between AT&T Communications of the Southern States, Inc. and GTE South Incorporated Pursuant to 47 U.S.C. § 252.

Docket No. 97-101-C: In Re: Entry of BellSouth Telecommunications, Inc. into the InterLATA Toll Market.

Docket No. 97-374-C: In Re: Proceeding to Review BellSouth Telecommunications, Inc. Cost for Unbundled Network Elements.

Docket No. 97-239-C: Intrastate Universal Service Fund.

Docket No. 97-124-C: BellSouth Telecommunications, Inc. Revisions to its General Subscriber Services Tariff and Access Service Tariff to Comply with the FCC's Implementation of the Pay Telephone Reclassification and Compensation Provisions of the Telecommunications Act of 1996.

Tennessee Public Service Commission

Docket No. 90-05953: In Re: Earnings Investigation of South Central Bell Telephone Company.

Docket Nos. 89-11065, 89-11735, 89-12677: AT&T Communications of the South Central States, MCI Telecommunications Corporation, US Sprint Communications Company -- Application for Limited IntraLATA Telecommunications Certificate of Public Convenience and Necessity.

Docket No. 91-07501: South Central Bell Telephone Company's Application to Reflect Changes in its Switched Access Service Tariff to Limit Use of the 700 Access Code.

Tennessee Regulatory Authority

Docket No. 96-01152: In Re: Petition by AT&T Communications of the South Central States, Inc. for Arbitration under the Telecommunications Act of 1996 and Docket No. 96-01271: In Re: Petition by MCI Telecommunications Corporation for Arbitration of Certain Terms and Conditions of a Proposed Agreement with BellSouth Telecommunications, Inc. Concerning Interconnection and Resale Under the Telecommunications Act of 1996 (consolidated).

Docket No. 96-01262: In Re: Interconnection Agreement Negotiations Between AT&T of the South Central States, Inc. and BellSouth Telecommunications, Inc. Pursuant to 47 U.S.C. § 252.

Docket No. 97-01262: Proceeding to Establish Permanent Prices for Interconnection and Unbundled Network Elements.

Docket No. 97-00888: Universal Service Generic Contested Case.

Public Utility Commission of Texas

Docket No. 12879: Application of Southwestern Bell Telephone Company for Expanded Interconnection for Special Access Services and Switched Transport Services and Unbundling of Special Access DS1 and DS3 Services Pursuant to P. U. C. Subst. R. 23.26.

Docket No. 18082: Complaint of Time Warner Communications against Southwestern Bell Telephone Company.

Virginia State Corporation Commission

Case No. PUC920043: Application of Virginia Metrotel, Inc. for a Certificate of Public Convenience and Necessity to Provide InterLATA Interexchange Telecommunications Services.

Case No. PUC920029: Ex Parte: In the Matter of Evaluating the Experimental Plan for Alternative Regulation of Virginia Telephone Companies.

Case No. PUC930035: Application of Contel of Virginia, Inc. d/b/a GTE Virginia to implement community calling plans in various GTE Virginia exchanges within the Richmond and Lynchburg LATAs.

Case No. PUC930036: Ex Parte: In the Matter of Investigating Telephone Regulatory Methods Pursuant to Virginia Code § 56-235.5, & Etc.

Washington Utilities and Transportation Commission

Docket Nos. UT-941464, UT-941465, UT-950146, and UT-950265 (Consolidated): Washington Utilities and Transportation Commission, Complainant, vs. US West Communications, Inc., Respondent; TCG Seattle and Digital Direct of Seattle, Inc., Complainant, vs. US West Communications, Inc., Respondent; TCG Seattle, Complainant, vs. GTE Northwest Inc., Respondent; Electric Lightwave, Inc., vs. GTE Northwest, Inc., Respondent.

Docket No. UT-950200: In the Matter of the Request of US West Communications, Inc. for an Increase in its Rates and Charges.

Public Service Commission of Wyoming

Docket No. 70000-TR-95-238: In the Matter of the General Rate/Price Case Application of US West Communications, Inc. (Phase I).

Docket No. PSC-96-32: In the Matter of Proposed Rule Regarding Total Service Long Run Incremental Cost (TSLRIC) Studies.

Docket No. 70000-TR-98-420: In the Matter of the Application of US West Communications, Inc. for authority to implement price ceilings in conjunction with its proposed Wyoming Price Regulation Plan for essential and noncompetitive telecommunications services (Phase III).

Docket No. 70000-TR-99-480: In the Matter of the Application of US West Communications, Inc. for authority to implement price ceilings in conjunction with its proposed Wyoming Price Regulation Plan for essential and noncompetitive telecommunications services (Phase IV).

Public Service Commission of the District of Columbia

Formal Case No. 814, Phase IV: In the Matter of the Investigation into the Impact of the AT&T Divestiture and Decisions of the Federal Communications Commission on Bell Atlantic - Washington, D. C. Inc.'s Jurisdictional Rates.

Puerto Rico Telecommunications Regulatory Board

Case No. 98-Q-0001: In Re: Payphone Tariffs.

COMMENTS - FEDERAL COMMUNICATIONS COMMISSION

CC Docket No. 92-91: In the Matter of Open Network Architecture Tariffs of Bell Operating Companies.

CC Docket No. 93-162: Local Exchange Carriers' Rates, Terms, and Conditions for Expanded Interconnection for Special Access.

CC Docket No. 91-141: Common Carrier Bureau Inquiry into Local Exchange Company Term and Volume Discount Plans for Special Access.

CC Docket No. 94-97: Review of Virtual Expanded Interconnection Service Tariffs.

CC Docket No. 94-128: Open Network Architecture Tariffs of US West Communications, Inc.

CC Docket No. 94-97, Phase II: Investigation of Cost Issues, Virtual Expanded Interconnection Service Tariffs.

CC Docket No. 97-231: Application by BellSouth to Provide In-Region InterLATA Services

CC Docket No. 98-121: Application by BellSouth to Provide In-Region InterLATA Services

TESTIMONY - STATE AND FEDERAL COURTS

Court of Common Pleas, Philadelphia County, Pennsylvania

Shared Communications Services of 1800-80 JFK Boulevard, Inc., Plaintiff, v. Bell Atlantic Properties, Inc., Defendant.

United States District Court for the District of South Carolina, Columbia Division

Brian Wesley Jeffcoat, on behalf of himself and others similarly situated, Plaintiffs, v. Time Warner Entertainment - Advance/Newhouse Partnership, Defendant.

Docket No. 990649-TP
Attachment DJW-2

HAI Model
Release 5.1

Inputs Portfolio

HAI Consulting, Inc.

737 29th Street, Suite 200
Boulder, Colorado 80303

April 20, 1999

HAI Model Release 5.1 Inputs Portfolio

Table of Contents

Page

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Page

Table of Contents

1. OVERVIEW

This draft document contains descriptions of the user-adjustable inputs to the HAI Model, version 5.1 ("HM5.1"), the default values assigned to the inputs, and the rationales and supporting evidence for these default values. The inputs and assumptions in HM5.1 are based on information in publicly available documents, expert engineering judgment, and/or price quotes from suppliers and contractors.

Prices of telecommunications equipment and materials are notoriously difficult to obtain from manufacturers and large sales organizations. Although salespeople will occasionally provide "ballpark" prices, they will do so only informally and with the caveat that they may not be quoted and the company's identity must be concealed. It is very nearly impossible to obtain written, and hence "citable," price quotations, even for "list" prices, from vendors of equipment, cable and wire, and other items that are used in the telecommunications infrastructure. Part of the reason for this is that the vendors have long-standing relationships with the principal users of such equipment, the incumbent local exchange carriers ("ILECs"), and they apparently believe that public disclosure of any prices, list or discounted, might jeopardize these relationships. Further, they may fear retaliation by the ILECs if they were to provide pricing explicitly for use in cost models such as HM5.1[1] The HM5.1 developers thus have often been forced to rely on informal discussions with vendor representatives and personal experience in purchasing or recommending such equipment and materials. Nevertheless, a great deal of experience and expertise in the industry underlies the estimates, where they were necessary to augment explicit, publicly-available information. In a few instances, studies done of public information, typically information filed with the Federal Communications Commission or another regulatory body, has supplemented the knowledge of the experts who have contributed to this document.

This document contains a number of graphs that illustrate a range of prices for particular kinds of telecommunications equipment. The information contained in these graphs was gathered to validate the opinions of outside plant experts who used their collective industry knowledge and experience to estimate the costs of particular items, but it is not the basis for those opinions

This document will continue to evolve as more documented sources are found to support the input values and assumptions.

Organization of Material:
Material is generally organized in this binder in the same order as default values appear in Model Input screens in the HAI Model.

[1] See, for example, "U S West to Suppliers: Back Us or Lose Business," *Inter@ctive Week*, September 16, 1996.

2. DISTRIBUTION

2.1 Network Interface Device (NID)

Definition: The investment in the components of the network interface device (NID), the device at the customers' premises within which the drop wire terminates, and which is the point of subscriber demarcation. The residence NID is assumed to have a capacity for 2 lines, and the business NID is assumed to have a capacity for 6 lines. The NID investment is calculated as the cost of the NID case plus the product of the protection block cost per line and the number of lines terminated.

Default Values:

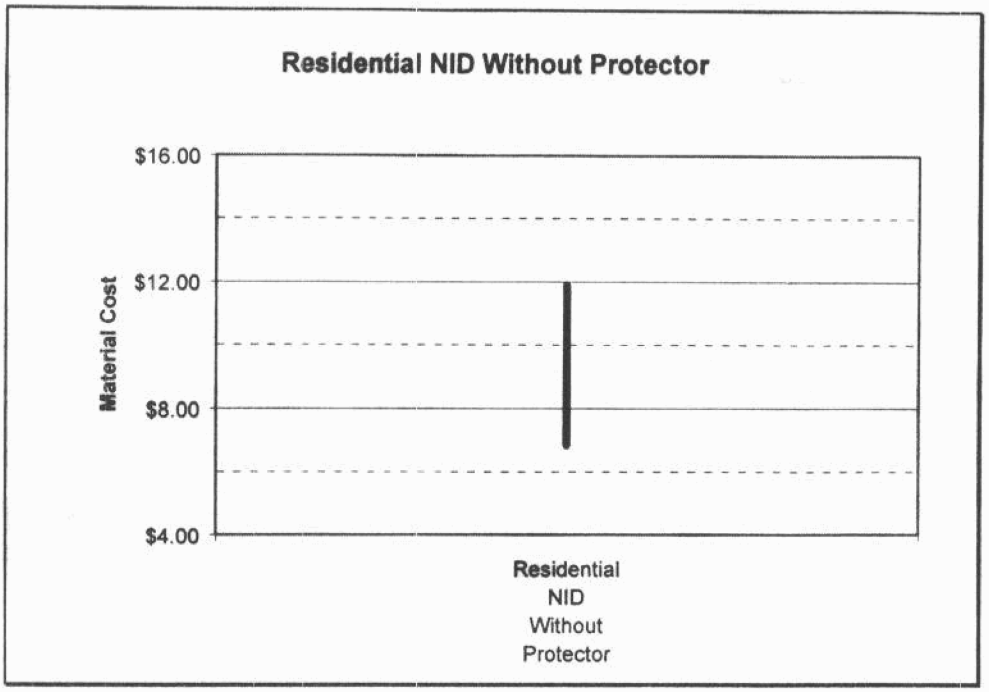
NID Materials and Installation	
	Cost
Residential NID case, no protector	$10.00
Residential NID basic labor	$15.00
Installed NID case	*$25.00*
Protection block, per line	$4.00
Business NID case, no protector	$25.00
Business NID basic labor	$15.00
Installed NID case	*$40.00*
Protection block, per line	$4.00
Indoor NID Case	$5.00

Support:

a) Residential NID Cost without Protector

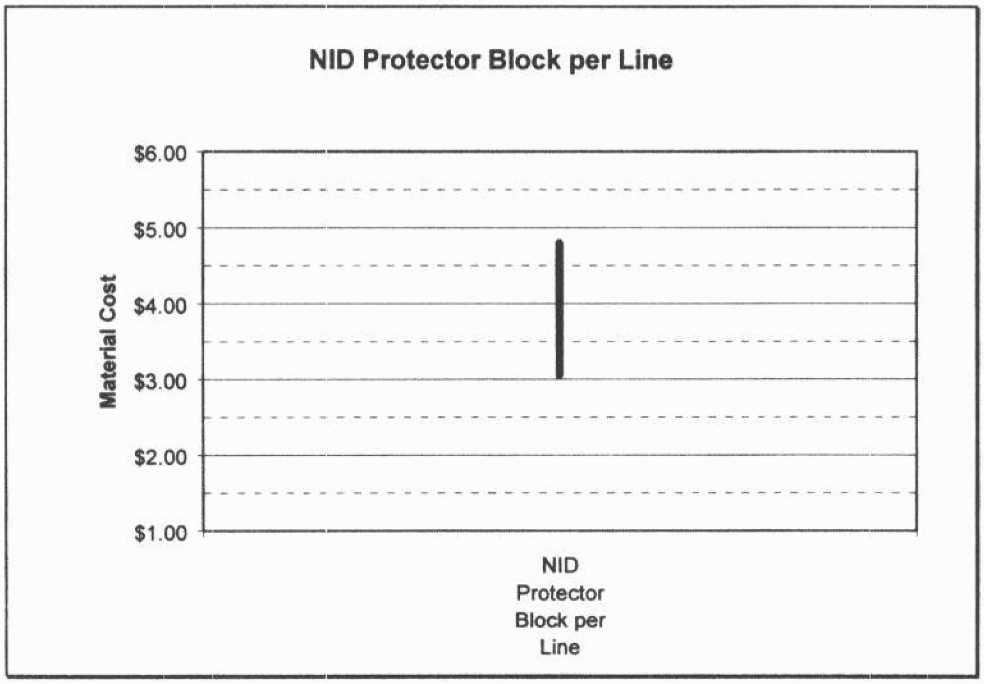
The labor estimate assumes a crew installing network interface devices throughout a neighborhood (in coordination with the installation of drops, terminals, and distribution cables). A work time of 25 minutes was used, based on the opinion of a team of outside plant experts. A loaded labor rate of $35 per hour excludes exempt material loadings which normally include the material cost of the NID and Drops. A residential NID shell has capacity for two protectors.

Price quotes for material were received from several sources. Results were as follows:



b) NID Protector Block per Line

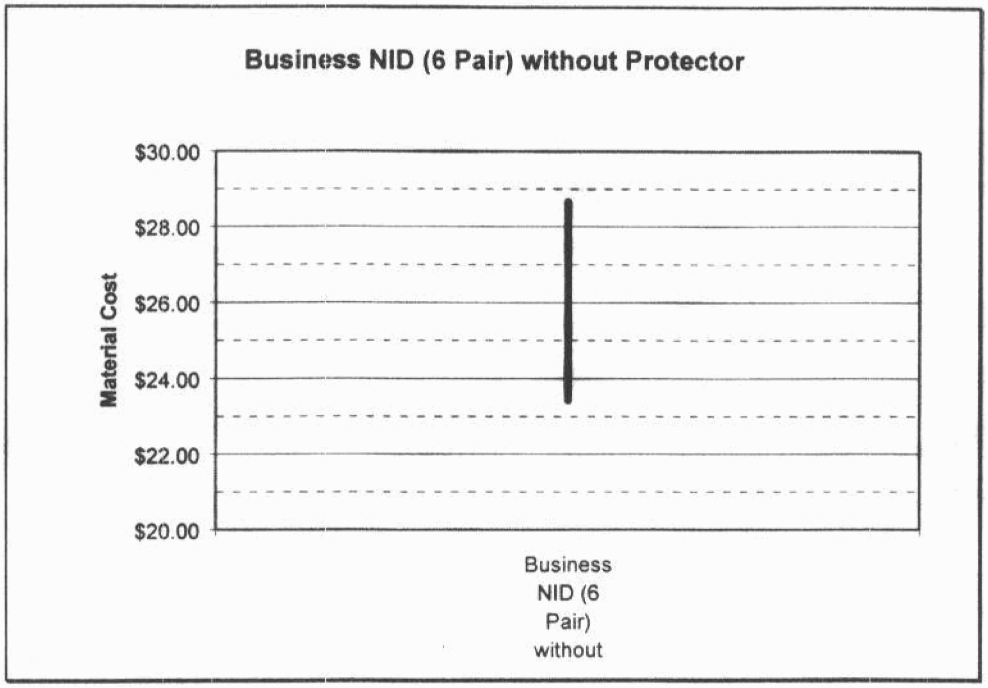
Price quotes for material were received from several sources. Results were as follows:



c) Business NID - No Protector

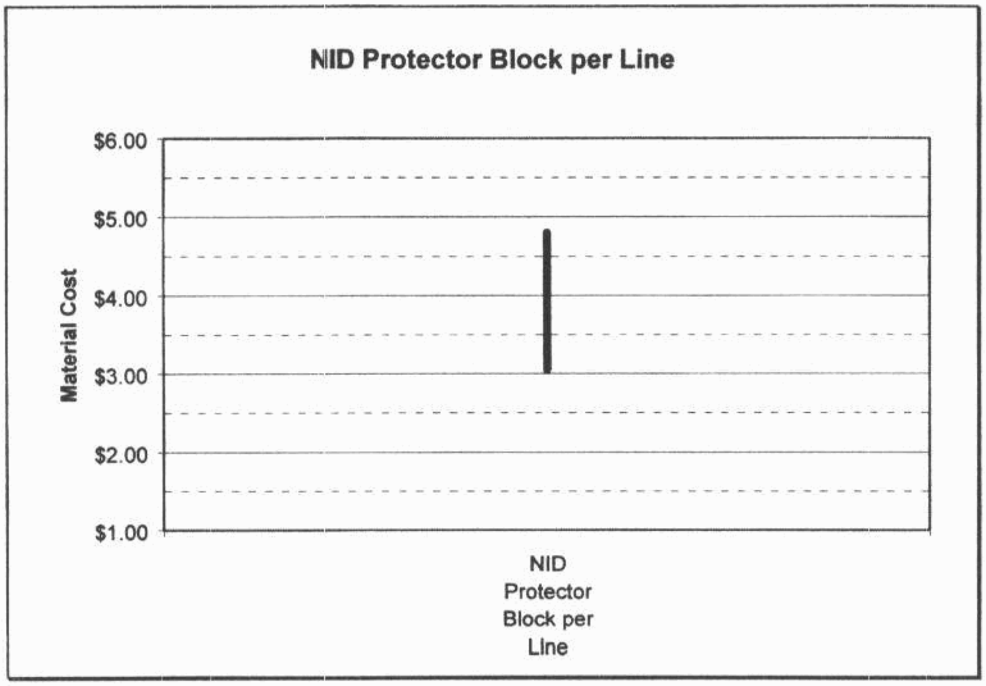
The labor estimate assumes a crew installing network interface devices throughout a neighborhood (in coordination with the installation of drops, terminals, and distribution cables). A work time of 25 minutes was used, based on the opinion of a team of outside plant experts. A loaded labor rate of $35 per hour excludes exempt material loadings which normally include the material cost of the NID and Drops. A business NID shell has capacity for six protectors.

Price quotes for material were received from several sources. Results were as follows:



d) NID Protector Block per Line

Price quotes for material were received from several sources. Results were as follows:



e) Indoor NID Case

Used for subscribers located in high-rise buildings. This is the investment in the NID that serves as the demarcation between subscriber wiring and network facilities. The indoor NID does not contain overvoltage protection devices; investment for these is included in the indoor SAI investment.

2.2. DROP

2.2.1. Drop Distance

Definition: The average length of a drop cable in each of nine density zones. The drop extends from the NID at the customer's premises to the block terminal at the distribution cable that runs along the street or the lot line.

Default Values:

Drop Distance by Density	
Density Zone	**Drop Distance, feet**
0-5	150
5-100	150
100-200	100
200-650	100
650-850	50
850-2,550	50
2,550-5,000	50
5,000-10,000	50
10,000+	50

Support: HM 5.1 assumes that drops are run from the front of the property line. House and building set-backs therefore determine drop length. Set-backs range from as low as 20 ft., in certain urban cases, to longer distances in more rural settings. While HM 5.1 assumes that lot sizes are twice as deep as they are wide, it is assumed that houses and buildings are normally placed towards the front of lots. Reasons for this include the cost of asphalt or cement driveways, unwillingness to remove snow from extremely long driveways in non-sunbelt areas, and the fact that private areas and gardens are usually situated in the backyard of a lot.

It should be noted that although exceptions to drop lengths may be observed, the model operates on average costs within density zones. The last nationwide study of actual loops produced results indicating that the average drop length is 73 feet.[2]

2.2.2. Drop Placement, Aerial and Buried

Definition: The total placement cost by density zone of an aerial drop wire, and the cost per foot for buried drop cable placement, respectively.

[2] Bellcore, BOC Notes on the Networks - 1997, p. 12-8.

Default Values:

Drop Placement, Aerial & Buried		
Density Zone	Aerial, total	Buried, per foot
0-5	$23.33	$0.60
5-100	$23.33	$0.60
100-200	$17.50	$0.60
200-650	$17.50	$0.60
650-850	$11.67	$0.60
850-2,550	$11.67	$0.60
2,550-5,000	$11.67	$0.75
5,000-10,000	$11.67	$1.50
10,000+	$11.67	$5.00

Support:

Aerial Drop Placement:

The opinions of expert outside plant engineers and estimators were used to project the amount of time necessary to attach a drop wire clamp at a utility pole, string the drop, and attach a drop wire clamp at the house or building. Labor to terminate the drop at the NID and the Block Terminal is included in the NID and Block Terminal investments respectively.

The labor estimate assumes a crew installing aerial drop wires throughout a neighborhood (in coordination with the installation of NIDs, terminals, and distribution cables), and consists of 10 minutes per drop plus 10 minutes for each 50 ft. of drop strung. The loaded labor rate excludes exempt material loadings which normally include the material cost of the Aerial Drop Wire.

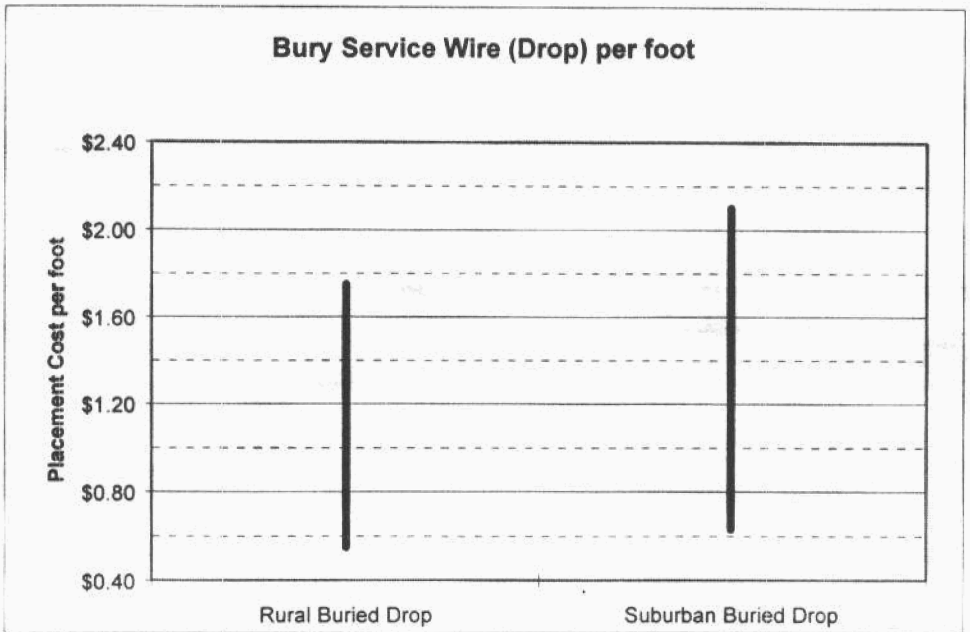
Aerial Drop Placement				
Density Zone	Aerial Drop Length (ft.)	Installation Time (min.)	Direct Loaded Labor Rate $/hr.	Aerial Total
0-5	150	40	$35	$23.33
5-100	150	40	$35	$23.33
100-200	100	30	$35	$17.50
200-650	100	30	$35	$17.50
650-850	50	20	$35	$11.67
850-2,550	50	20	$35	$11.67
2,550-5,000	50	20	$35	$11.67
5,000-10,000	50	20	$35	$11.67
10,000+	50	20	$35	$11.67

Buried Drop Placement

The labor estimate is based on a crew installing buried drop wires throughout a neighborhood (in coordination with the installation of NIDs, terminals, and distribution cables).

Of the quotes that were received for suburban and rural buried drop placement, several of them price buried drop placement at the HM 5.1 default values. Because buried drops are rare in urban areas, the expert opinion of outside plant experts was used in lieu of verifiable forward looking alternatives from public sources or ILECs.

Price quotes for contractor placement of buried drop wire were as follows:



2.2.3. Buried Drop Sharing Fraction

Definition: The fraction of buried drop cost that is assigned to the telephone company. The other portion of the cost is borne by other utilities.

Default Values:

Buried Drop Sharing Fraction	
Density Zone	**Fraction**
0-5	.50
5-100	.50
100-200	.50
200-650	.50
650-850	.50
850-2,550	.50
2,550-5,000	.50
5,000-10,000	.50
10,000+	.50

Support: Drop wires in new developments are most often placed in conjunction with other utilities to achieve cost sharing advantages, and to ensure that one service provider does not cut another's facilities during the trenching or plowing operation.

Conversations with architects and builders indicate that the builder will most often provide the trench at no cost, and frequently places electric, telephone, and cable television facilities into the trench if material is delivered on site. Research done in Arizona has indicated that developers not only provide trenches, but also provide small diameter PVC conduits across front property lines to facilitate placement of wires.

HM 5.1 determines the sharing of buried drop structures based on density zones. It is the judgment of outside plant experts that buried drops will normally be used with buried distribution cable. Although many cases would result in three-way sharing of such structure, a conservative approach was to use 50% sharing.

2.2.4. Aerial and Buried Drop Structure Fractions

Definition: The percentage of drops that are aerial and buried, respectively, as a function of density zone.

Default Values:

Drop Structure Fractions		
Density Zone	Aerial	Buried
0-5	.25	.75
5-100	.25	.75
100-200	.25	.75
200-650	.30	.70
650-850	.30	.70
850-2,550	.30	.70
2,550-5,000	.30	.70
5,000-10,000	.60	.40
10,000+	.85	.15

Support: HM 5.1 determines the use of distribution structures based on density zones. It is the judgment of outside plant experts that aerial drops will normally be used with aerial distribution cable and buried drops with buried and underground distribution cable. Therefore, the percentage of aerial drops equals the percentage of aerial distribution cable (see Section 2.5). The high percentage of aerial drops in the two most dense zones reflects the fact that such drops, if present at all, are extensions of riser cable, which is treated as aerial.

2.2.5. Average Lines per Business Location

Definition: The average number of business lines per business location, used to calculate NID and drop cost. This parameter should be set the same value as the input described in 5.4.15.

Default Value:

Number of Lines per Business Location
4

Support: The number of lines per business location estimated by HAI is based on data in the *1995 Common Carrier Statistics* and the *1995 Statistical Abstract of the United States.*

2.2.6. Aerial and Buried Terminal and Splice per Line

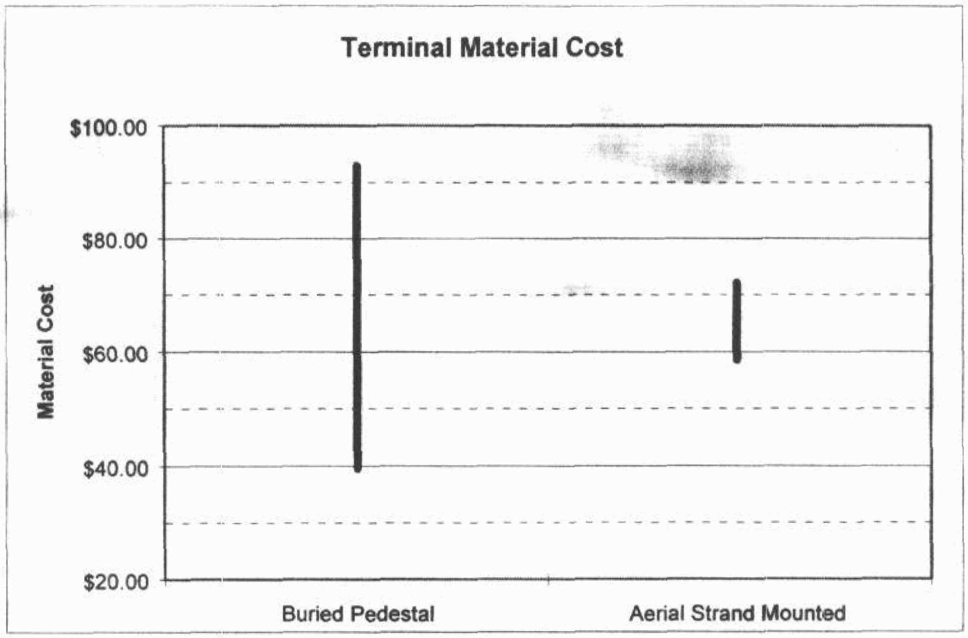
Definition: The installed cost per line for the terminal and splice that connect the drop to the distribution cable.

Default Values:

Terminal and Splice Investment per Line	
Buried	Aerial
$42.50	$32.00

Support: The figures above represent 25% of the cost of a terminal assuming a terminal is shared between four premises. The full cost is $128 Aerial and $170 Buried for both material and labor for 25 pair terminals. HM 5.1 assigns this investment per line in all but the two lowest density zones, where the cost is doubled to represent two premises served per terminal.

Price quotes for just the material portion were received from several sources. Results were as follows:



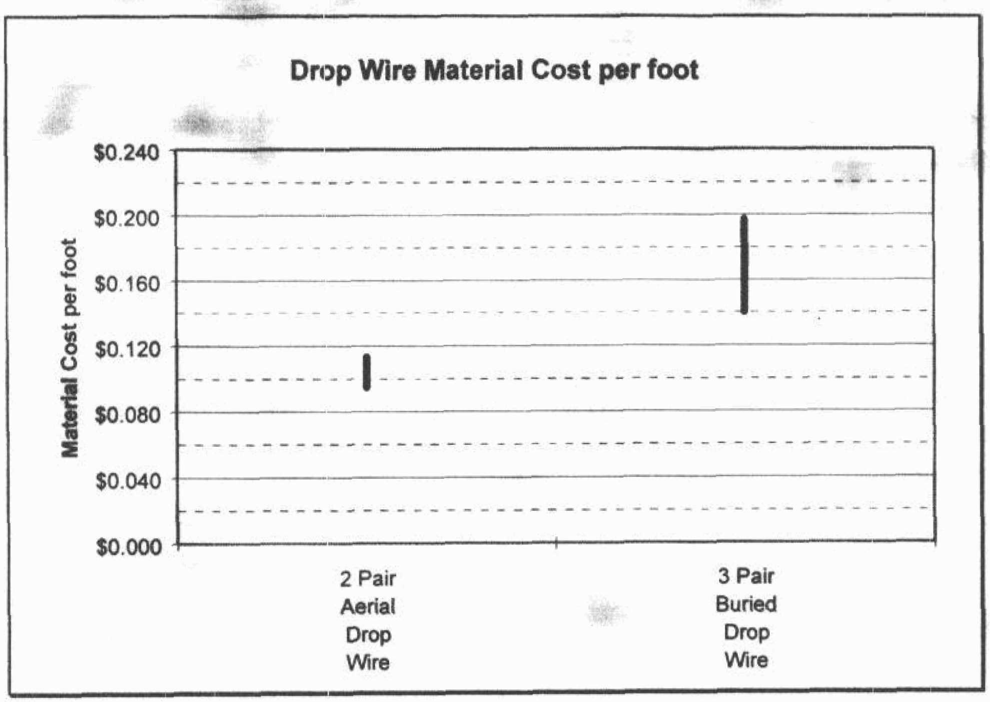
2.2.7. Drop Cable Investment, per Foot and Pairs per Drop

Definition: The investment per foot required for aerial and buried drop wire, and the number of pairs in each type of drop wire.

Default Values:

Drop Cable Investment, per foot		
	Material Cost Per foot	Pairs
Aerial	$0.095	2
Buried	$0.140	3

Support: Price quotes for material were received from several sources. Results were as follows:



2.3 CABLE AND RISER INVESTMENT

2.3.1. Distribution Cable Sizes

Definition: Cable sizes used for distribution cable variables (in pairs).

Default Values:

Cable Sizes
2400
1800
1200
900
600
400
200
100
50
25
12
6

Support: Distribution plant connects feeder plant, normally terminated at a Serving Area Interface (SAI), to the customer's block terminal. "Distribution network design requires more distribution pairs than feeder pairs, so distribution cables are more numerous, but smaller in cross section, than feeder cables."[3] The HAI Model default values represent the array of distribution cable sizes assumed to be available for placement in the network. Although three additional sizes of distribution cable (2100 pair, 1500 pair, and 300 pair cable) can be used, the industry has largely abandoned use of those sizes in favor of reduced, simplified inventory.

2.3.2. Distribution Cable, Cost per Foot

Definition: The cost per foot of copper distribution cable, as a function of cable size, including the costs of engineering, installation, and delivery, as well as the cable material itself.

[3] Bellcore, Telecommunications Transmission Engineering, 1990, p. 91.

Default Values:

Copper Distribution Cable, $/foot	
Cable Size	Cost/foot (including engineering, installation, delivery and material)
2400	$20.00
1800	$16.00
1200	$12.00
900	$10.00
600	$7.75
400	$6.00
200	$4.25
100	$2.50
50	$1.63
25	$1.19
12	$0.76
6	$0.63

Support: These costs reflect the use of 24-gauge copper distribution cable for cable sizes below 400 pairs, and 26-gauge copper distribution cable for cable sizes of 400 pairs and larger. Although 24-gauge copper is not required to meet transmission requirements within 18,000 feet of a digital central office with a 1,500 ohm limit, or a GR-303 integrated digital loop carrier system with a 1,500 ohm limit, a heavier gauge of copper is used in smaller cable sizes to prevent damage from craft handling wires in distribution terminals and pedestals. For cables of 400 pairs and larger, splices are normally enclosed in splice cases, and are not subject to wire handling problems.

Cable below 400 Pairs: Outside plant planning engineers commonly assume that the cost of cable material can be represented as an a + bx straight line graph. In fact, Bellcore Planning tools, EFRAP I, EFRAP II, and LEIS:PLAN have the engineer develop such an a + bx equation to represent the cost of cable. As technology, manufacturing methods, and competition have advanced, the price of cable has been reduced. While in the past, the cost of copper cable was typically ($0.50 + $0.01 per pair) per foot, current costs are typically ($0.30 + $0.007 per pair) per foot.

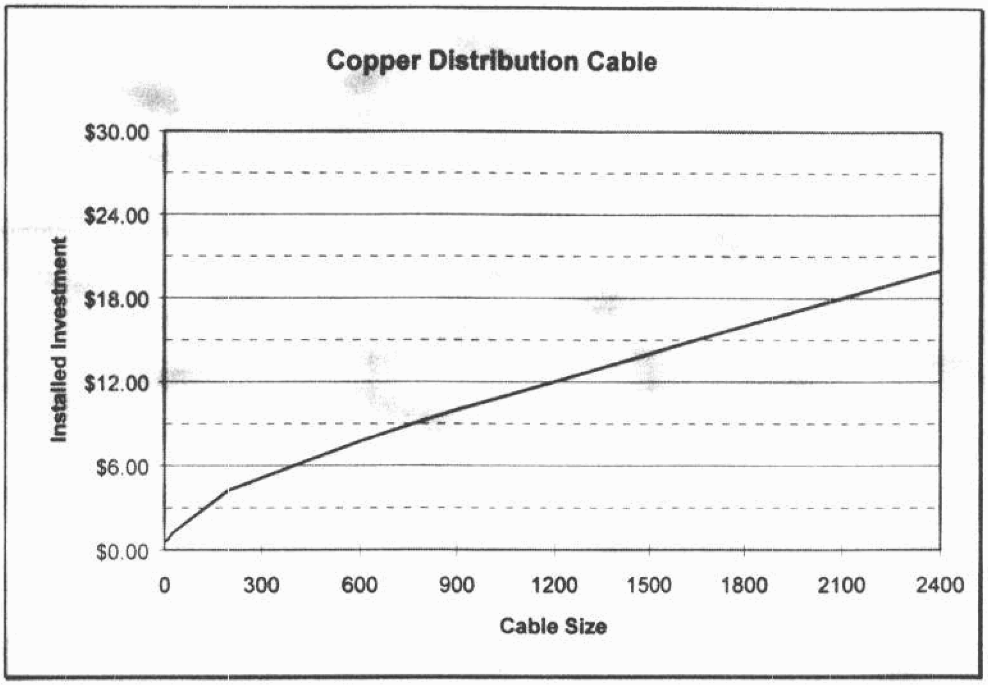
In the opinion of expert outside plant engineers whose experience includes writing and administering hundreds of outside plant "estimate cases" (large undertakings), material represents approximately 40% of the total installed cost. This is a widely used rule of thumb among outside plant engineers. Such expert opinions were also used to determine that the average engineering content for installed copper cable is 15% of the installed cost. The remaining 45% represents direct labor for placing and splicing cable, exclusive of the cost of splicing block terminals into the cable.[4]

Cable of 400 Pairs and Larger: As copper cable sizes become larger, engineering cost is based more on sheath feet, rather than cable size. The same is true for cable placing and splice set-up. Therefore the linear relationship between the number of copper pairs and installed cost is somewhat reduced. A review of many

[4] The formula would produce a material price of $0.38/ft. for 12 pair 24 gauge cable, and $0.34/ft. for 6 pair 24 gauge cable. An actual quote for materials was obtained at $0.18/ft. for 12 pair 24 gauge cable, and $0.12/ft. for 6 pair 24 gauge cable. The significant difference in material cost is perceived to be the result of the very small quantity of sheath required for 12 and 6 pair cables. Therefore, the formula generated material price was reduced by $0.20 and $0.22 for 12 and 6 pair cables respectively, but the engineering and labor components were retained at original formula levels, since neither would be affected by the reduction in material price.

installed cable costs around the country were used by the engineering team to estimate the installed cost of copper cable for sizes of 400 pairs and larger.

The following chart represents the values used in the model.



2.3.3. Riser Cable Size and Cost per Foot

Definition: The cost per foot of copper riser cable (cable inside high-rise buildings), as a function of cable size, including the costs of engineering, installation, and delivery, as well as the cable material itself.

Default Values:

Riser Cable, $/foot	
Cable Size	**Cost/foot (including engineering, installation, delivery and material)**
2400	$25.00
1800	$20.00
1200	$15.00
900	$12.50
600	$10.00
400	$7.50
200	$5.30
100	$3.15
50	$2.05
25	$1.50
12	$0.95
6	$0.80

Support: Riser cable is assumed to cost approximately 25% more than aerial copper distribution cable. Material cost is slightly higher, and the amount of engineering and direct labor per foot is higher than aerial cable.

2.4. POLES AND CONDUIT

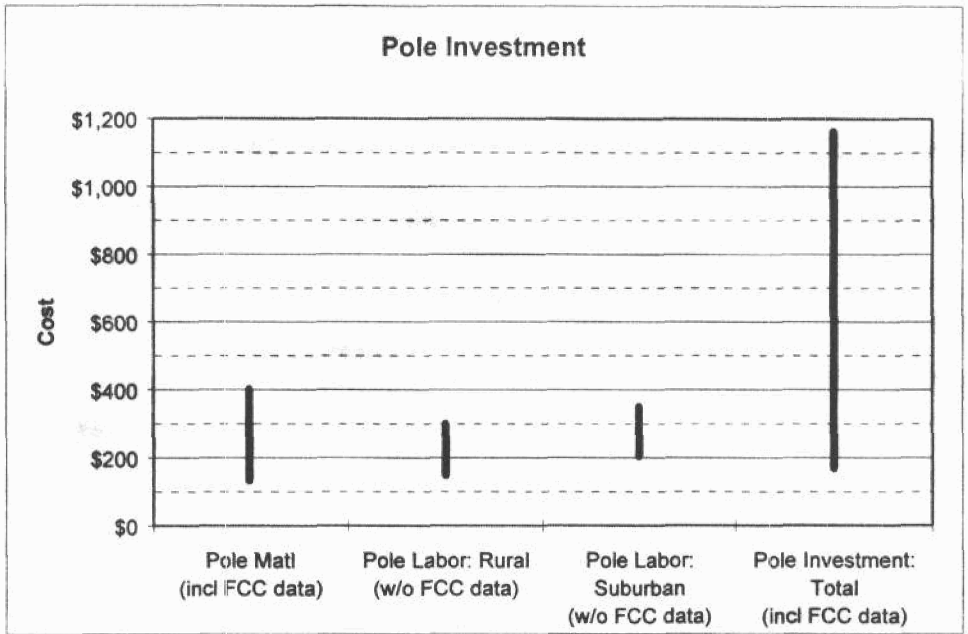
2.4.1. Pole Investment

Definition: The installed cost of a 40-foot Class 4 treated southern pine utility pole.

Default Values:

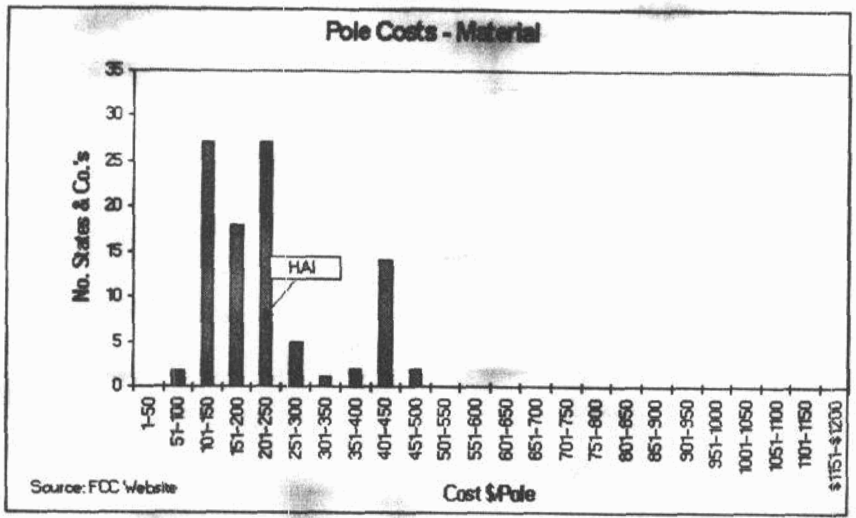
Pole Investment	
Materials	$201
Labor	$216
Total	*$417*

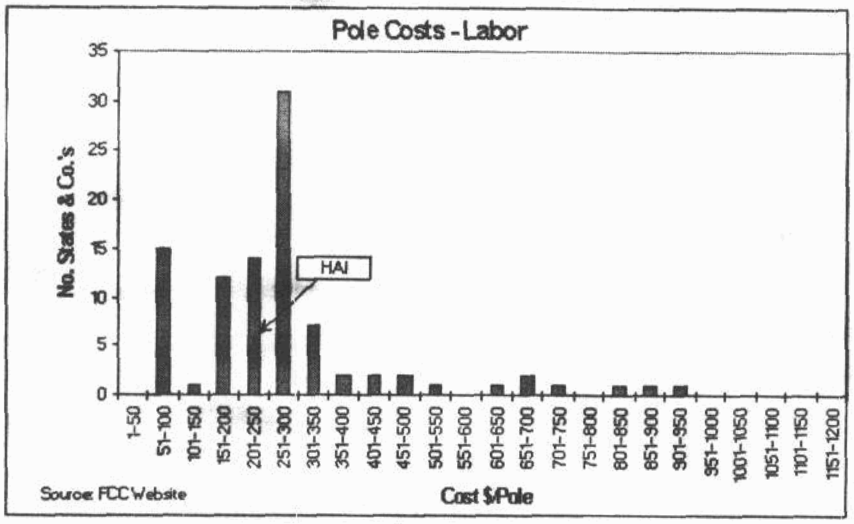
Support: Pole investment is a function of the material and labor costs of placing a pole. Costs include periodic down-guys and anchors. Utility poles can be purchased and installed by employees of ILECs, but are frequently placed by contractors. Several sources revealed the following information on prices.

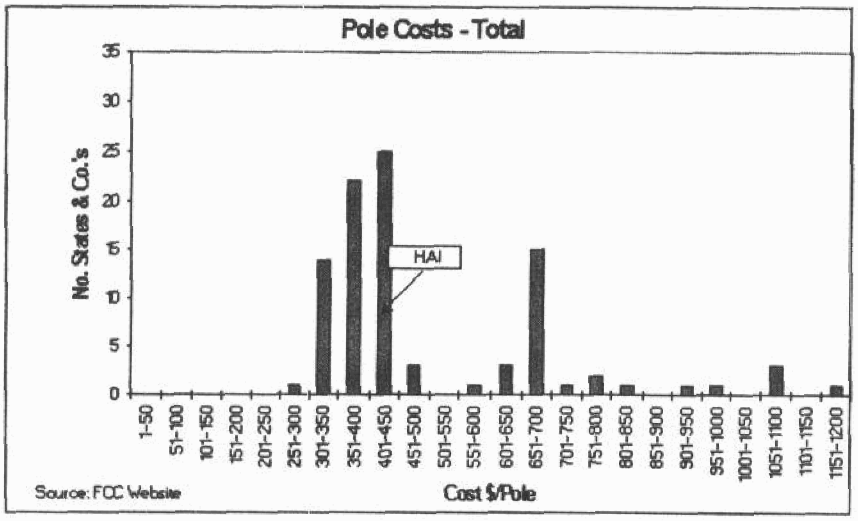


Pole data has also been recently filed by large telephone companies with the FCC.[5] A compilation of that information is shown below:

[5] See the downloadable files at the FCC Web site : http://www.fcc.gov/Bureaus/Common_Carrier/Comments/da971433_data_request/datareq.html


Pole Costs - Material
No. States & Co.'s
HAI
Cost $/Pole
Source: FCC Website


Pole Costs - Labor
No. States & Co.'s
HAI
Cost $/Pole
Source: FCC Website


Pole Costs - Total
No. States & Co.'s
HAI
Cost $/Pole
Source: FCC Website

The exempt material load on direct labor includes ancillary material not considered by FCC Part 32 as a unit of plant. This includes items such as down-guys and anchors that are already included in the pole placement labor cost. Outside plant engineering experts have concluded that a typical anchor plus anchor rod material investment is $45, and the typical guy material investment is $10. Also, one anchor and down-guy per 1,000 feet would be typical. Therefore the embedded anchor and guy exempt material loading included in the default value of $216 is approximately $8.25 - $13.75 per pole.

The steel strand run between poles is likewise an exempt material item, charged to the aerial cable account. The cost of steel strand is not included in the cost of poles; it is included in the installed cost of aerial cable.

2.4.2. Buried Copper Cable Sheath Multiplier (feeder and distribution)

Definition: The additional cost of the filling compound used in buried cable to protect the cable from moisture, expressed as a multiplier of the cost of non-filled cable.

Default Value:

Buried Copper Cable Sheath Multiplier	
Multiplier	1.04

Support: Filled cable is designed to minimize moisture penetration in buried plant. This factor accounts for the extra investment incurred by using more expensive cable and splicing procedures, designed specifically for buried application.

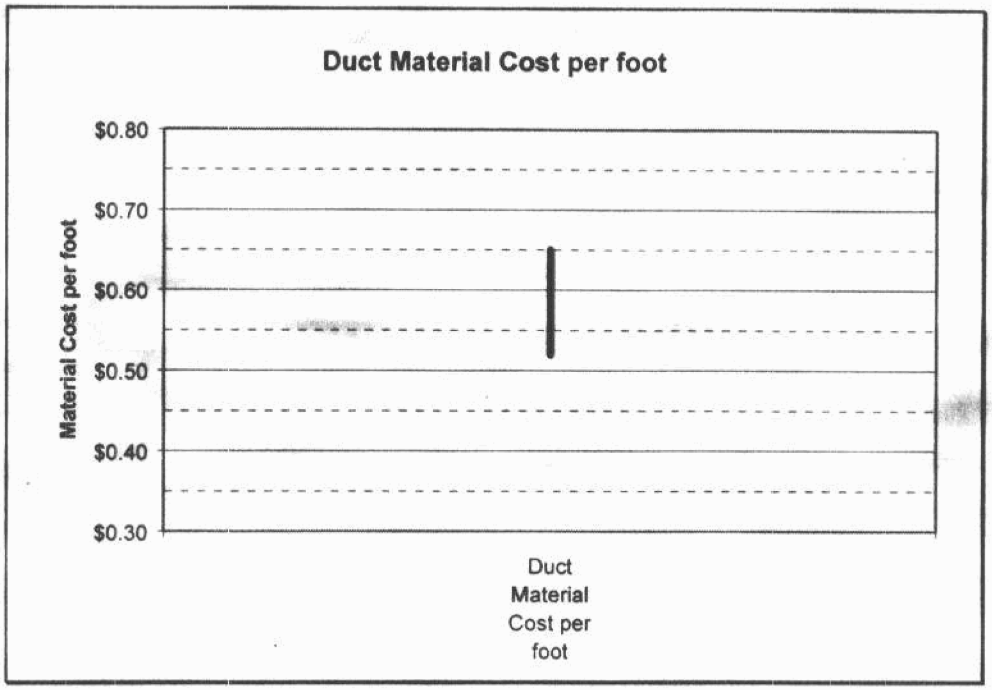
2.4.3. Conduit Material Investment per Foot

Definition: Material cost per foot of 4" PVC pipe.

Default Values:

Material cost per foot of duct for 4" PVC	
4" PVC	$0.60

Support: Several suppliers were contacted for material prices. Results are shown below.



The labor to place conduit in trenches is included in the cost of the trench, not in the conduit cost.

Under the Model's assumptions, a relatively few copper cables serving short distances (e.g., less than 9,000 ft. feeder cable length), and one or more fiber cables to serve longer distances, will be needed. Since the number of cables in each of the four feeder routes is relatively small, the predominant cost is that of the trench, plus the material cost of a few additional 4" PVC conduit pipes.

2.4.4. Spare Tubes per Route

Definition: The number of spare tubes (i.e., conduit) placed per route.

Default Value:

Spare Tubes per Route	
# Spare Tubes	1

Support: "A major advantage of using conduits is the ability to reuse cable spaces without costly excavation by removing smaller, older cables and replacing them with larger cables or fiber facilities. Some companies reserve vacant ducts for maintenance purposes."[6] HM 5.1 provides one spare maintenance duct (as a default) in each conduit run. In addition, if there is also a fiber feeder cable along with a copper feeder cable in the run, an additional maintenance duct (as a default) is provided in each conduit run to facilitate a fiber cable replacement at the same time a copper cable replacement may be required.

[6] Bellcore, *BOC Notes on the Networks - 1997*, p. 12-46.

2.5. BURIED, AERIAL, AND UNDERGROUND PLACEMENT FRACTION

General:

Outside plant structure refers to the set of facilities that support, house, guide, or otherwise protect distribution and feeder cable. There are three types of structure: aerial, buried, and underground.

a) Aerial Structure

Aerial structure includes poles and associated hardware. Pole investment is a function of the material and labor costs of placing a pole. A user-adjustable input adjusts the labor component of poles investment to local conditions. The HAI Model computes the total investment in aerial distribution and feeder structure within a study area by evaluating relevant parameters, including the distance between poles, the investment in the pole itself, the total cable sheath mileage, and the fraction of aerial structure along the route.

Poles are assumed to be 40 foot Class 4 poles. The spacing between poles for aerial cable is fixed within a given density range, but may vary between density ranges.[7]

b) Buried Structure

Buried structure consists of trenches. The additional cost for protective sheathing and waterproof filling of buried cable is a fixed amount per foot in the case of fiber cable, and is a multiplier of cable cost in the case of copper cable.[8] The total investment in buried structure is a function of total route mileage, the fraction of buried structure, investment in protective sheathing and filling and the density-range-specific cost of trenching.

c) Underground Structure

Underground structure consists of conduit and, for feeder plant, manholes and pullboxes. Manholes are used in conjunction with copper cable routes; pullboxes are used with fiber cable. The total investment in a manhole varies by density zone, and is a function of the following investments: materials, frame and cover, excavation, backfill, and site delivery. Investment in fiber pullboxes is a function of materials and labor. Underground cables are housed in conduit facilities that extend between manholes or pullboxes. The total investment in underground structure is a function of total route mileage, the fraction of underground structure, investment in conduit, manholes and pullboxes for copper and fiber feeder or plant, and the cost of trenching needed to hold the conduit.

In each line density range, there may be a mixture of aerial, buried, and underground structure. For example, in downtown urban areas it is frequently necessary to install cable in underground conduit systems, while rural areas may consist almost exclusively of aerial or direct-buried plant. Users can adjust the mix of aerial, underground and buried cable assumed within the HAI model. These settings may be made separately by density zone for fiber feeder, copper feeder, and copper distribution cables.

d) Buried Fraction Available for Shift

This input addresses the ability of the model to perform a dynamic calculation to determine the most efficient life-cycle costs of buried vs. aerial structure. The calculation considers the different values

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[7] In the two highest density zones, aerial structure is also assumed to consist partly of intrabuilding riser cable and "block cable" attached to buildings. In HM 5.1 this portion of "aerial" structure does not include poles.

[8] The default values for sheathing are an additive $0.20 per foot for fiber and a multiplier of 1.04 for copper. The different treatment reflects the fact that the outside dimension of fiber cable is essentially constant for different strand numbers, while the dimension of copper cable increases with the number of pairs it contains.

involved in buried vs. aerial structure in terms of initial investment, sub-surface conditions, soil texture, percent structure sharing, depreciation rates, and maintenance costs.

Underground conduit is not considered as a candidate for structure shifting, since the motivation for placing underground conduit and cable is usually a function of high pavement costs and the need to allow for future replacement and addition of cables without disturbing the above ground pavement conditions.

2.5.1 Distribution Structure Fractions

Definition: The relative amounts of different structure types supporting distribution cable in each density zone. In the highest two density zones, aerial structure includes riser and block cable.

Default Values: See under 2.5.2, below.

Support: It is the opinion of outside plant engineering experts that density, measured in Access Lines per Square Mile, is a good determinant of structure type. That judgment is based on the fact that increasing density drives more placement in developed areas, and that as developed areas become more dense, placements will more likely occur under pavement conditions.

Aerial/Block/Building Cable:

"The most common cable structure is still the pole line. Buried cable is now used wherever feasible, but pole lines remain an important structure in today's environment."[9]

Where an existing pole line is available, cable is normally placed on the existing poles. Abandoning an existing pole line in favor of buried plant is not usually done unless such buried plant provides a much less costly alternative.

HM 5.1 accounts for drop wire separately; drop wire is not considered part of aerial cable in HM 5.1. However, cable attached to the [out]sides of buildings and intrabuilding riser cable, which are normally found in higher density areas, are appropriately classified to the aerial cable account. To facilitate modeling, HM 5.1 includes cable attached to and within buildings under its treatment of aerial cable, while allowing the user to separately specify the fraction of cable that falls in these two categories; poles are not applied to these types of aerial cable.

The default aerial percentages above 5,000 lines per square mile reflect a growing amount of block and intrabuilding cable, rather than cable placed on poles (although existing joint use poles are also more prevalent in older, more dense neighborhoods built prior to 1980). The specification of the amount of aerial cable supported via attachment to the outsides or insides of buildings is handled by the parameter "Block / Building Fraction of Aerial Distance" (see para. 2.5.3.). Use of that parameter removes pole costs from such cable investment calculations.

Buried Cable:

Default values in HM 5.1 reflect an increasing trend toward use of buried cable in new subdivisions. Since 1980, new subdivisions have usually been served with buried cable for several reasons. First, before 1980, cables filled with water blocking compounds had not been perfected. Thus, prior to that time, buried cable was relatively expensive and unreliable. Second, reliable splice closures of the type required for buried facilities were not the norm. And third, the public now clearly desires more out-of-sight plant for both aesthetic and safety-related reasons. Contacts with telephone outside plant engineers, architects and property developers in several states confirm that in new subdivisions, builders typically not only prefer buried plant that is capable of accommodating multiple uses, but they usually dig the trenches at their own expense and place power, telephone, and CATV cables in the trenches, if the utilities are willing to supply the materials. Thus, many buried structures are available to the LEC at no charge, although the Model does not reflect such savings.

[9] Bellcore, BOC Notes on the Networks - 1997, p. 12-45.

Underground Cable:

Underground cable, conduit, and manholes are primarily used for feeder and interoffice transport cables, not for distribution cable. Distribution plant in congested, extensively paved, high density areas usually runs only a short distance underground from the SAI to the block terminal, thus it requires no intermediate splicing chambers. In high density residential areas, distribution cables are frequently run from pole lines, under a street, and back up onto a pole line, or from buried plant, under a street, and back to a buried cable run. Such conduit runs are short enough to not require a splicing chamber or manhole and are therefore classified to the aerial or buried cable account, respectively.

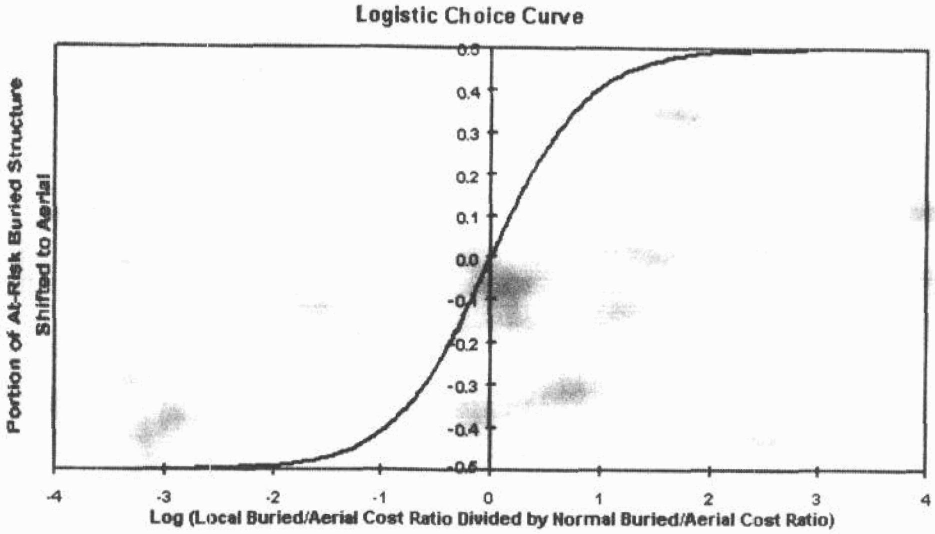
There may be rare exceptions where distribution cable from a SAI is so long that it requires an underground splicing chamber (manhole). Sometimes feeder cable will be extended, via a lateral, into a SAI, and distribution pairs in the same feeder stub will run back into the same manhole for further routing to aerial or buried structures down a street. In those cases, manholes and conduit were placed for feeder cable and have already been accounted for in the cost of feeder plant structure. To account for such manholes and conduit in distribution plant as well would result in double counting the cost.

In a "campus environment," where underground structure is used, it is owned and operated by the owner of the campus and not the ILEC. The cable is treated as Intrabuilding Network Cable between buildings on one customer's premises, and the cost of such cable is not included in the model.

2.5.2 Buried Fraction Available for Shift

Fraction of buried cable structure available to be shifted from buried to aerial or aerial to buried (if the model finds abnormal local terrain conditions making a shift from aerial to buried advantageous, a check in the model prevents the percent buried from going greater than unity and the percent aerial from going below zero). The fraction is expressed as the total range over which the buried fraction can vary after shifting. If, for example, the user has entered an initial value of 0.50 for the buried cable fraction in a given density zone and then enters 0.80 as the range of the shift that may occur in the buried fraction, the model can allow the computed buried fraction to vary between 0.30 (= 0.50 - 40% of 0.50) and 0.70 (= 0.50 + 40% of 0.50), according to changes in the relative costs of buried versus aerial structure occasioned by local surface and bedrock conditions.

HM 5.1 uses a "Logistic Choice Curve" to control the sensitivity of the shift in structure to changes in the local relative cost of buried versus aerial plant. In the chart below, the horizontal axis represents the ratio of the local buried to aerial cost ratio to the national norm buried to aerial cost ratio. Its scale is logarithmic, thus the value of zero indicates that the local buried/aerial cost ratio equals the national buried/aerial cost ratio. Increasing positive values indicate the local buried to aerial cost ratio has increased relative to the national ratio – as would occur, for instance, if local bedrock were closer to the surface than normal. Negative values indicate a local buried to aerial cost ratio that is less than the national ratio. The vertical axis represents the portion of "swing" buried plant that is shifted to aerial. A value of 0.0 means there is no movement away from the input amount of buried structure; 0.5 means the maximum amount of shift has occurred from buried to aerial, and negative 0.5 means the maximum amount of shift has occurred from aerial to buried.



Default Values:

Distribution Cable Structure Fractions				
Density Zone	Aerial/Block /Building Cable	Buried Cable	Underground Cable (calculated)	Buried Fraction Available for Shift
0-5	.25	.75	0	.75
5-100	.25	.75	0	.75
100-200	.25	.75	0	.75
200-650	.30	.70	0	.75
650-850	.30	.70	0	.75
850-2,550	.30	.70	0	.75
2,550-5,000	.30	.65	.05	.75
5,000-10,000	.60	.35	.05	-
10,000+	.85	.05	.10	-

Support: Since shifting of structure type from buried to aerial, or vice versa is permitted, the HAI Model allows the user to affect such shifting by the application of engineering judgment. Should aerial structure be the most economic solution in a particular cable section, the model's inputs could be set to allow a shift of all buried structure to aerial. However, there may be local ordinances or regulatory rules that encourage utilities to place out-of-sight facilities under certain conditions. Thus, in the event shifting from buried to aerial is not practical, the HAI Model allows the user to reserve a percentage of buried cable structure that remains buried, irrespective of the relative costs. A team of outside plant engineering experts recommends that the allowed range of the shifted buried fraction be only 75% of the input buried percentage.

The user should note that this default value can be adjusted to allow the model to optimize the cable structure choice between aerial and buried structure without constraint other than ensuring the aerial percentage is not less than 0%. On the other hand, setting the fraction available for shift to 0% means that no optimization will take place, thereby locking in the judgement of the user in setting the input values for the various structure percentages regardless of situations uncovered by the model in examining unique pockets of difficult terrain where a more economic solution would prevail.

2.5.3. Block / Building Fraction of Total Distance

Definition: This value represents, by density zone, the fraction of the total distribution structure that is block or building riser cable. Subtracting this fraction from the Aerial/Block/Building cable fraction discussed in sections 2.5.1 will yield the fraction of aerial structure requiring poles. For instance, in the highest density zone, the default fraction of aerial cable (parameter 2.5.1) is .85, while in the table below, the default fraction of block/building cable is .65, so in this density zone, poles are applied to .85 minus .65, or .2, of the distribution cable route miles.

Default Values:

Block/Building Fraction of Total Distance	
Density Zone	Fraction
0-5	0
5-100	0
100-200	0
200-650	0
650-850	0
850-2,550	0
2,550-5,000	0
5,000-10,000	.35
10,000+	.65

Support: As stated in paragraph 2.5.1., aerial structure includes riser and block cable in the two highest density zones. In addition, cable attached to the sides of buildings, normally found in higher density areas, is appropriately classified to the aerial cable account. To facilitate modeling, the HAI Model includes both block and Intrabuilding Network Cable under its treatment of aerial cable.

HM 5.0a was criticized for its lack of pole costs in the highest two density zones. HM 5.1 recognizes that aerial cable in the two highest density zones can either be supported by poles, can be attached to the sides and backs of buildings, or can consist of Intrabuilding Network (Riser) cable inside elevator shafts or other pathways inside a building. HM 5.1 has thus been modified to apply pole costs in each density zone, including the two highest density zones, except that pole costs will be applied only to that fraction of aerial cable that remains after the block and intrabuilding cable fraction represented by this fraction is subtracted.. Generally speaking, building owners now have the right to own their own building cable. In many states, the ILEC is still the provider of last resort, and in those cases must still provide building riser cable. HM 5.1 conservatively assumes that the ILEC will own all building riser cable, as well as distribution cable attached to the outside walls of buildings.

Pathways for cable inside buildings are the responsibility of the building owner, not the ILEC. Therefore, there are no structure costs akin to pole investments. Cable attached to the outsides of buildings requires simple wall anchors, the cost of which is already included in the exempt material loadings on labor. Therefore, while pole costs are included for all aerial cable that is not building-mounted or intrabuilding cable, there are no structure costs associated with the latter two categories of aerial cable.

2.6. CABLE SIZING FACTORS AND POLE SPACING

2.6.1. Distribution Cable Sizing Factors

Definition: The factor by which distribution cable is increased above the size needed to serve a given quantity of demand in order to provide spare pairs for breakage, line administration, and some amount of growth. Calculated as the target ratio of the number of assigned pairs to the total number of available pairs in the cable.

Default Values:

Distribution Cable Sizing Factors	
Density Zone	Factors
0-5	.75
5-100	.75
100-200	.75
200-650	.75
650-850	.75
850-2,550	.75
2,550-5,000	.75
5,000-10,000	.75
10,000+	.75

Support: HM5.1 uses uniform copper cable sizing factors across all density zones for the following reasons:

- The ratio of adjacent cable sizes is considerably greater for small cables than for large ones. Pair counts for small cables essentially double between cable sizes, so that such cables easily allow enough extra pairs to accommodate administrative spare needs.[10] The controlling effect is the "breakage," or modularity in cable sizes, which produces an effective fill factor that is often considerably less than the corresponding input cable sizing factor.[11]

- A small copper cable may serve a small (and compact) pocket of customer locations in a high density zone or a more widely-dispersed (but still small) set of customers in a low density zone; there is no need for the cable sizing factors to be different for these cases. For this reason, the cable sizing factor should be constant across all density ranges.

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[10] Simple calculations readily show that using 50% copper cable sizing factors in low density zones is unreasonable. For example, eleven households with an average of 1.2 lines per household require a total of thirteen lines. Dividing the line total by a 50% copper cable sizing factor yields a requirement for 26 equipped pairs, which would be satisfied by installing a 50-pair cable, the next available size. The achieved cable fill is only 26%, even though the sizing factor is nearly twice that. If demand were to increase at a compounded rate of 4% per year, after ten years the cable utilization would be only 39%. After twenty years, the cable's useful life, it would still only be at 57% utilization, and 43% of the cable's capacity would be wasted because of inefficient design.

[11] Several states have been modeled using a 75% distribution cable sizing factor and an 80% copper feeder cable sizing factor. The corresponding achieved copper cable fills ranged from 50% to 65% for distribution cable and between 65% and 78% for copper feeder cable.

- Some state commissions, along the FCC, have adopted uniform or nearly-uniform copper cable sizing factors across density zones for running the HAI Model. Selecting such factors thus recognizes this trend among regulatory bodies.

In general, the level of spare capacity provided by the default value of 75% in HM 5.1 is sufficient to meet current demand plus some amount of growth over the lifetime of the smaller cable sizes normally selected by the model to serve a given area. Because the model calculates the unit loop investment cost as the total loop investment (including spare capacity), divided by the current loop demand, the resulting unit costs are a conservatively high estimate of the economic cost of meeting current loop demand. This occurs because, in reality, some of the spare distribution plant can and will be used to satisfy additional loop demand in the future, without causing any additional investment cost, thus a larger number of customers will pay for the cable over time. In this sense, the HM 5.1 default values for the distribution cable sizing factors are conservatively low from an economic costing standpoint.

2.6.2. Distribution Pole Spacing

Definition: Spacing between poles supporting aerial distribution cable.

Default Values:

Distribution Pole Spacing	
Density Zone	Spacing
0-5	250
5-100	250
100-200	200
200-650	200
650-850	175
850-2,550	175
2,550-5,000	150
5,000-10,000	150
10,000+	150

Support: Distances between poles are longer in more rural areas for a several reasons. Poles are usually placed on property boundaries, and at each side of road intersections (unless cable is run below the road surface in conduit). Property boundaries tend to be farther apart in less dense areas, and road intersections are also farther apart.

Depending on the weight of the cable, and the generally accepted guideline that sag should not exceed 10 feet at mid-span, while still maintaining appropriate clearances as designated by the National Electric Safety Code, very long spans between poles may be achieved. This length may be as great as 1,500 feet using heavy gauge strand and very light cable, or may be shorter for heavier cables.[12] In practice, much shorter span distances are employed, usually 400 feet or less.

"…where conditions permit, open wire spans can approach 400 feet in length with practical assurance that the lines will withstand any combination of weather condition. Longer spans mean savings in construction

[12] Bellcore, Clearance for Aerial Cable and Guys in Light, Medium and Heavy Loading Areas, (BR 627-070-015), Issue 1, 1987.
see also, Bellcore, Clearances for Aerial Plant, (BR 918-117-090), Issue 5, 1987.
see also, Bellcore, Long Span Construction (BR 627-370-XXX), date unk.

costs and a net reduction in over-all plant investment, including fewer poles to buy, smaller quantity of pole hardware required, and less construction time. The use of long spans also means a reduction in maintenance expense."[13]

[13] Lee, Frank E., *Outside Plant, abc of the Telephone Series, Volume 4*, abc TeleTraining, Inc., Geneva, IL, 1987, p. 41.

2.7. GEOLOGY AND POPULATION CLUSTERS

2.7.1. Distribution Distance Multiplier, Difficult Terrain

Definition: The amount of extra distance required to route distribution and feeder cable around difficult soil conditions, expressed as a multiplier of the distance calculated for normal situations.

Default Value:

Distribution Distance Multiplier, Difficult Terrain
1.0

Support: HM 5.1 treats difficult buried cable placement in rock conditions using five parameters: 1) Distribution Distance Multiplier, Difficult Terrain; 2) Surface Texture Multiplier; 3) Rock Depth Threshold, inches; 4) Hard Rock Placement Multiplier; and 5) Soft Rock Placement Multiplier. The last three of these pertain to the effect of bedrock close to the surface – see Section 2.7.2 through 2.7.5. The first pertains to difficult soil conditions such as the presence of boulders.

While the typical response to difficult soil conditions is often to simply route cable around those conditions, which could be reflected in this parameter, HM 5.1 instead treats the effect of difficult soil conditions as a multiplier of placement cost - see Parameter 6.5, Surface Texture Multiplier. Therefore, the distribution distance multiplier is set to 1.0.

2.7.2. Rock Depth Threshold, Inches

Definition: The depth of bedrock, above which (that is, closer to the surface) additional costs are incurred for placing distribution or feeder cable. The depth of bedrock is provided by USGS data for each CBG, and assigned by the Model to the CBs belonging to that CBG.

Default Value:

Rock Depth Threshold, inches
24 inches

Support: Cable is normally placed at a minimum depth of 24 inches. Where USGS data indicates the presence of rock closer to the surface, HM 5.1 imposes additional costs.

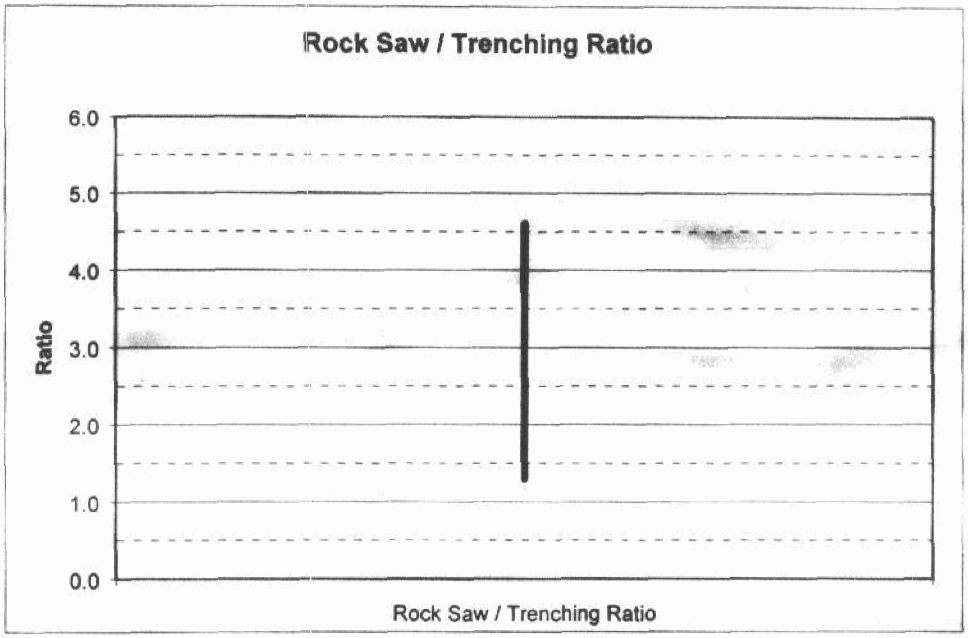
2.7.3. Hard Rock Placement Multiplier

Definition: The increased cost required to place distribution or feeder cable in bedrock classified as hard, when it is within the rock depth threshold of the surface, expressed as a multiplier of normal installation cost per foot.

Default Value:

Hard Rock Placement Multiplier
3.5

Support: A rock saw is used whenever hard rock must be excavated. Information received from independent contractors who perform this type of work is reflected below. Hard rock costs are reflected at the high end of the scale.



2.7.4. Soft Rock Placement Multiplier

Definition: The increased cost required to place distribution or feeder cable in bedrock classified as soft, when it is within the rock depth threshold of the surface, expressed as a multiplier of normal installation cost per foot.

Default Value:

Soft Rock Placement Multiplier
2.0

Support: A rock saw or tractor-mounted ripper is used whenever soft rock must be excavated. Information received from independent contractors who perform this type of work is reflected in the figure in section 2.7.3. Soft rock costs are reflected at the lower end of the scale.

2.7.5. Sidewalk / Street Fraction

Definition: The fraction of small, urban clusters that are streets and sidewalks, used in the comparison of cluster area with number of lines to identify cases where high rise buildings are present. To qualify as a small urban cluster, the total land area after multiplying by (1-this fraction) must be less than .03 square miles, and the line density must exceed 30,000 lines per square mile.

Default Value:

Sidewalk / Street Fraction
.20

Support: The sidewalk/street fraction is computed using a .03 square mile (836,352 square feet) cluster, the largest cluster to which it applies. This dense urban cluster is assumed to be square, which means each side of the cluster is approximately 915 feet long. As a result, the roads and sidewalks running around the outside of such a cluster would cover a total land area of approximately 165,000 square feet (915 feet per side times 4 sides times (15 foot wide sidewalk + .5 times 60 foot wide street), or 20 percent of the cluster's total area. The remaining 80 percent, or non-sidewalk/street land area, is occupied by buildings.

2.7.6. Maximum Analog Copper Total Distance

Definition: The maximum total copper cable length that is allowed to carry voiceband analog signals. When the potential copper cable length exceeds this threshold, it triggers long loop treatment using digital transmission and/or the deeper penetration of fiber-based DLC.

Default Value:

Maximum Analog Copper Total Distance
18,000 ft.

Support: From the Bellcore document, *BOC Notes on the Networks – 1997, p.12-4,* the following principles are invoked. "To help achieve acceptable transmission in the distribution network, design rules are used to control loop transmission performance. Loops are designed to guarantee that loop transmission loss is statistically distributed and that no single loop in the distribution network exceeds the signaling range of the central office. Revised Resistance Design (RRD) guidelines recommend that loops 18 kft in length or less, including bridged-tap, should be nonloaded and have loop resistances of 1300 Ohms or less; loops 18 kft to 24 kft in length (including bridged-tap) should be loaded and have loop resistances less than or equal to 1500 Ohms; loops longer than 24 kft should be implemented using Digital Loop Carrier (DLC)." The default value was chosen to be consistent with the minimum distance at which long loop treatment is usually required. [14]

2.7.7. Feeder Steering Enable

Definition: An option that, if enabled, instructs the model to adjust each main feeder route direction toward the preponderance of clusters in a quadrant. In the default state, feeder routes run north, east, south, and west from the wire center..

Default Value:

[14] Bellcore, BOC Notes on the Networks - 1997, p. 12-4.

Feeder Steering Enable
Disabled

Support: The HAI Model will normally assume that four feeder routes emanate from each wire center in the four cardinal directions of north, east, south, and west. When the "Feeder Steering Enable" indicator is selected, the model will adjust the direction of a main feeder route to be closer to the more distant serving area interfaces.

2.7.8. Main Feeder Route/Air Multiplier

Definition: Route-to-air multiplier applied to main feeder distance when feeder steering is enabled to account for routing main feeder cable around obstacles.

Default Value:

Main Feeder Route / Air Multiplier
1.27

Support: Although the feeder route between a wire center and the serving area interface can run in a straight line, such routes may encounter natural obstacles, property boundaries, and the like which cause some degree of rerouting. The Model in default mode assumes right angle routing to accommodate these various obstacles. However, when feeder steering is enabled, the model accounts for non-direct routing through the use of a route-to-air distance multiplier. Because SAIs can be located at any point on the compass, the weighted average right angle routing distance of $4/\pi$, or 1.27, is the most appropriate solution for the average route to air factor.

2.7.9. Require Serving Areas to be Square

Definition: An option that, if enabled, instructs the model to treat all main clusters as square. In the default state, main clusters are computed as rectangular, with the height to width ratio determined by the process that produces the cluster input data.

Default Value:

Require serving areas to be square
disabled

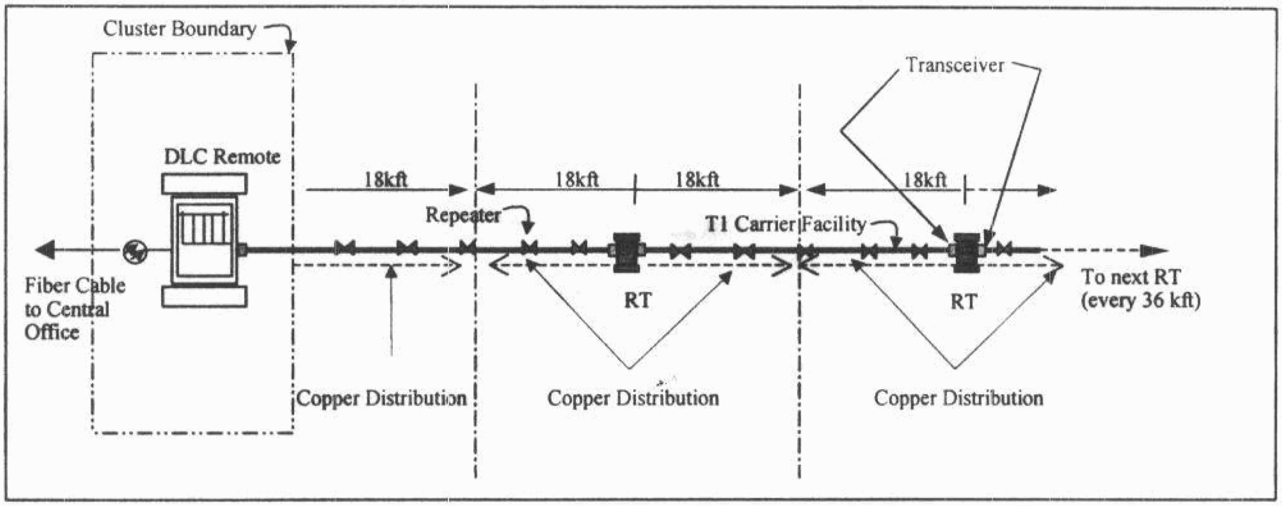
Support: Main clusters are normally treated as if they are rectangular, with the height to width ratio (aspect ratio) determined by the process that produces the cluster input data. The aspect ratio for each cluster is computed by PNR and included in the input data. However, to allow comparisons with results of the Benchmark Cost Proxy Model ("BCPM"), the Model allows the user to override the calculated aspect ratio and specify the use of square areas, even though useful information is ignored in doing so.

2.8. LONG LOOP INVESTMENTS

General:

HM 5.1 extends fiber-fed Integrated Digital Loop Carrier (IDLC) sufficiently deep into the main cluster to ensure no main cluster loop length exceeds the maximum analog copper loop length. An additional test is performed to determine if the copper distribution cable from the main cluster to a given associated outlier cluster is longer than the Maximum Analog Copper Distance, if the outlier cluster is connected to the main cluster through one or more other outlier clusters, or if any other outlier clusters are connected to the one in question. If none of these conditions hold, the Model will serve the outlier cluster using analog copper distribution cable. Otherwise, the Model serves the outlier cluster in question using T1 on an appropriate number of copper pairs, equipped with T1 repeaters as necessary, feeding small DLC remote terminals (RTs) which are strategically placed along the route to limit the distribution cable to the maximum analog distance. The T1 carrier extensions are assumed to be extended from a Low Density DLC located within the main cluster.

The system configuration for such T1 "long loop" extensions have a number of components described in parameters 2.8.1. through 2.8.8. The relationship among these components is shown in the following figure.



2.8.1. T1 Repeater Investments, Installed

Definition: The investment per T1 repeater, including electronics, housing, and installation, used for T1 carrier long loop extensions.

Default Value:

Repeater Investment, Installed
$527

Support: The cost of a line powered T1 repeater was estimated by a team of experienced outside plant experts with extensive experience in purchasing such units, and arranging for their installation. The equipment portion of this investment is based on supplier information less discount. The repeater spacing is calculated within the model considering the transmission loss of aerial and buried cable, and a transmission objective of 32 dB loss at 772 kHz.

2.8.2. Integrated COT, Installed

Definition: The installed central office multiplexer investment required per road cable used for T1 long loop extensions.

Default Value:

Integrated COT, Installed
$420

Support: This is the pro rata share of investment for hardware and commons involving multiplexer capacity in the central office utilized by each T1 carrier long loop extension. It was estimated by a team of experienced outside plant experts who were in contact with vendors of appropriate small size IDLC equipment with the capability of being fed by T1 carrier on copper pairs. The material portion of this investment is based on vendor list prices less discount.

2.8.3. Installed RT Cabinet and Commons

Definition: The installed investment per T1 RT used for T1 carrier long loop extensions.

Default Value:

Installed RT Cabinet and Commons
$8,200

Support: The cost of this type small size DLC remote terminal was estimated by a team of experienced outside plant experts who were in contact with vendors of appropriate small size DLC equipment fed by T1 carrier on copper pairs. The equipment portion of this investment is based on vendor list prices less discount.

2.8.4. T1 Channel Unit Investment per Subscriber

Definition: The investment per line in POTS channel units installed in T1 RT used for T1 carrier long loop extensions.

Default Value:

Channel Unit Investment per Subscriber
$125

Support: The cost of appropriate line cards, including a pro rata share of DS1 plug-ins at the CO multiplexer used for this type of Integrated Digital Loop Electronics, was estimated by a team of experienced outside plant experts who were in contact with vendors of appropriate small size DLC equipment suitable for extending bandwidth on conditioned copper pairs. The equipment portion of this investment is based on vendor list prices less discount.

2.8.5. Transceivers

Definition: The installed investment for the transceiver plug-in per T1 RT used to interface with the T1 carrier and to power the repeaters.

Default Value:

Transceiver, Installed
$1170

Support: The cost was estimated by a team of experienced outside plant experts who were in contact with equipment vendors. This cost includes the investment for the transceiver plug-in installed at each end of the T1 carrier feeding the small size RT. The material portion of this investment is based on vendor list prices less discount.

2.8.6. T1 Remote Terminal Fill Factor

Definition: The line unit fill factor in a T1 RT; that is, the ratio of lines served by a T1 remote terminal to the number of line units equipped in the RT.

Default Value:

T1 Remote Terminal Fill Factor
0.90

Support: Fill factors are largely a function of the time frame needed to provide incremental additions. Since line cards are a highly portable asset, facility relief can be provided by dispatching a technician with line cards, rather than engaging in a several month long copper cable feeder addition. Therefore high fill rates should be the norm for an efficient provider using forward looking technology.

2.8.7. Maximum T1s per Cable

Definition: Maximum number of T1s that can share a cable without binder group separation or internal shielding.

Default Value:

Maximum T1s per Cable
8

Support: The use of T-Carrier technology involves the use of high frequency pulse code modulation techniques. High frequency signals can cause interference with other high frequency signals, if a number of electrical engineering characteristics are ignored. While screened cable can be used to isolate copper pairs in cables with very large numbers of T-1's, that is not necessary for small numbers of T-1s in a cable. Experts in outside plant engineering have used the conservative approach of limiting the number of T-1s in a single copper cable sheath to preclude such interference. The default value of no more than 8 T-1s is frequently used in actual design of facilities. Although there are very few cases where the HAI Model now generates long loops on T-1 technology, this limit has been included to ensure that interference does not occur.

2.8.8. T1 Repeater Spacing Parameters

Definition: Minimum design separation, measured in decibels, on copper cable as a function of the maximum loss between adjacent repeaters at 772 kHz, and the loss of the copper cable on which the repeaters are installed. Used for T1 carrier long loop extensions.

Default Values:

DB Loss at 772 kHz		
Maximum dB Loss Between T1 Repeaters	dB Loss per 1,000 ft. of Aerial Air Core PIC Distribution Cable	dB Loss per 1,000 ft. of Buried & Underground Filled Solid PIC Cable
32.0	6.3	5.0

Support: Since these conditions occur on extremely long and small distribution cables, and since the HAI Model assumes 24 gauge cable for cable sizes of less than 400 pairs, the model assumes 24 gauge copper cable for these circuits. Although a maximum of 35 dB between T1 repeaters has been noted in the literature[15], a conservative value of 32.0 dB is recommended for the HAI Model default. T1 circuits are normally designed at the 772 kHz frequency point. Copper cable attenuation at this frequency is a function of the type of cable and the temperature of operation. The higher the temperature, the greater the attenuation.

Aerial cable is normally air core PIC (Plastic Insulated Conductor) cable. At the highest envisioned temperature of 140 degrees Fahrenheit, the attenuation is 6.3 dB/kft.[16]

Buried and Underground cable is normally considered to operate within normal temperature ranges. The HAI Model default values assume cables are filled with water blocking compound, using solid PIC insulation. The attenuation for such cable is 5.0 dB/kft.[17]

2.9. SAI INVESTMENT

Definition: The installed investment in the Serving Area Interface (SAI) that acts as the physical interface point between distribution and feeder cable.

[15] Roger L. Freeman, Reference Manual for Telecommunications Engineering – Second Edition, p.574-575.

[16] Lucent, Outside Plant Engineering Handbook, 1996, p. 5-14.

[17] Lucent, Outside Plant Engineering Handbook, 1996, p. 5-15.

Default Values:

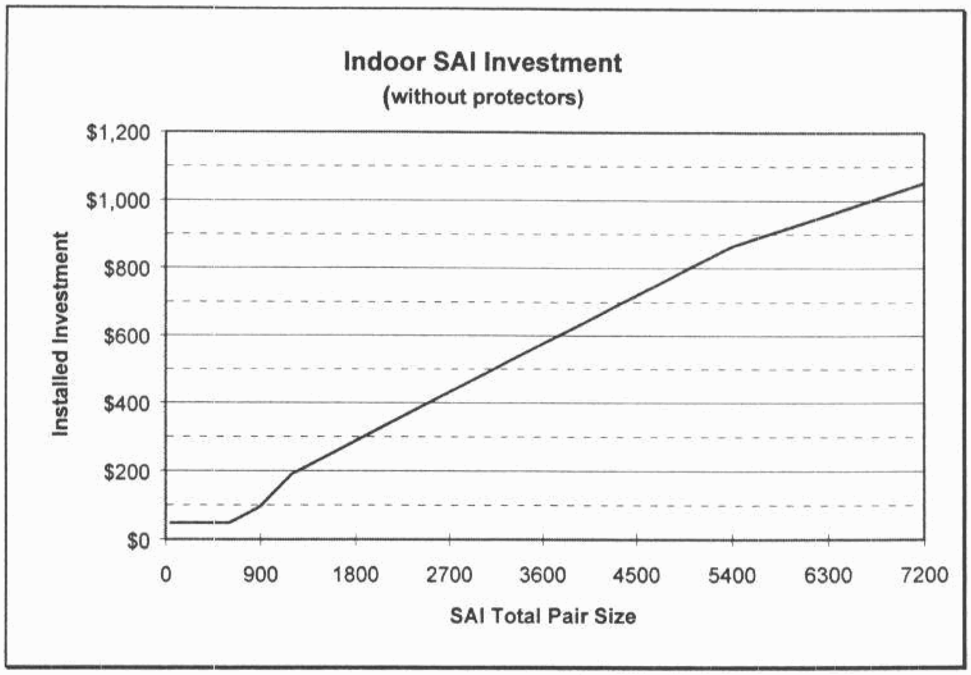
SAI Investment		
SAI Size	**Indoor SAI**	**Outdoor SAI**
7200	$9,656	$10,000
5400	$7,392	$8,200
3600	$4,928	$6,000
2400	$3,352	$4,300
1800	$2,464	$3,400
1200	$1,776	$2,400
900	$1,232	$1,900
600	$888	$1,400
400	$592	$1,000
200	$296	$600
100	$148	$350
50	$98	$250

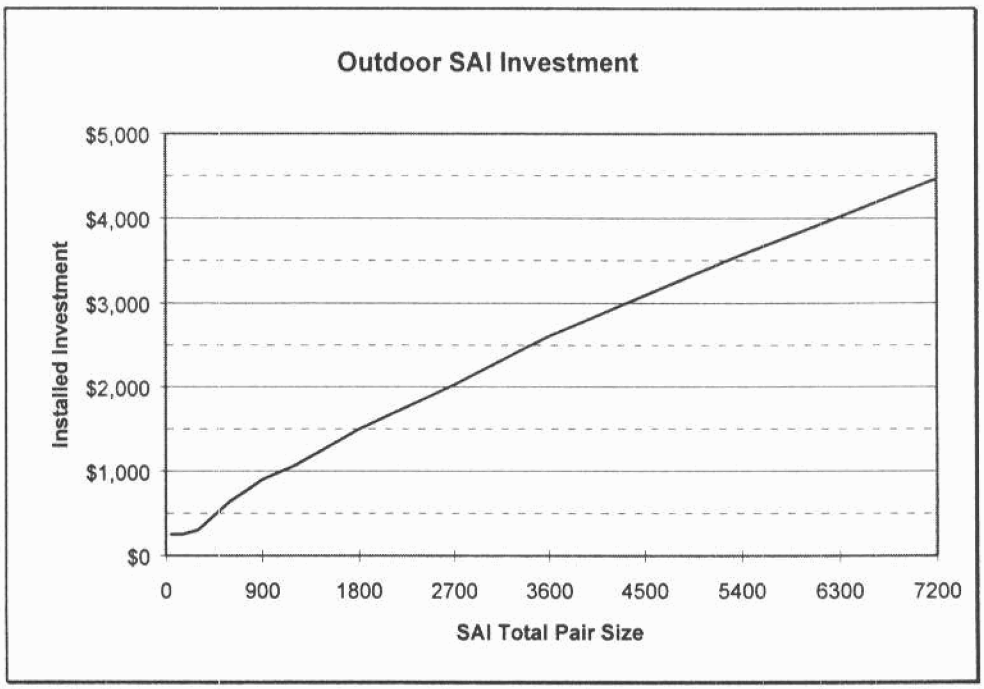
Support: Indoor Serving Area Interfaces are used in buildings, and consist of simple terminations, or punch down blocks, and lightning protection where required. Equipment is normally mounted on a plywood backboard in common space. Outdoor Serving Area Interfaces are more expensive, requiring steel cabinets that protect the cross connection terminations from the direct effects of water. Both indoor and outdoor SAI investments are a function of the total number of pairs, both Feeder and Distribution, that the SAI terminates.

The total number of pairs terminated in the SAI is computed as follows. a) The number of Feeder Pair terminations provided is equal to 1.5 times the number of households plus the number of business, special access, and public lines required. b) The number of Distribution Pair terminations provided is equal to 2.0 time the number of households plus the number of business, special access, and public lines required.

Indoor SAI investments include the cost of over-voltage protection. Costs for that protection are assumed to be based on splicing protector equipment on feeder pairs at a cost of $200 per 100 pair protector. SAIs with fewer than 200 feeder pairs are priced accordingly at $50 per 25 pair protector.

Prices are the opinion of a group of engineering experts.


Indoor SAI Investment
(without protectors)
Installed Investment
$1,200
$1,000
$800
$600
$400
$200
$0
0
900
1800
2700
3600
4500
5400
6300
7200
SAI Total Pair Size


Outdoor SAI Investment
Installed Investment
$5,000
$4,000
$3,000
$2,000
$1,000
$0
0
900
1800
2700
3600
4500
5400
6300
7200
SAI Total Pair Size

2.10. DEDICATED CIRCUIT INPUTS

2.10.1. Percentage of Dedicated Circuits

Definition: The fractions of total circuits included in the count of total private line and special access circuits that are DS-0 and DS-1 circuits, respectively. The fraction of DS-3 and higher capacity circuits is calculated by the model as (1 - fraction DS0 - fraction DS-1). The equivalence between the three circuit types -- that is, DS-0, DS-1, and DS-3 -- and wire pairs is expressed in Section 2.10.2.

Default Values:

Percentage of Dedicated Circuits	
DS-0	DS-1
100%	0%

Support: These parameters provide the breakdown of reported dedicated circuits into voice-grade equivalents and DS-0s, DS-1s, and DS-3s. The default database values for dedicated circuits represent special access voice-grade and DS-0 equivalents as reported in ARMIS 43-08. Thus, the default input values are 100 percent for DS-0/voice grade, and 0 percent for DS-1 and DS-3.

2.10.2. Pairs per Dedicated Circuit

Definition: Factor expressing the number of wire pairs required per dedicated circuit classification.

Default Values:

Pairs per Dedicated Circuit		
DS-0	DS-1	DS-3
1	2	56

Support: A DS-1 bit stream on copper requires one transmit pair and one receive pair. Although a DS-3 signal can only be transmitted on fiber or coax, the bit stream carries the equivalent of 28 DS-1's. Since a DS-1 requires 2 pairs, a DS-3 is represented in HM 5.1 as requiring 28 times 2 pairs, or a total of 56 pairs. While many DS-0s are provided on 4-wire circuits, the model conservatively assumes only one pair per DS-0.

2.11. WIRELESS INVESTMENT INPUTS

2.11.1. Wireless Investment Cap Enable

Definition: When enabled, invokes wireless investment cap for distribution plant investment calculations. In the default mode, the model does not impose the wireless cap.

Default Value:

Wireless Investment Cap Enable
Disabled

Support: If a viable wireless technology exists using forward looking, currently deployable technology, with available frequency spectrum allocation, then this alternative may be used to cap distribution costs at a pre-determined investment cost.

2.11.2. Wireless Point to Point Investment Cap – Distribution

Definition: Per-subscriber investment for hypothetical point to point subscriber radio equipment..

Default Value:

Wireless Point to Point Investment Cap
$7,500

Support: Based on HAI judgment of potential cost of such a system.

2.11.3. Wireless Common Investment

Definition: Base Station Equipment investment for hypothetical broadcast wireless loop system

Default Value:

Wireless Common Investment
$112,500

Support: Based on HAI judgment of potential cost of such a system.

2.11.4. Wireless per Line Investment

Definition: Per-subscriber investment for hypothetical broadcast wireless loop systems, including customer premises equipment and per subscriber share of base station radios..

Default Value:

Wireless per Line Investment
$500

Support: Based on HAI judgment of potential cost of such a system.

2.11.5. Maximum Broadcast Lines per Common Investment

Definition: Hypothetical capacity of base station common equipment.

Default Value:

Wireless Broadcast Lines per Common Investment
30

Support: Based on HAI judgment of representative capacity of such a wireless broadcast system.

2.12. OCCUPANCY RATES

Definition: These values represent the fraction of various dwelling unit types that are occupied in a particular density range; they are used in the calculation of drop structure investment.

Default Values:

Occupancy Rates										
Density Zone	Single Family Detach	Single Family Attach	2	4	5-9	10-19	20-49	50+	Mobile	Other
0-5	0.785	0.823	0.762	0.740	0.700	0.627	0.576	0.554	0.753	0.639
5-100	0.879	0.843	0.867	0.834	0.804	0.768	0.694	0.614	0.847	0.735
100-200	0.923	0.869	0.889	0.871	0.851	0.830	0.748	0.705	0.873	0.801
200-650	0.933	0.883	0.892	0.889	0.865	0.853	0.814	0.766	0.879	0.801
650-850	0.944	0.883	0.864	0.888	0.865	0.856	0.840	0.806	0.876	0.826
850-2,550	0.952	0.912	0.893	0.891	0.877	0.869	0.864	0.844	0.877	0.861
2,550-5,000	0.961	0.928	0.904	0.895	0.886	0.880	0.880	0.874	0.881	0.894
5,000-10,000	0.961	0.933	0.923	0.908	0.898	0.890	0.890	0.885	0.918	0.904
10,000+	0.953	0.935	0.934	0.918	0.913	0.910	0.920	0.919	0.928	0.916

Support: Drop structure requirements are tailored to include rate of occupancy by housing type and density zone. Occupancy rates are determined using 1990 Census data. Occupancy is calculated using the specified number of occupied and vacant housing units reported for each Census Block Group (CBG) and Housing Type. Each CBG is assigned a density zone, consistent with the assignment approach used throughout the Model. CBGs are then aggregated to density zone and occupancy is calculated by dividing occupied housing by the sum of occupied and vacant housing

2.13. DISTRIBUTION ROUTE DISTANCE ADJUSTMENTS

2.13.1 Strand Adjustment Factors

Definition: Two parameters that together provide the optional ability of normalizing the distribution route distance (DRD) produced by the model to a function of the calculated strand distance. The two parameters can be set independently for each density zone.

The first parameter, called the *Strand Adjustment Switch*, is a logical "on-off switch" that determines if the strand distance provided as part of the cluster information database is to be used in that density zone. The second, called the *Initial Strand Multiplier*, is a multiplier of the strand distance that can be used to correct any systematic bias in the strand distance.

These parameters are used as follows (see Section 6.3.4 of the HAI Model Release 5.1 Description ["HM 5.1 Description"] for more detail] . If the switch is off, no adjustment is made to the DRD. If it is on, the strand distance for the cluster, provided in the cluster data record, is multiplied by the Initial Strand Multiplier. The DRD is then "normalized" to the revised strand distance by multiplying all the components of the DRD by the ratio of the revised strand distance to the DRD.

Default Values:

Strand Adjustment Factors		
Density Zone	Strand Adjustment Switch	Initial Strand Multiplier
0-5	0	-999
5-100	0	-999
100-200	0	-999
200-650	0	-999
650-850	0	-999
850-2,550	0	-999
2,550-5,000	0	-999
5,000-10,000	0	-999
10,000+	0	-999

Support:

In default mode, the switch is "off," and the Initial Strand Multiplier is -999.[18] . . Setting the switch "off" is consistent with the HM 5.1 developers strong reservations about the usefulness of the MST as an indicator of what the DRD should be. Turning it on, however, would be consistent with the FCC finding that the strand distance is an indicator of the correct DRD value

The Model calculates the Initial Strand Multiplier by density zone. The built in calculation produces a value of 1.0 at 0% geocoding, and increases it linearly to 1.27 at 100% geocoding. As explained in the HM 5.1 Model Description, Section 6.3.4, this reflects the offsetting effect of 1) a conservatively-high dispersion, and hence strand distance, associated with geocoding, on the one hand; and 2) the fact that the strand distance is based on "beeline" routing and may be appropriately adjusted upward by a route-air multiplier. Setting the Initial Strand Multiplier value to -999 in a given density zone causes the Model to use the built-in calculation, using the geocoded rates by density zone for the state in question (see Section 2.13.2). Alternatively, setting the value of this parameter to a positive value overrides the built-in calculation and causes the Model to use the specified value instead. The HM 5.1 developers believe the built-in calculation of the multiplier yields the most appropriate value.

2.13.2 Manual Distribution Design Adjustment

Definition: The percentage of customer locations that are successfully geocoded in each density zone.

Default Values:

Manual Distribution Design Adjustment	
Density Zone	**Geocoded Rate**
0-5	-999
5-100	-999
100-200	-999
200-650	-999
650-850	-999
850-2,550	-999
2,550-5,000	-999
5,000-10,000	-999
10,000+	-999

Support: Referring to Section 2.13.1, the built-in calculation of the Initial Strand Multiplier requires the geocode success rate by density zone as one of its parameters. The database provided with the model contains the geocode success rate by density zone by state. Inserting the value of -999 in the Geocoded Rate causes the Model to use the database values for the success rate in each density zone appropriate to the state in question. Inserting a positive value in the Geocoded Rate in any density zone will cause the inserted value to override the database value. Given that the current cluster data in the database is based on geocoding information whose corresponding geocode success rate is specified in the database, consistency dictates that using the success rates from the database is appropriate. Thus the default values have been set to -999.

[18] Of course, with the switch off, the other parameter is not used; however, a default value is still needed in case the user turns the switch "on."

3. FEEDER INPUT PARAMETERS

3.1. COPPER PLACEMENT

3.1.1. Copper Feeder Structure Fractions

Definition: The relative amounts of different structure types supporting copper feeder cable in each density zone. Aerial feeder cable is attached to telephone poles, buried cable is laid directly in the earth, and underground cable runs through underground conduit.

Note that Copper Feeder Structure Fraction values will be automatically adjusted by HM 5.1 based on input values used in Section 3.2.1, Fiber Feeder Structure Fractions, Fraction of Buried Available for Shift.

Default Values:

Copper Feeder Structure Fractions			
Density Zone	Aerial/Block Cable	Buried Cable	Underground Cable (calculated)
0-5	.50	.45	*.05*
5-100	.50	.45	*.05*
100-200	.50	.45	*.05*
200-650	.40	.40	*.20*
650-850	.30	.30	*.40*
850-2,550	.20	.20	*.60*
2,550-5,000	.15	.10	*.75*
5,000-10,000	.10	.05	*.85*
10,000+	.05	.05	*.90*

Support: ***{NOTE: Excerpts from the discussion in Section 2.5. [Distribution] are reproduced here for ease of use.}***

It is the opinion of outside plant engineering experts that density, measured in Access Lines per Square Mile, is a good determinant of structure type. That judgment is based on the fact that increasing density drives more placement in developed areas, and that as developed areas become more dense, placements will more likely occur under pavement conditions.

Aerial/Block Cable:

"The most common cable structure is still the pole line. Buried cable is now used wherever feasible, but pole lines remain an important structure in today's environment."[19]

Where an existing pole line is available, cable is normally placed on the existing poles. Abandoning an existing pole line in favor of buried plant is not usually done unless such buried plant provides a much less costly alternative.

[19] Bellcore, BOC Notes on the Networks - 1997, p. 12-45.

Buried Cable:

Default values in HM 5.1 reflect an increasing trend toward use of buried cable. Since 1980, there has been an increase in the use of buried cable for several reasons. First, before 1980, cables filled with water blocking compounds had not been perfected. Thus, prior to that time, buried cable was relatively expensive and unreliable. Second, reliable splice closures of the type required for buried facilities were not the norm. And third, the public now clearly desires more out-of-sight plant for both aesthetic and safety-related reasons.

Underground Cable:

Underground cable, conduit, and manholes are primarily used for feeder and interoffice transport cables, not for distribution cable. Any conduit runs short enough to not require a splicing chamber or manhole are classified to the aerial or buried cable account, respectively.

3.1.2. Copper Feeder Manhole Spacing, Feet

Definition: The distance, in feet, between manholes for copper feeder cable.

Default Values:

Copper Feeder Manhole Spacing, feet	
Density Zone	Distance between manholes, ft.
0-5	800
5-100	800
100-200	800
200-650	800
650-850	600
850-2,550	600
2,550-5,000	600
5,000-10,000	400
10,000+	400

Support: "The length of a conduit section is based on several factors, including the location of intersecting conduits and ancillary equipment such as repeaters or loading coils, the length of cable reels, pulling tension, and physical obstructions. Conduit sections typically range from 350 to 700 ft in length. Pulling tension is determined by the weight of the cable, the coefficient of friction, and the geometry of the duct run. Plastic conduit has a lower coefficient of friction than does concrete or fiberglass conduit and thus allows longer cable pulls."[20]

The higher density zones reflect reduced distances between manholes to provide transition points for changing types of sheaths and the increased number of branch points.

Maximum distances between manholes is also a function of the longest amount of cable that can be placed on a normal cable reel. Although larger reels are available, the common type 420 reel supports over 800 feet of 4200 pair cable[21], the largest used by the HAI Model. Therefore the longest distance between manholes used for copper cable is 800 feet.

[20] Bellcore, BOC Notes on the Networks - 1997, p. 12-46

[21] AT&T, Outside Plant Engineering Handbook, August 1994, pp. 1-7.

3.1.3. Copper Feeder Pole Spacing, Feet

Definition: Spacing between poles supporting aerial copper feeder cable.

Default Values:

Copper Feeder Pole Spacing	
Density Zone	**Spacing, ft.**
0-5	250
5-100	250
100-200	200
200-650	200
650-850	175
850-2,550	175
2,550-5,000	150
5,000-10,000	150
10,000+	150

Support: *{NOTE: The discussion in Section 2.6.2. [Distribution] is reproduced here for ease of use.}*

Distances between poles are longer in more rural areas for a several reasons. Poles are usually placed on property boundaries, and at each side of road intersections (unless cable is run below the road surface in conduit). Property boundaries tend to be farther apart in less dense areas, and road intersections are also farther apart.

Depending on the weight of the cable, and the generally accepted guideline that sag should not exceed 10 feet at mid-span, while still maintaining appropriate clearances as designated by the National Electric Safety Code, very long spans between poles may be achieved. This length may be as great as 1,500 feet using heavy gauge strand and very light cable, or may be shorter for heavier cables.[22] In practice, much shorter span distances are employed, usually 400 feet or less.

"...where conditions permit, open wire spans can approach 400 feet in length with practical assurance that the lines will withstand any combination of weather condition. Longer spans mean savings in construction costs and a net reduction in over-all plant investment, including fewer poles to buy, smaller quantity of pole hardware required, and less construction time. The use of long spans also means a reduction in maintenance expense."[23]

3.1.4. Copper Feeder Pole Investment

Definition: The installed cost of a 40' Class 4 treated southern pine pole.

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[22] Bellcore, Clearance for Aerial Cable and Guys in Light, Medium and Heavy Loading Areas, (BR 627-070-015), Issue 1, 1987.
see also, Bellcore, Clearances for Aerial Plant, (BR 918-117-090), Issue 5, 1987.
see also, Bellcore, Long Span Construction (BR 627-370-XXX), date unk.

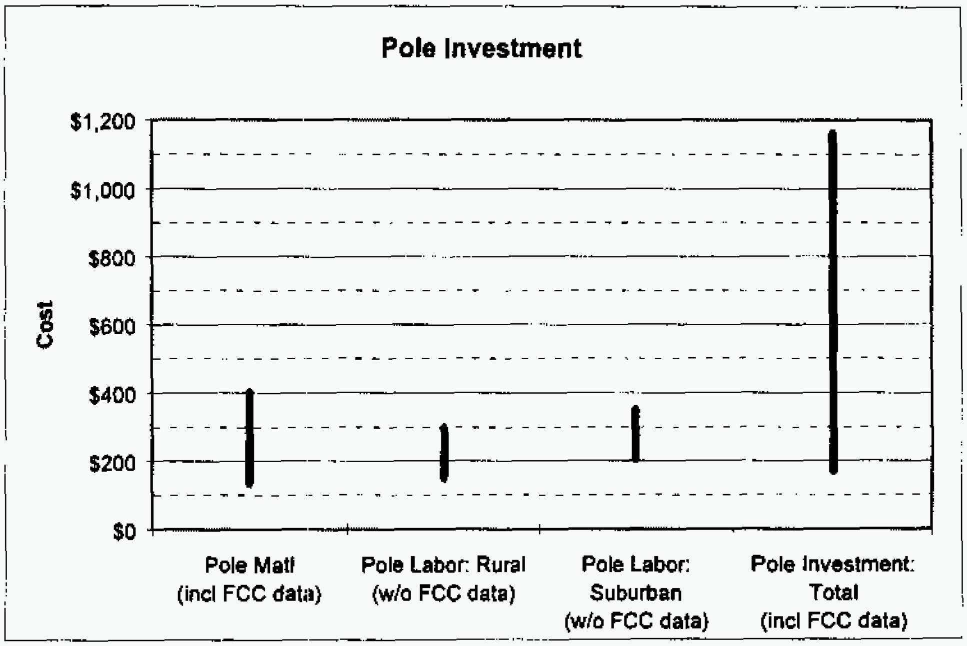
[23] Lee, Frank E., *Outside Plant, abc of the Telephone Series, Volume 4*, abc TeleTraining, Inc., Geneva, IL, 1987, p. 41.

Default Values:

Pole Investment	
Materials	$201
Labor	$216
Total	$417

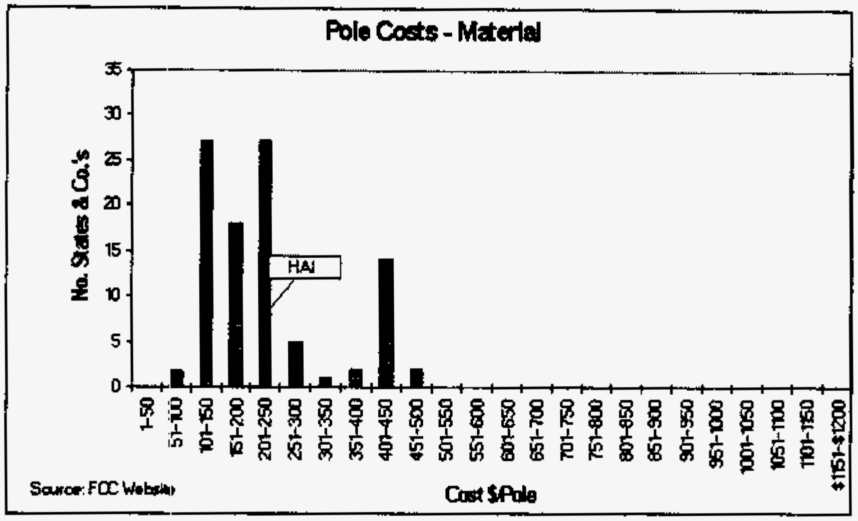
Support: *{NOTE: The discussion in Section 2.4.1. [Distribution] is reproduced here for ease of use.}*

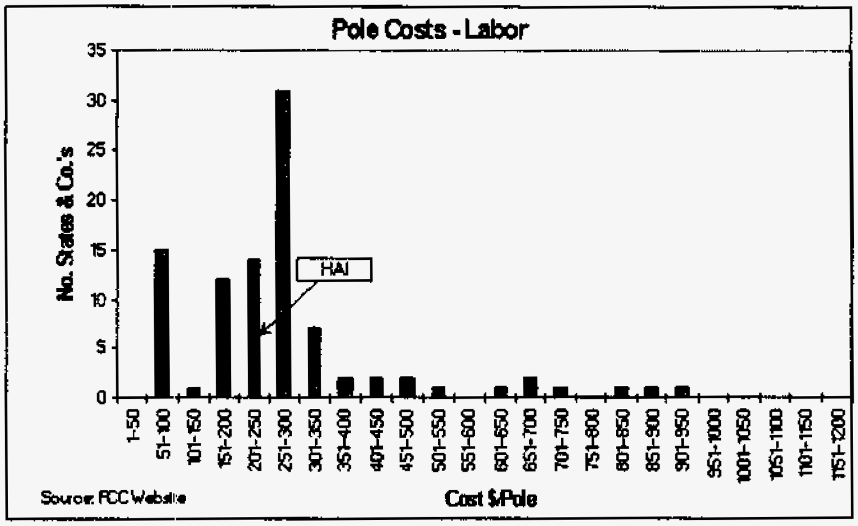
Pole investment is a function of the material and labor costs of placing a pole. Costs include periodic down-guys and anchors. Utility poles can be purchased and installed by employees of ILECs, but are frequently placed by contractors. Several sources revealed the following information on prices.

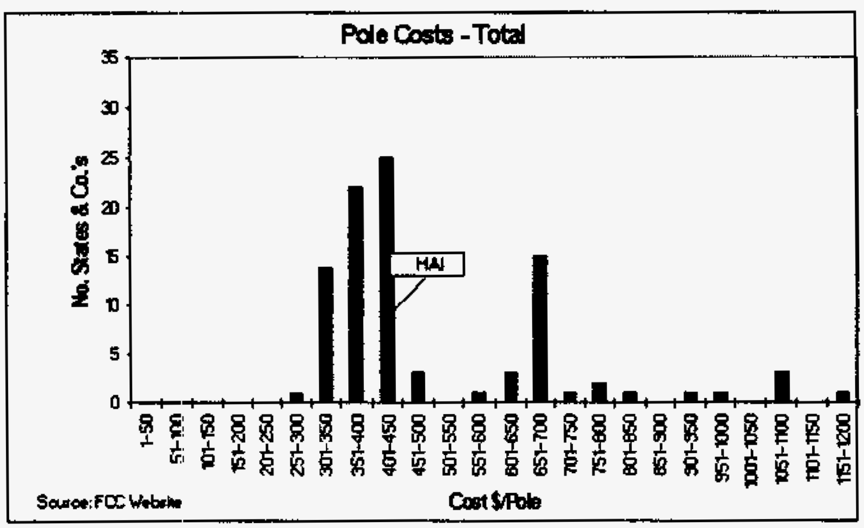


Pole data has also been recently filed by large telephone companies with the FCC.[24] A compilation of that information is shown below:

[24] See the downloadable files at the FCC Web site : http://www.fcc.gov/Bureaus/Common_Carrier/Comments/da971433_data_request/datareq.html







The exempt material load on direct labor includes ancillary material not considered by FCC Part 32 as a unit of plant. That includes items such as downguys and anchors that are already included in the pole placement labor cost. Outside plant engineering experts have concluded that a typical anchor plus anchor rod material investment is $45, and the typical guy material investment is $10. Also, one anchor and downguy per 1,000 feet would be typical. Therefore the embedded anchor and guy exempt material loading included in the default value of $216 is approximately $8.25 - $13.75 per pole.

The steel strand run between poles is likewise an exempt material item, charged to the aerial cable account. The cost of steel strand is not included in the cost of poles; it is included in the installed cost of aerial cable.

3.1.5. Innerduct Material Investment per Foot

Definition: Material cost per foot of innerduct.

Default Value:

Inner Duct Material Investment per foot
$0.30

Support:

Innerduct:
Innerduct might permit more than one fiber cable per 4" PVC conduit. The model adds investment whenever fiber overflow cables are required. This is a conservative assumption, since proper planning allows the placement of multiple fiber cables in a single 4" PVC without the use of innerduct.[25] Since HM 5.1 provides an additional spare 4" PVC conduit whenever fiber cable is run, additional innerduct is not required for a maintenance spare.

Outerduct:
Outerduct is similar to innerduct, but can be used in aerial or buried construction. Although commercially available, it is not recommended for use by outside plant engineering experts working with the HAI Model. Aerial outerduct should not be used in a forward looking model for several reasons. First, if outerduct is placed first, lashed to strand, and then fiber optic cable placed inside the outerduct later, this involves significant additional cost. At $0.30 per foot, outerduct becomes a significant cost compared to the relatively inexpensive fiber cable material cost. Second, it requires twice the cable placing effort – the innerduct must be placed and lashed, then a separate second operation is performed to pull fiber cable into the innerduct, and to secure it at each pole. Third, because of pulling resistance between the outerduct and the fiber optic cable, longer lengths of cable cannot be placed without unnecessary splicing, unless cable is pulled out of the outerduct, "figure-eighted" on the ground, and then reinserted into the outerduct for an additional distance. Fourth, although outerduct can be manufactured with the fiber optic cable inside, it serves little purpose and provides significant problems because the larger 1-1/2 inch outside diameter outerduct now has such a large diameter that only relatively short lengths can be spooled on a normal cable placing reel, compared to maximum placing lengths of 35,000 feet otherwise. Fifth, the use of outerduct in aerial applications presents a risk of "freeze outs", when water enters the innerduct, lays in low mid-span points and freezes, thereby expanding approximately 10% and exerting compression on the fiber cable.

[25] In fact, two outside plant engineering experts working with the HAI Model have had extensive experience is placing as many as 8 fiber cables in a single 4" PVC duct without innerduct.

3.2. FIBER PLACEMENT

3.2.1. Fiber Feeder Structure Fractions

Definition: The relative amounts of different structure types supporting fiber feeder cable in each density zone. Aerial feeder cable is attached to telephone poles, buried cable is laid directly in the earth, and underground cable runs through underground conduit. HM 5.1 may adjust the input values based on the buried fraction available for shift parameter using the process described in Section 2.5.2.

Default Values:

Fiber Feeder Structure Fractions				
Density Zone	Aerial/Block Cable	Buried Cable	Underground Cable (calculated)	Buried Fraction Available for Shift[26]
0-5	.35	.60	.05	.75
5-100	.35	.60	.05	.75
100-200	.35	.60	.05	.75
200-650	.30	.60	.10	.75
650-850	.30	.30	.40	.75
850-2,550	.20	.20	.60	.75
2,550-5,000	.15	.10	.75	.75
5,000-10,000	.10	.05	.85	.75
10,000+	.05	.05	.90	.75

Support: *{NOTE: Excerpts from the discussion in Section 2.5. [Distribution] are reproduced here for ease of use.}*

It is the opinion of outside plant engineering experts that density, measured in Access Lines per Square Mile, is a good determinant of structure type. That judgment is based on the fact that increasing density drives more placement in developed areas, and that as developed areas become more dense, placements will more likely occur under pavement conditions.

Aerial/Block Cable:

"The most common cable structure is still the pole line. Buried cable is now used wherever feasible, but pole lines remain an important structure in today's environment."[27]

Where an existing pole line is available, cable is normally placed on the existing poles. Abandoning an existing pole line in favor of buried plant is not usually done unless such buried plant provides a much less costly alternative.

[26] The Fiber Feeder Buried Fraction Available for Shift applies to copper feeder structure in the same way it applies to fiber feeder structure.

[27] Bellcore, BOC Notes on the Networks - 1997, p. 12-45.

Buried Cable:

Default values in HM 5.1 reflect an increasing trend toward use of buried cable. Since 1980, there has been an increase in the use of buried cable for several reasons. First, before 1980, cables filled with water blocking compounds had not been perfected. Thus, prior to that time, buried cable was relatively expensive and unreliable. Second, reliable splice closures of the type required for buried facilities were not the norm. And third, the public now clearly desires more out-of-sight plant for both aesthetic and safety-related reasons.

Underground Cable:

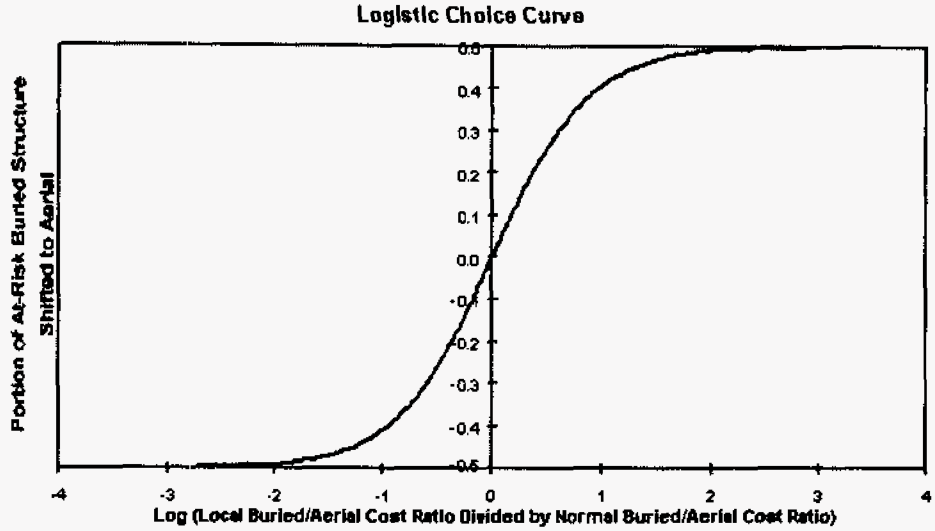
Underground cable, conduit, and manholes are primarily used for feeder and interoffice transport cables, not for distribution cable. Any conduit runs short enough to not require a splicing chamber or manhole are classified to the aerial or buried cable account, respectively.

Buried Fraction Available for Shift: This input addresses the ability of the model to perform a dynamic calculation to determine the most efficient life-cycle costs of buried vs. aerial structure. The calculation considers the different values involved in buried vs. aerial structure in terms of initial investment, sub-surface conditions, soil texture, percent structure sharing, depreciation rates, and maintenance costs.

Underground conduit is not considered as a candidate for structure shifting, since the motivation for placing underground conduit and cable is usually a function of high pavement costs and the need to allow for future replacement and addition of cables without disturbing the above ground pavement conditions.

The fraction is expressed as the total range over which the buried fraction can vary after shifting. If, for example, the user has entered an initial value of 0.50 for the buried cable fraction in a given density zone and then enters -0.80 as the range of the shift that may occur in the buried fraction, the model can allow the computed buried fraction to vary between 0.30 (= 0.50 - 40% of 0.50) and 0.70 (= 0.50 + 40% of 0.50), according to changes in the relative costs of buried versus aerial structure occasioned by local surface and bedrock conditions.

HM 5.1 uses a "Logistic Choice Curve" to control the sensitivity of the shift in structure to changes in the local relative cost of buried versus aerial plant. In the chart below, the horizontal axis represents the ratio of the local buried to aerial cost ratio to the national norm buried to aerial cost ratio. Its scale is logarithmic, thus the value of zero indicates that the local buried/aerial cost ratio equals the national buried/aerial cost ratio. Increasing positive values indicate the local buried to aerial cost ratio has increased relative to the national ratio – as would occur, for instance, if local bedrock were closer to the surface than normal. Negative values indicate a local buried to aerial cost ratio that is less than the national ratio. The vertical axis represents the portion of "swing" buried plant that is shifted to aerial. A value of 0.0 means there is no movement away from the input amount of buried structure; 0.5 means the maximum amount of shift has occurred from buried to aerial, and negative 0.5 means the maximum amount of shift has occurred from aerial to buried.



Since shifting of structure type from buried to aerial, or vice versa is permitted, the HAI Model allows the user to affect such shifting by the application of engineering judgment. There may be local ordinances or regulatory rules, that encourage utilities to place out-of-sight facilities under certain conditions. Therefore, should aerial structure be the most economic solution in a particular cable section, the model could shift all buried structure to aerial. However, in the event such shifting is not practical, the HAI Model allows the user to reserve a percentage of buried cable structure, regardless of the opportunity for a shift to less expensive aerial cable. Our outside plant engineering experts recommend that only 75% of the buried percentage be allowed to shift to aerial.

The user should note that this default value can be adjusted to to allow the model to optimize the cable structure choice between aerial and buried structure without constraint other than ensuring the aerial percentage is not less than 0%. On the other hand, setting the fraction available for shift to 0% means that no optimization will take place, thereby locking in the judgement of the user in setting the input values for the various structure percentages regardless of situations uncovered by the model in examining unique pockets of difficult terrain where a more economic solution would prevail.

3.2.2. Fiber Feeder Pullbox Spacing, Feet

Definition: The distance, in feet, between pullboxes for underground fiber feeder cable.

Default Values:

Fiber Feeder Pullbox Spacing, feet	
Density Zone	**Distance between pullboxes, ft.**
0-5	2,000
5-100	2,000
100-200	2,000
200-650	2,000
650-850	2,000
850-2,550	2,000
2,550-5,000	2,000
5,000-10,000	2,000
10,000+	2,000

Support: Unlike copper manhole spacing, the spacing for fiber pullboxes is based on the practice of coiling spare fiber (slack) within pullboxes to facilitate repair in the event the cable is cut or otherwise impacted. Fiber feeder pullbox spacing is not a function of the cable reel lengths, but rather a function of length of cable placed. The standard practice during the cable placement process is to provide for five percent excess cable to facilitate subsurface relocation, lessen potential damage from impact on cable, or provide for ease of cable splicing when cable is cut or damaged.[28] It is common practice for outside plant engineers to require approximately two slack boxes per mile.[29]

3.2.3. Buried Fiber Sheath Addition, per Foot

Definition: The cost of dual sheathing for additional mechanical protection of buried fiber feeder cable.

Default Value:

Buried Fiber Sheath Addition, per foot
$0.20 / ft.

Support: Incremental cost for mechanical sheath protection on fiber optic cable is a constant per foot, rather than the ratio factor used for copper cable, because fiber sheath is approximately ½ inch in diameter, regardless of the number of fiber strands contained in the sheath. The incremental per foot cost was estimated by a team of experienced outside plant experts who have purchased millions of feet of fiber optic cable.

[28] CommScope, *Cable Construction Manual, 4th Edition*, p. 75.

[29] Lucent, *AT&T Outside Plant Handbook, August 1994*, p. 5-19 recommends a fiber design transmission allowance for one maintenance/restoration splice per kilometer (3,275 feet). The HAI Model uses a more conservative approach of 2,000 feet.

3.3. CABLE SIZING FACTORS

3.3.1. Copper Feeder Cable Sizing Factors

Definition: The factor by which feeder cable capacity is increased above the size needed to serve a given quantity of demand in order to provide spare pairs for breakage, line administration, and some amount of growth. Calculated as the target ratio of the number of assigned pairs to the total number of available pairs in the cable.

Default Values:

Copper Feeder Cable Sizing Factors	
Density Zone	**Factors**
0-5	.80
5-100	.80
100-200	.80
200-650	.80
650-850	.80
850-2,550	.80
2,550-5,000	.80
5,000-10,000	.80
10,000+	.80

Support: ***{NOTE: Excerpts from the discussion in Section 2.6.1. [Distribution Cable Sizing Factors] are reproduced here for ease of use.}***

HM5.1 uses uniform copper cable feeder sizing factors across all density zones for the following reasons:

- The ratio of adjacent cable sizes is considerably greater for small cables than for large ones. Pair counts for small cables essentially double between cable sizes, so that such cables easily allow enough extra pairs to accommodate administrative spare needs.[30] The controlling effect is the "breakage," or modularity in cable sizes, which produces an effective fill factor that is often considerably less than the corresponding input cable sizing factor.[31]
- A small copper cable may serve a small (and compact) pocket of customer locations in a high density zone or a more widely-dispersed (but still small) set of customers in a low density zone; there is no need for the cable sizing factors to be different for these cases. For this reason, the cable sizing factor should be constant across all density ranges.

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[30] Simple calculations readily show that using 50% copper cable sizing factors in low density zones is unreasonable. For example, eleven households with an average of 1.2 lines per household require a total of thirteen lines. Dividing the line total by a 50% copper cable sizing factor yields a requirement for 26 equipped pairs, which would be satisfied by installing a 50-pair cable, the next available size. The achieved cable fill is only 26%, even though the sizing factor is nearly twice that. If demand were to increase at a compounded rate of 4% per year, after ten years the cable utilization would be only 39%. After twenty years, the cable's useful life, it would still only be at 57% utilization, and 43% of the cable's capacity would be wasted because of inefficient design.

[31] Several states have been modeled using a 75% distribution cable sizing factor and an 80% copper feeder cable sizing factor. The corresponding achieved copper cable fills ranged from 50% to 65% for distribution cable and between 65% and 78% for copper feeder cable.

- Some state commissions, along with the FCC, have adopted uniform or nearly-uniform copper cable sizing factors across density zones for running the HAI Model. Selecting such factors thus recognizes this trend among regulatory bodies.

In general, the level of spare capacity provided by the default value of 80% in HM 5.1 is sufficient to meet current demand plus several years of growth. Copper Feeder Cable Sizing Factors are slightly higher than Copper Distribution Cable Sizing Factors because, "To meet future service needs, sections of the feeder plant are designed to be augmented periodically. Typical relief time periods for feeder plants vary between four and fifteen years, depending on individual company needs and practices."[32] With the advent of extensive fiber fed Integrated Digital Loop Carrier systems, most ILECs currently employ a strategy of designing copper feeder with augmentation periods of 3 to 5 years. Use of a Copper Feeder Cable Sizing Factor of 80% exceeds this augmentation cycle strategy. Because the model calculates the unit loop investment cost as the total loop investment (including spare capacity), divided by the current loop demand, the resulting unit costs are a conservatively high estimate of the economic cost of meeting current loop demand. This occurs because, in reality, some of the spare feeder plant can and will be used to satisfy additional loop demand in the future, without causing any additional investment cost, thus a larger number of customers will pay for the cable over time. In this sense, the HM 5.1 default values for the feeder cable sizing factors are conservatively low from an economic costing standpoint.

3.3.2. Fiber Feeder Cable Sizing Factor

Definition: Target percentage of fiber strands in a cable that is available to be used.

Default Values:

Fiber Feeder Cable Sizing Fill Factor	
Density Zone	**Fill Factor**
0-5	1.00
5-100	1.00
100-200	1.00
200-650	1.00
650-850	1.00
850-2,550	1.00
2,550-5,000	1.00
5,000-10,000	1.00
10,000+	1.00

Support: Standard fiber optic multiplexers operate on 4 fibers. One fiber each is assigned to primary optical transmit, primary optical receive, redundant optical transmit, and redundant optical receive. Since the fiber optic multiplexers used by HM 5.1 have 100 percent redundancy, and do not reuse fibers in the loop, there is no reason to divide the number of fibers needed by a cable sizing fill factor, prior to sizing the fiber cable to the next larger available size.

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[32] Bellcore, Bellcore Notes on the Networks, Issue 3, December 1997, p. 12-1. See also Bellcore, Telecommunications Transmission Engineering, Third Edition, 1990, p. 91.

3.4. CABLE COSTS

3.4.1. Copper Feeder Cable: Cost per Foot, Cost per Pair-Foot

Definition: The cost per foot ($/foot) and per pair-foot of copper feeder cable, as a function of cable size, including the costs of engineering, installation, and delivery, as well as the cable material itself. The copper investment per pair-foot is used in estimating comparative life-cycle costs for copper feeder.

Default Values:

Copper Feeder Investment	
Cable Size	**$/foot (u/g & aerial)**
4200	$29.00
3600	$26.00
3000	$23.00
2400	$20.00
1800	$16.00
1200	$12.00
900	$10.00
600	$7.75
400	$6.00
200	$4.25
100	$2.50
Copper Investment per Pair - foot	
$ 0.0075 / pair-ft.	

{NOTE: Excerpts from the discussion in Section 2.3.2. [Distribution] are reproduced here for ease of use.

Support: These costs reflect the use of 24-gauge copper feeder cable for cable sizes below 400 pairs, and 26-gauge copper feeder cable for cable sizes of 400 pairs and larger. Although 24-gauge copper is not required for transmission requirements within 18,000 feet of a digital central office with a 1,500 ohm limit, a heavier gauge of copper is used in smaller cable sizes to prevent damage from craft handling wires in pedestals where wires may be exposed, rather than sealed in splice cases. For cables of 400 pairs and larger, splices are normally enclosed in splice cases, and are not subject to wire handling problems.

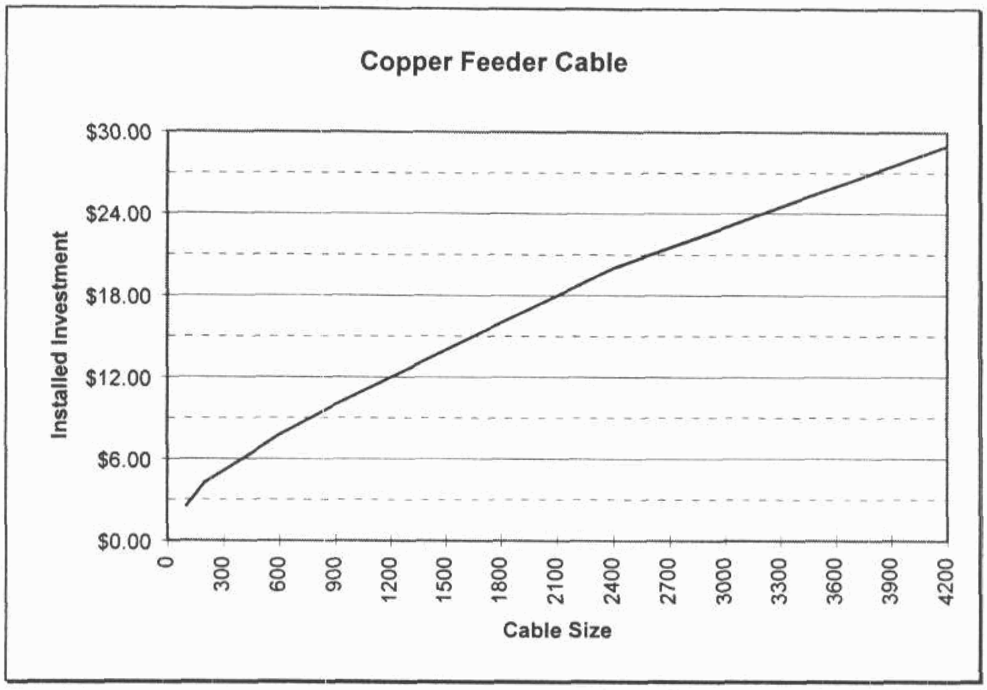
<u>Cable below 400 Pairs</u>: Outside plant planning engineers commonly assume that the cost of cable material can be represented as an a + bx straight line graph. In fact, Bellcore Planning tools, EFRAP I, EFRAP II, and LEIS:PLAN have the engineer develop such an a + bx equation to represent the cost of cable. As technology, manufacturing methods, and competition have advanced, the price of cable has been reduced. While in the past, the cost of copper cable was typically ($0.50 + $0.01 per pair) per foot, current costs are typically ($0.30 + $0.007 per pair) per foot.

In the opinion of expert outside plant engineers, whose experience includes writing and administering hundreds of outside plant "estimate cases" (large undertakings), material represents approximately 40% of the total installed cost. This is a widely used rule of thumb among outside plant engineers. Such expert opinions were also used to determine that the average engineering content for installed copper cable is 15% of the installed cost. The remaining 45% represents direct labor for placing and splicing cable, exclusive of the cost of splicing block terminals into the cable.

<u>Cable of 400 Pairs and Larger</u>: As copper cable sizes become larger, engineering cost is based more and more on sheath feet, rather than cable size. The same is true for cable placing and splice set-up. Therefore

the linear relationship between the number of copper pairs and installed cost is somewhat reduced. A review of many installed cable costs around the country were used by the engineering team to estimate the installed cost of copper cable for sizes of 400 pairs and larger.

The following chart represents the default values used in the Model.



__Copper Investment per Pair-Foot:__
At the point in the model where a decision is required regarding copper vs. fiber feeder, it is not possible to determine how many copper pairs will be aggregated along each tapered section of the feeder route. Therefore a design assumption is required to determine how much of the fixed cost of the copper cable placement and sheath cost is distributed over the number of copper feeder pairs deployed. This is approximately $0.0075 per copper pair foot in the model, a value that falls in the range of the various cable sizes listed above.

3.4.2. Fiber Feeder Cable: Cost per Foot, Cost per Strand – Foot

Definition: The cost per foot ($/foot) and per strand-foot of fiber feeder cable, as a function of cable size, including the costs of engineering, installation, and delivery, as well as the cable material itself. The fiber investment per strand-foot is used in estimating comparative life-cycle costs for copper and fiber feeder.

Default Values:

Fiber Feeder Investment	
Cable Size	$/foot (u/g & aerial)
216	$8.13
144	$5.75
96	$4.17
72	$3.38
60	$2.98
48	$2.58
36	$2.19
24	$1.79
18	$1.59
12	$1.40
Fiber Investment per Strand – foot	
$ 0.054 / fiber-ft.	

Support: Outside plant planning engineers have commonly assumed that the cost of cable material can be represented as an a + bx straight line graph. In fact, Bellcore Planning tools, EFRAP I, EFRAP II, and LEIS:PLAN have had the engineer develop such an a + bx equation to represent the cost of cable. As technology, manufacturing methods, and competition have advanced, the price of cable has been reduced. While 10 years ago, the cost of fiber cable was typically $0.50 + $0.10 per fiber per foot, and as recently as 4 years ago was typically $0.30 + $0.05 per fiber per foot as represented in HM 5.0a, extensive deployment of fiber, especially by CATV companies has driven the cost of fiber even lower.

The Rural Utilities Service ("RUS") supplied Dr. David Gabel (on behalf of NRRI[33]) with a substantial amount of data from actual contracts. That data is available from the NRRI Website at http://www.nrri.ohio-state.edu/. An analysis of data involving fiber cable was performed to obtain the new default values recommended for HAI 5.1.

71 of 1,505 observations were excluded from the analysis (32 observations with zero footage quantities, 10 observations with zero total cost, 23 observations containing labor only without any material, 3 observations of cables with 0-3 fibers, and 3 observations with costs far outside reasonable bounds, e.g., 24-fiber cable with material cost greater than a 216-fiber cable). The remaining 1,434 observations (1,028 buried, 243 aerial, and 163 underground) were analyzed to produce the new default values for installed fiber cable.

The analysis of 1,434 observations provided an a + bx result of $1.00 per foot plus $.032 per fiber-foot.

Splicing Engineering and Direct Labor are included in the cost of the Remote Terminal Installations, and the Central Office Installations, since field splicing is unnecessary with fiber cable pulls that are as long as 35,000 feet between splices.

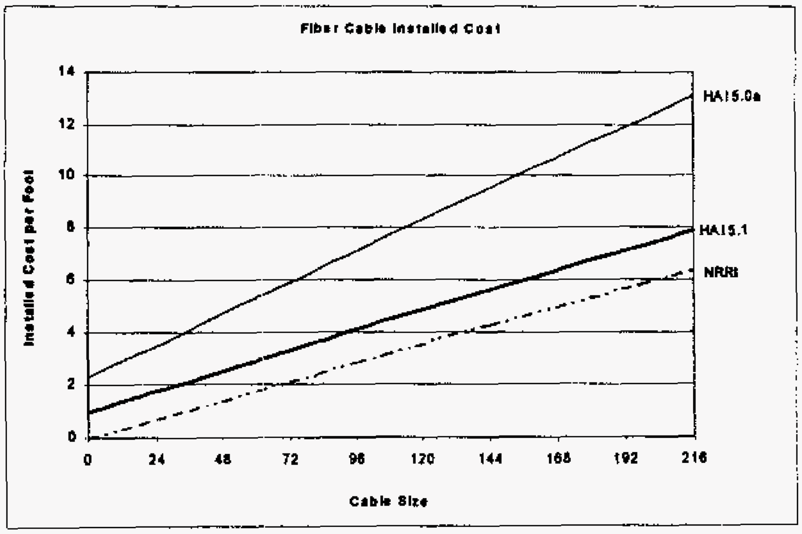
The NRRI analysis recognized that the fixed component included structure costs, or partial structure costs for buried and underground installations. NRRI then excluded the fixed component of fiber cable costs. In contrast to that approach, this analysis normalized buried data to remove the cost of buried structure, and underground data was normalized to remove the cost of innerduct structure[34]. Engineering costs were

[33] National Regulatory Research Institute.

[34] Buried fixed cost per foot was reduced by $0.88, and underground fixed cost per foot was reduced by $0.62. Installed costs per foot were as follows: Buried = $0.97 + $0.030/fiber; Aerial = $0.88 + $0.037/fiber; Underground = $1.02 + $0.032/fiber; Average all types = $0.96 + $0.032/fiber.

assumed to be $0.04/ft. (2,000 ft./hr. @ $75/hr.); engineering of fiber cable is simpler than copper cable engineering because tasks involve route layout with construction forces reporting "as built" conditions.

The following chart represents the default values used in the model HAI ver. 5.1, plus a comparison with HAI ver. 5.0a and the NRRI study.



Fiber Investment per Strand – foot:

At the point in the model where a decision is required regarding copper vs. fiber feeder, it is not possible to determine how many fibers will be aggregated along each tapered section of the feeder route. Therefore a design assumption is required to determine how much of the fixed cost of the fiber cable placement and sheath cost is distributed over the number of fibers deployed. This is approximately $0.054 per fiber strand foot in the model.

3.5. DLC EQUIPMENT

3.5.1. DLC Site and Power per Remote Terminal

Definition: The investment in site preparation and power for the remote terminal of a Digital Loop Carrier (DLC) system. The meaning of "High Density DLC" and "Low Density DLC" are explained in Section 3.5.2.

Default Values:

Remote Terminal Site and Power	
High Density GR-303 DLC	Low density GR-303 DLC
$3,000	$1,300

Support: The incremental per site cost was estimated by a team of outside plant experts with extensive experience in contracting for remote terminal site installations.

3.5.2. Maximum Line Size per Remote Terminal

Definition: The maximum number of lines supported by the initial line module of a remote terminal.

Default Values:

Maximum Line Increment per Remote Terminal	
High Density GR-303 DLC	Low density GR-303 DLC
672	120

Support:

High Density Applications:
The forward looking DLC optimized for high-line-density applications is an integrated NGDLC (Next Generation Digital Loop Carrier) compliant with Bellcore Generic Requirements GR-303, which employs an optical fiber SONET OC-3 transport capable of supporting 2016 full time DS0 POTS time slots. This is a large capacity and highly efficient digital loop carrier for serving the high density environment. While products from different vendors are available in a variety of sizes, HM 5.1 uses typical digital loop carrier remote sizes, which are as follows:

672 DS0s Modeled by HM 5.1 as an Initial Line Increment
1344 DS0s Modeled by HM 5.1 as an Initial Line Increment plus One Additional Increment
2016 DS0s Modeled by HM 5.1 as an Initial Line Increment plus Two Additional Increments

Low Density Applications:
Similar to the high density environment, there are a wide variety of DLC products available for low-line-density applications. These DLC products are NFDLC and are also GR-303 compliant. HM 5.1 uses a 50 Mbps fiber optic based NGDLC that can be configured in a variety of ways (Point-to-Point, Drop and Insert, and Tree Configurations), both as an Integrated Digital Loop Carrier and as a "stand-alone" or Universal Digital Loop Carrier. HM 5.1 utilizes the IDLC configuration. This is a highly efficient digital loop carrier for low density applications. While a variety of sizes are available, the following sizes are used in HM 5.1:

120 DS0s Modeled by HM 5.1 as an Initial Line Increment
240 DS0s Modeled by HM 5.1 as an Initial Line Increment plus One Additional Increment

3.5.3. Remote Terminal Sizing Factor

Definition: The line unit sizing factor in a DLC remote terminal, that is, the ratio of lines served by a DLC remote terminal to the number of line units equipped in the remote terminal.

Default Values:

Remote Terminal Fill Factors	
High Density GR-303 DLC	Low Density GR-303 DLC
.90	.90

Support: The most expensive part of integrated digital loop carrier provisioning is the digital to analog conversion that takes place in the Remote Terminal line card. This expensive card (HM5.1 defaults to $310 per four-line card) calls for stringent inventory control on the part of the ILEC. Also, fill factors are largely a function of the time frame needed to provide incremental additions. Since line cards are a highly portable asset, facility relief can be provided by dispatching a technician with line cards, as opposed to, for instance, engaging in a several month long copper cable feeder addition. Therefore high fill rates should be the norm for an efficient provider using forward looking technology.

3.5.4. DLC Initial Common Equipment Investment

Definition: The total installed cost of all common equipment and housing in the remote terminal, as well as the fiber optics multiplexer required at the CO end, for the initial line module of the DLC system (assumes integrated digital loop carrier (IDLC) with a GR-303 interface to the local digital switch).

Default Values:

Remote Terminal Initial Common Equipment Investment	
High Density GR-303 DLC	Low Density GR-303 DLC
$66,000	$16,000

Support: The cost of an initial increment of Integrated Digital Loop Electronics was estimated by a team of experienced outside plant experts with extensive experience in contracting for remote terminal site installations. Low Density DLC material investments are based on vendor list prices and an estimated 25 percent discount based on large volume purchases.

A breakdown of investments for the various parts of this equipment are as follows:

High Density GR-303 DLC			
Central Office Terminal Common Equipment		**Central Office Terminal Labor**	
SONET Firmware	$7,000	Engineering	$660 (12.0 hrs.)
SONET Transceivers	$4,500	Place Frames & Racks	$165 (3.0 hrs.)
Multiplexer Commons	$2,000	Splice DSX Metallic Cable	$55 (1.0 hr.)
Time Slot Interchanger	$3,500	Place DSX Cross Connections	$28 (0.5 hrs.)
DS-1 Shelf Commons	$500	Connect Alarms, CO Timing & Power	$55 (1.0 hr.)
DSX-1 & Cabling	$800	Place Common Plug Ins (21 ea.)	$28 (0.5 hrs.)
		Turn Up & Test System	$165 (3.0 hrs.)
Subtotal	$18,300	Subtotal	$1,200
Remote Terminal Common Equipment		**Remote Terminal Labor**	
Cabinet	$27,500	Engineering	$1,760 (32.0 hrs.)
SONET Transceivers	$4,500	Place Cabinet	$220 (4.0 hrs.)
Multiplexer Commons	$2,000	Copper Splicing (2 hrs. + 672 pairs @ 400/hr.)	$220 (4.0 hrs.)
Time Slot Interchanger	$3,500	Place Batteries & Turn Up Power	$110 (2 hrs.)
Channel Bank Assemblies	$4,000	Place Common Plug Ins (21 ea.)	$28 (0.5 hrs.)
Channel Bank Assembly Commons	$2,500	Turn Up & Test System	$165 (3.0 hrs.)
Subtotal	$44,000	Subtotal	$2,500
Total = $66,000			

Low Density GR-303 DLC			
Central Office Terminal Common Equipment		**Central Office Terminal Labor**	
SONET Firmware	$3,000	Engineering	$660 (12.0 hrs.)
SONET Transceivers*	See Below*	Place Frames & Racks	$165 (3.0 hrs.)
Common COT Plug Ins	$1,200	Splice DSX Metallic Cable	$55 (1.0 hr.)
DSX-1 & Cabling	$800	Place DSX Cross Connections	$28 (0.5 hrs.)
		Connect Alarms, CO Timing & Power	$55 (1.0 hr.)
		Place Common Plug Ins (21 ea.)	$28 (0.5 hrs.)
		Turn Up & Test System	$165 (3.0 hrs.)
Subtotal	$5,000	Subtotal	$1,200
Allocation of COT Host Digital Terminal Investment per 120 RT 120 lines / 672 lines per COT HDT = 17.86% x 75% assumed HDT fill = 23.81%	.2381	Allocation of COT Host Digital Terminal Investment per 120 RT 120 lines / 672 lines per COT HDT = 17.86% x 75% assumed HDT fill = 23.81%	.2381
Subtotal	$1,200	Subtotal	$300
SONET Transceivers*	$2,000*		
Subtotal	$3,200	Subtotal	$300
Remote Terminal Common Equipment		**Remote Terminal Labor**	
Cabinet w/ Channel Bank Assembly	$5,500	Engineering	$990 (18.0 hrs.)
SONET Transceivers	$2,000	Place Cabinet	$165 (3.0 hrs.)
Multiplexer and Channel Bank Assembly Commons	$3,500	Copper Splicing (2 hrs. + 120 pairs @ 400/hr.)	$127 (2.3 hrs.)
		Place Batteries & Turn Up Power	$55 (1 hr.)
		Turn Up & Test System	$165 (3.0 hrs.)
Subtotal	$11,000	Subtotal	$1,600
Total = $16,000			

Any review of alternative costs for Integrated Digital Loop Carrier systems should not only focus on material costs, but especially should focus on hidden costs included in the category of Engineering and Installation of such systems. Engineering of standardized, simplified, factory pre-assembled systems is a simple affair. To quote a major vendor of such systems, "The cabinet is completely assembled and tested at the factory. Once the cabinet is on site and bolted to its mounting pad, the only assembly required consists of connecting local power, connecting outside plant (OSP) facilities, connecting optical fiber facilities, installing the backup battery strings, and plugging the circuit packs into their assigned locations in the equipment."

3.5.5. DLC Channel Unit Investment

Definition: The investment in channel units required in the remote terminal of the DLC system.

Default Values:

GR-303 and low density DLC channel unit investment per unit		
	POTS Channel Unit	Coin Channel Unit
DLC Type	Channel Card	Channel Card
High Density GR-303	$310	$250
Low Density GR-303	$600	$600

Support: The cost of individual POTS Channel Unit Cards was estimated by a team of experienced outside plant experts with extensive experience in contracting for DLC channel units. For the Low Density DLC, the cost is based on vendor list prices and an estimated 25 percent discount based on large volume purchases.

High Density GR-303 POTS Channel Units are based on costs for Regular POTS (RPOTS) Cards. Low Density GR-303 POTS Channel Units are based on costs for Extended Range POTS (EPOTS) Cards.

3.5.6. DLC Lines per Channel Unit

Definition: The number of lines that can be supported on a single DLC channel unit.

Default Values:

Lines per Channel Unit		
	POTS Channel Unit	Coin Channel Unit
DLC Type	No. Lines	No. Lines
High Density GR-303	4	2
Low Density GR-303	6	6

Support: This is based on vendor documentation.

3.5.7. Low Density DLC to GR-303 DLC Cutover

Definition: The threshold number of lines served, above which the GR-303 DLC will be used.

Default Value:

Low Density GR-303 DLC to High Density GR-303 DLC Cutover
480 lines

Support: An analysis of initial costs reveals that 2 Low Density DLC units, at 240 lines each, are more cost effective than a single large IDLC unit with a capacity of 672 lines. Beyond two 240 line Low Density DLC units, the larger unit is less costly.

3.5.8. Fiber Strands per Remote Terminal

Definition: The number of fibers connected to each DLC remote terminal.

Default Values:

Fibers per Remote Terminal	
High Density GR-303 DLC	Low density GR-303 DLC
4	4

Support: HM 5.1 assumes a configuration with two main fibers (one for transmit and one for receive) and two protection fibers (one for transmit and one for receive). The protection fibers are equipped and provide transmission redundancy for improved service reliability. The number of fibers required is based on vendor documentation.

3.5.9. Optical Patch Panel

Definition: The investment required for each optical patch panel associated with a DLC remote terminal.

Default Values:

Optical Patch Panel	
High Density GR-303 DLC	Low density GR-303 DLC
$1,000	$1,000

Support: The cost for an installed fiber optic patch panel, including splicing of the fibers to pigtails, was estimated by a team of experienced outside plant experts with extensive experience in contracting for optical patch panels. A fiber optic patch panel contains no electronics, nor moving parts, but allows for the physical cross connection of fiber pigtails.

3.5.10. Copper Feeder Maximum Distance, Feet

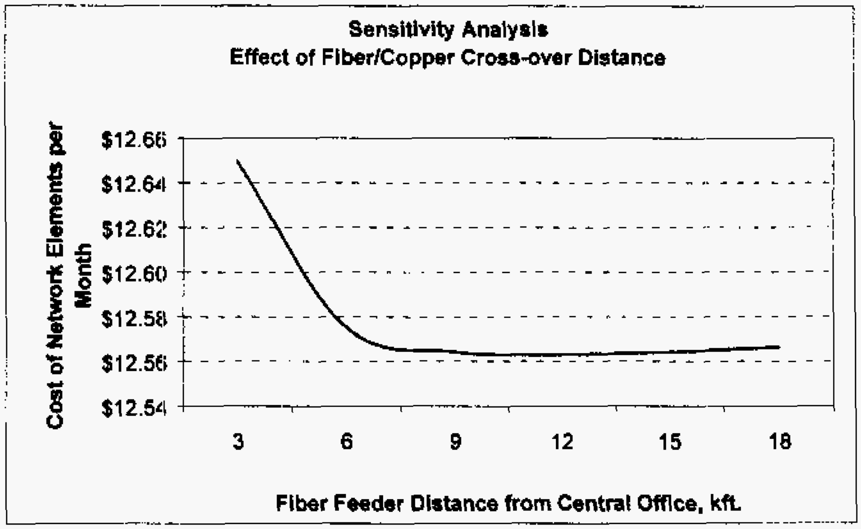
Definition: The feeder length above which fiber feeder cable is used in lieu of copper cable. The value must be less than Maximum Analog Copper Distance.

Default Value:

Copper Feeder Maximum Distance
9,000 feet

Support: The chart below depicts the result of multiple sensitivity runs of the HAI Model, wherein the only variable changed is the copper/fiber maximum distance point. Results indicate that Loop Costs per month drop off as the fiber/copper cross-over distance is increased. This reduction in monthly costs is a function of the investment and maintenance carrying charges for the loop. There is a significant slope from an all fiber feeder at 0 kft. down to 9,000 feet, where the slope becomes essentially flat.

HM 5.1 uses several parameters to determine the need for fiber feeder cable, rather than copper feeder cable. These include 1) assuring that the total copper cable length for both copper feeder and copper distribution do not exceed the Maximum Analog Copper Distance, set by default at 18,000 feet; 2)assuring that the copper distribution distance alone does not exceed this distance; 3) assuring that copper feeder cable does not exceed the Copper Feeder Maximum Distance set by default here at 9,000 feet; and 4) if copper feeder would otherwise be selected, based on the above three criteria, analyzing whether fiber feeder would have a lower life-cycle cost than copper feeder based on annual carrying charges that include the effects of differences for investment in copper cable vs. fiber cable plus IDLC, depreciation rate differences between technologies, and maintenance cost differences between technologies. If fiber based technology has a lower life cycle cost, HM 5.1 will designate the use of fiber feeder. If the user wants to maximize the ability of the model to select the most economic technology in each case, this parameter value can be reset to the Maximum Analog Copper Distance, which means that the economic test is performed over a wider range of feeder lengths.



3.5.11. Common Equipment Investment per Additional Line Increment

Definition: The cost of the common equipment required for each additional line module in a remote terminal.

Default Values:

Common Equipment Investment per Additional Line Increment	
High Density GR-303 DLC	Low density GR-303 DLC
672 Line Increment	120 Line Increment
$18,500	$9,400

Support: The cost of an additional increment of Integrated Digital Loop Electronics was estimated by a team of experienced outside plant experts with extensive experience in contracting for remote terminal site installations. Low Density DLC material costs are based on vendor list prices and an estimated 25 percent discount based on large volume purchases.

A breakdown of investments for the various parts of this equipment are as follows:

High Density GR-303 DLC 672 Line Increment			
Central Office Terminal Common Equipment		**Central Office Terminal Labor**	
DSX-1 & Cabling	$800	Splice DSX Metallic Cable	$55 (1.0 hr.)
		Place DSX Cross Connections	$28 (0.5 hrs.)
		Turn Up & Test System	$110 (2.0 hrs.)
Subtotal	$800	Subtotal	$200
Remote Terminal Common Equipment		**Remote Terminal Labor**	
Cabinet	$7,300	Copper Splicing (2 hrs. + 672 pairs @ 400/hr.)	$110 (2.0 hrs.)
Time Slot Interchanger	$3,500	Turn Up & Test System	$110 (2.0 hrs.)
Channel Bank Assemblies	$4,000		
Channel Bank Assembly Commons	$2,500		
Subtotal	$17,400	Subtotal	$200
Total = $18,500			

Low Density GR-303 DLC			
Central Office Terminal Common Equipment		**Central Office Terminal Labor**	
SONET Firmware	$3,000	Engineering	$660 (12.0 hrs.)
Common COT Plug Ins	$1,200	Place Frames & Racks	$165 (3.0 hrs.)
DSX-1 & Cabling	$800	Splice DSX Metallic Cable	$55 (1.0 hr.)
		Place DSX Cross Connections	$28 (0.5 hrs.)
		Connect Alarms, CO Timing & Power	$55 (1.0 hr.)
		Place Common Plug Ins (21 ea.)	$28 (0.5 hrs.)
		Turn Up & Test System	$165 (3.0 hrs.)
Subtotal	$5,000	Subtotal	$1,200
Allocation of COT Host Digital Terminal Investment per 120 RT 120 lines / 672 lines per COT HDT = 17.86% x 75% assumed HDT fill = 23.81%	.2381	Allocation of COT Host Digital Terminal Investment per 120 RT 120 lines / 672 lines per COT HDT = 17.86% x 75% assumed HDT fill = 23.81%	.2381
Subtotal	$1,200	Subtotal	$300
Remote Terminal Common Equipment		**Remote Terminal Labor**	
Cabinet w/ Channel Bank Assembly	$5,500	Place Cabinet	$55 (1.0 hrs.)
Channel Bank Assembly Commons	$2,200	Copper Splicing (2 hrs. + 120 pairs @ 400/hr.)	$17 (0.3 hrs.)
		Turn Up & Test System	$110 (2.0 hrs.)
Subtotal	$7,700	Subtotal	$200
Total = $9,400			

3.5.12. Maximum Number of Additional Line Modules per Remote Terminal

Definition: The number of line modules (in increments of 672 or 120 lines, respectively, for the two types of DLC) that can be added to a remote terminal.

Default Values:

Max. # Add. Line Modules/RT	
High Density GR-303 DLC	**Low density GR-303 DLC**
2	1

Support: A standard OC-3 multiplexed site can provide 3 OC-1 systems, each at 672 lines. The HAI Model allows for adding 2 additional Common Equipment Investment modules to an initial 672 line system, and 1 additional Common Equipment Investment module to an initial 120 line system.

High Density Applications:

While products from different vendors of large NGDLC remotes for high density applications are available in a variety of sizes, HM 5.1 models typical digital loop carrier remote sizes as follows:

672 DS0s Modeled by HM 5.1 as an Initial Line Increment
1344 DS0s Modeled by HM 5.1 as an Initial Line Increment plus One Additional Increment
2016 DS0s[35] Modeled by HM 5.1 as an Initial Line Increment plus Two Additional Increments

Low Density Applications:
Similarly, there are a wide variety of DLC products available for low density applications. The following sizes are modeled in HM 5.1:

120 DS0s Modeled by HM 5.1 as an Initial Line Increment
240 DS0s Modeled by HM 5.1 as an Initial Line Increment plus One Additional Increment

3.5.13. DLC Extended Range Copper Multiplier

Definition: For a loop with feeder plant provided over fiber fed High Density GR-303 DLC, this multiplier adjusts the installed cost of a "High Density GR-303 DLC POTS Channel Unit" (see para. 3.5.5.) upward for any case where the distribution copper distance is equal to or greater than the "Remote Terminal Extended Range Threshold" (see para. 3.5.14.) and no greater than 18,000 feet. The maximum analog copper distance, Section 2.7.6, should never be set larger than 18,000 ft.

For a loop with feeder plant provided by fiber fed Low Density GR-303 DLC, this multiplier adjusts the installed cost of a "Low Density GR-303 DLC POTS Channel Unit" (see para. 3.5.5.) downward for any case where the distribution copper distance is shorter than the "Remote Terminal Extended Range Threshold" (see para. 3.5.14.), since the default cost of the channel units for the low-density DLC assumes they are used in extended-range applications.

Default Values:

DLC Extended Range Copper Multiplier	
High Density GR-303 DLC	Low density GR-303 DLC
1.00	1.00

Support: In the HAI Model version 5.0a, the default value for a "High Density GR-303 DLC POTS Channel Unit" (see para. 3.5.5.) assumed use of a Regular POTS ("RPOTS") card. Other parties criticized use of this card as being inadequate for extended range copper distribution loops. In HM 5.1, this new parameter allows an adjustment to line card investment for cases where a copper distribution pair length is equal to or greater than the "Remote Terminal Extended Range Threshold," whose default is 17,600 feet (see para. 3.5.14). According to the manufacturer, the most economical extended range alternative for POTS services is the RUVG2 card, at a cost premium of 24%.

In the HAI Model version 5.0a, the default value for a "Low Density GR-303 DLC POTS Channel Unit" (see para. 3.5.5.) assumed use of an Extended Range POTS ("EPOTS") card, under the assumption that most low density loops would be long loops. HM 5.1 allows the use of a less costly low-density channel unit for regular POTS service when loop lengths are below the "Remote Terminal Extended Range Threshold." Information available to the engineering team supporting the HAI Model shows that the regular POTS channel unit is 24% less than the EPOTS channel unit card.

[35] *Note: 2016 line Remote Terminal Cabinets have been available in the market place for some time; one example is the Reltec Mesa 6 Cabinet for housing Litespan-2000 DLC.*

3.5.14. Remote Terminal Extended Range Threshold

Definition:

For a loop with feeder plant consisting of fiber fed GR-303 DLC, this parameter allows the user to set a threshold to determine whether regular or extended range POTS Channel Units should be used. For the high-density DLC, if the copper distribution distance is equal to or greater than the threshold value, then the Model uses extended range POTS Channel Units by applying the "DLC Extended Range Copper Multiplier" to the Channel Unit investment. (see para 3.5.13.). For the low density DLC, if the copper distribution distance is less than the threshold value, the the Model uses a regular POTS card rather than the more expensive EPOTS card.

Default Values:

RT Extended Range Threshold, ft
17,600 feet

Support:

This figure was presented and justified in an AT&T *Ex Parte* presentation to the FCC Joint Board on Universal Service in Docket 96-45 on January 6, 1998.

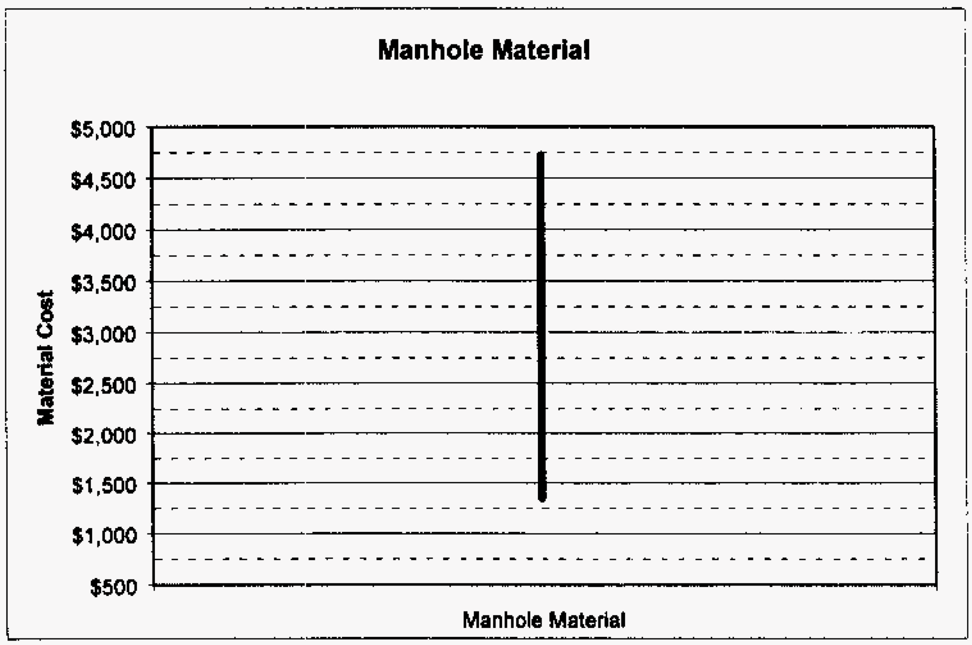
3.6. MANHOLE INVESTMENT – COPPER FEEDER

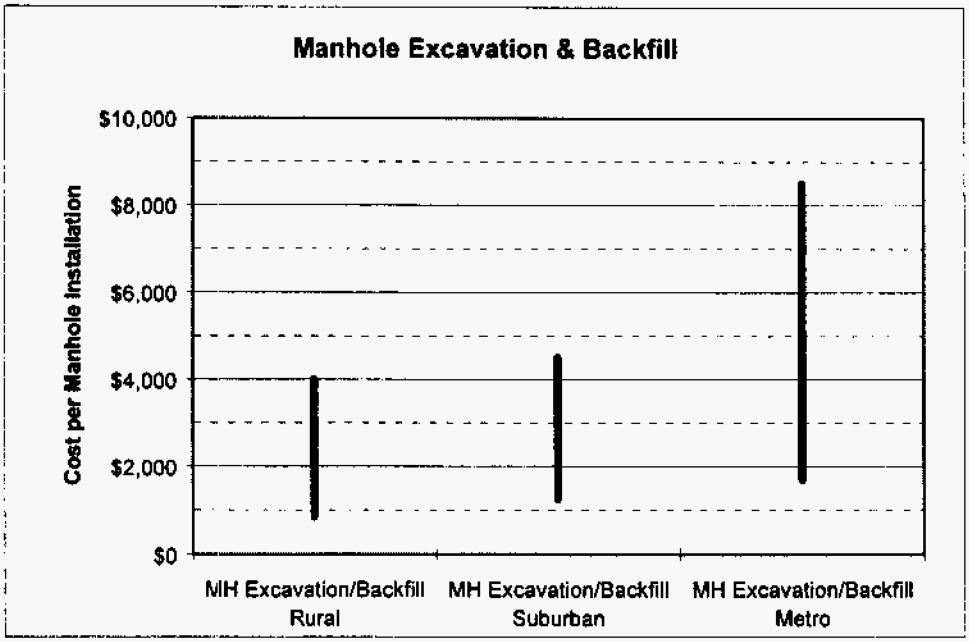
Definition: The installed cost of a prefabricated concrete manhole, including backfill and restoration. All the non-italicized costs in the following table are separately adjustable.

Default Values:

Copper Cable Manhole Investment						
Density Zone	Materials	Frame & Cover	Site Delivery	Total Material	Excavation & Backfill	Total Installed Manhole
0-5	$1,865	$350	$125	*$2,340*	$2,800	*$5,140*
5-100	$1,865	$350	$125	*$2,340*	$2,800	*$5,140*
100-200	$1,865	$350	$125	*$2,340*	$2,800	*$5,140*
200-650	$1,865	$350	$125	*$2,340*	$2,800	*$5,140*
650-850	$1,865	$350	$125	*$2,340*	$3,200	*$5,540*
850-2,550	$1,865	$350	$125	*$2,340*	$3,500	*$5,840*
2,550-5,000	$1,865	$350	$125	*$2,340*	$3,500	*$5,840*
5,000-10,000	$1,865	$350	$125	*$2,340*	$5,000	*$7,340*
10,000+	$1,865	$350	$125	*$2,340*	$5,000	*$7,340*

Support: Costs for various excavation methods were estimated by a team of experienced outside plant experts. Additional information was obtained from printed resources. Still other information was provided by several contractors who routinely perform excavation, conduit, and manhole placement work for telephone companies. Results of those inquiries validated the opinions of outside plant experts and are revealed in the following charts.





3.6.1. Dewatering Factor for Manhole Placement

Definition: The fractional increase in manhole placement to reflect additional cost required to install manholes in the presence of shallow water table. Default value is 0.2, indicating that high water tables will increase excavation and restoral cost by 20%.

Default Value:

Dewatering Factor Manhole Investment
0.20

Support: Ground water is not normally a problem with plowing and trenching; it softens the ground and usually does not hinder excavation work. In the rare cases of very wet conditions, contractors simply make sure they always use track vehicles, which is the normal type of equipment used in any case.

Manhole excavation and placement, however, can involve somewhat increased costs. In very high water table areas, a concrete manhole will actually tend to float while contractors attempt placement, requiring additional pumping and dewatering during construction work. After the manhole is in place, no additional cost is involved because of water.

3.6.2. Water Table Depth for Dewatering

Definition: Water table depth at which dewatering factor is invoked.

Default Value:

Water Table Depth for Dewatering, ft.
5.00 ft.

Support: Class A manholes are normally placed at a depth of approximately 8 feet. Some residual water is typical. Therefore, a default value of 5 feet is recommended to represent any additional cost incurred to care for high water difficulties in manhole placements.

3.7. PULLBOX INVESTMENT – FIBER FEEDER

Definition: The investment per fiber pullbox in the feeder portion of the network.

Default Values:

Fiber Pullbox Investment		
Density Zone	**Pullbox Materials**	**Pullbox Installation**
0-5	$280	$220
5-100	$280	$220
100-200	$280	$220
200-650	$280	$220
650-850	$280	$220
850-2,550	$280	$220
2,550-5,000	$280	$220
5,000-10,000	$280	$220
10,000+	$280	$220

Support: The information was received from a Vice President of PenCell Corporation at Supercom '96. He stated a price of approximately $280 for one of their larger boxes, without a large corporate purchase discount. Including installation, HM 5.1 uses a default value of $500.

4. SWITCHING AND INTEROFFICE TRANSMISSION PARAMETERS

4.1. END OFFICE SWITCHING

4.1.1. Switch Real-Time Limit, BHCA

Definition: The maximum number of busy hour call attempts (BHCA) a switch can handle. If the model determines that the load on a processor, calculated as the number of busy hour call attempts times the processor feature load multiplier, exceeds the switch real time limit multiplied by the switch maximum processor occupancy, it will add a switch to the wire center.

Default Values:

Switch Real-time limit, BHCA	
Lines Served	BHCA
1-1,000	10,000
1,000-10,000	50,000
10,000-40,000	200,000
40,000+	600,000

Support: Industry experience and expertise of HAI. These numbers are well within the range of the BHCA limitations NORTEL supplies in its Web site.[36]

Busy Hour Call Attempt Limits from Northern Telecom Internet Site	
Processor Series	BHCA
SuperNode Series 10	200,000
SuperNode Series 20	440,000
SuperNode Series 30	660,000
SuperNode Series 40	800,000
SuperNode Series 50 (RISC)	1,200,000
SuperNode Series 60 (RISC)	1,400,000 (burst mode)

4.1.2. Switch Traffic Limit, BHCCS

Definition: The maximum amount of traffic, measured in hundreds of call seconds (CCS), the switch can carry in the busy hour (BH). If the model determines that the offered traffic load on an end office switching network exceeds the traffic limit, it will add a switch.

[36] See Northern Telecom's Web site at *http://www.nortel.com*

Default Values:

Lines	Busy Hour CCS
1-1,000	30,000
1,000-10,000	150,000
10,000-40,000	600,000
40,000+	1,800,000

Support: Values selected to be consistent with BHCA limit assuming an average holding time of five minutes.

4.1.3. Switch Maximum Equipped Line Size

Definition: The maximum number of lines plus trunk ports that a typical digital switching machine can support.

Default Value:

Switch Maximum Equipped Line Size
80,000

Support: This is a conservative assumption based on industry common knowledge and the Lucent Technologies web site.[37] The site states that the 5ESS-2000 can provide service for "up to as many as 100,000 lines but can be engineered even larger." The HAI Model lowers the 100,000 to 80,000, or 80 percent, recognizing that planners will not typically assume the full capacity of the switch can be used.

4.1.4. Switch Port Administrative Fill

Definition: The percent of lines in a switch that are assigned to subscribers compared to the total equipped lines in a switch.

Default Value:

Switch Port Administrative Fill
0.98

Support: Industry experience and expertise of HAI in conjunction with subject matter experts.

4.1.5. Switch Maximum Processor Occupancy

Definition: The fraction of total capacity (measured in busy hour call attempts, BHCA) an end office switch is allowed to carry before the model adds another switch.

[37] See Lucent's Web site at http://www.lucent.com/netsys/5ESS/5esswtch.html

Default Value:

Switch Maximum Processor Occupancy
0.90

Support: Bell Communications Research, *LATA Switching Systems Generic Requirements*, Section 17: Traffic Capacity and Environment, TR-TSY-000517, Issue 3, March 1989, figure 17.5-1, p. 17-24.

4.1.6. MDF/Protector Investment per Line

Definition: The Main Distribution Frame investment, including protector, required to terminate one line. According to Lucent's Web site, a main distribution frame is "a framework used to cross-connect outside plant cable pairs to central office switching equipment, but also carrier facility equipment such as Office Repeater Bays and SLC[R] Carrier Central Office Terminals. The MDF is usually used to provide protection and test access to the outside plant cable pairs."

Default Value:

MDF/Protector Investment per Line
$12.00

Support: This price was obtained by Telecom Visions, Inc., a consulting firm that assisted in the preparation of this Input Portfolio,, from a major manufacturer of MDF frames and protectors. A review of this price with information available in various proceedings indicates that this is a competitive investment cost.

4.1.7. Analog Line Circuit Offset for DLC Lines, per Line

Definition: The reduction in per line switch investment resulting from the fact that line cards are not required in both the switch and remote terminal for DLC-served lines.

Default Value:

Analog Line Circuit Offset for DLC Lines
$5.00 per line

Support: This is an HAI estimate, based on consultations with AT&T and MCI subject matter experts.

4.1.8. Switch Installation Multiplier

Definition: The telephone company investment in switch engineering and installation activities, expressed as a multiplier of the switch investment.

Default Value:

Switch Installation Multiplier
1.10

Support: The 10% factor used in the HAI model was derived based on the following information: Bell Atlantic ONA filing (FCC Docket 92-91) on February 13, 1992, showed a range of engineering factors for the different Bell Atlantic states between .08 and .108. The SBC ONA filing (FCC Docket 92-91) on May 18, 1992, showed a range of engineering and plant labor factors added together between .0879 and .1288. The 10% incremental-based factor is a fairly conservative estimate, given the ranges filed by two RBOCs using traditional ARMIS-based embedded cost factor development.

4.1.9. End Office Switching Investment Constant Term

Definition: The value of the constant ("B") appearing in the function that calculates the per line switching investment as a function of switch line size for an amalgam of host-remote and stand alone switches, expressed separately for BOCs and large independents (ICOs), on the one hand, and for small ICOs, on the other hand. The function is cost per line = A *ln* X + B, where X is the number of lines.

Default Values:

End Office Switching Investment Constant Term	
BOC & Large ICO	Small ICO
$242.73	$416.11

Support: The switching cost surveys were developed using typical per-line prices paid by BOCs, GTE and other independents as reported in the Northern Business Information (NBI) publication, "U.S., Central Office Equipment Market: 1995 Database," compared to switch size and data from the ARMIS 43-07 report.[38] Details of the derivation of this formula and its values are provided in the HAI Model Description.

4.1.10. End Office Switching Investment Slope Term

Definition: The constant multiplying the log function appearing in the EO switching investment function ("A" in the function shown in parameter 4.1.9.) that calculates the per line switching investment as a function of switch line size for an amalgam of host-remote and stand alone switches. This term is the same for BOCs, large independents, and small independents.

Default Value:

EO Switching Investment Slope Term
-14.922

Support: The switching cost surveys were developed using typical per-line prices paid by BOCs, GTE and other independents as reported in the Northern Business Information (NBI) publication, "U.S., Central Office Equipment Market: 1995 Database," compared to switch size and data from the ARMIS 43-07 report.[39] Details of the derivation of this formula and its values are provided in the HAI Model Description.

[38] Northern Business Information study: *U.S. Central Office Equipment Market – 1995*, McGraw-Hill, New York, 1996.

4.1.11. Processor Feature Loading Multiplier

Definition: The amount by which the load on a processor exceeds the load associated with ordinary telephone calls, due to the presence of vertical features, Centrex, etc., expressed as a multiplier of nominal load.

Default Value: 1.20 for business line percentage up to the variable business penetration rate, increasing linearly above that rate to a final value of 2.00 for 100% business lines.

Support: This is an HAI estimate of the impact of switch features typically utilized by businesses on switch processor load. The assumption is that business lines typically invoke more features and services. Therefore, business lines affect processor real time loading more than residential lines. It is based on consultations with AT&T and MCI subject matter experts.

4.1.12. Business Penetration Ratio

Definition: The ratio of business lines to total switched lines at which the processor feature loading multiplier is assumed to reach the "heavy business" value of 2.

Default Value:

Business Penetration Ratio
0.30

Support: This is an HAI estimate of the point at which the number of business lines will cause the 20 percent processor load addition. It is based on consultations with AT&T and MCI subject matter experts.

4.2. WIRE CENTER

4.2.1. Lot Size, Multiplier of Switch Room Size

Definition: The multiplier of switch room size to arrive at total lot size to accommodate building and parking requirements.

Default Value:

Lot Size, Multiplier of Switch Room Size
2.0

Support: This is an HAI estimate.

4.2.2. Tandem/EO Wire Center Common Factor

Definition: The percentage of tandem switches that are also end office switches. This accounts for the fact that tandems and end offices are often located together, and is employed to avoid double counting of switch common equipment and wire center investment in these instances.

Default Value:

Tandem/EO Wire Center Common Factor
0.4

Support: This is a conservatively low estimate of the number of shared-use switches based on Bellcore's Local Exchange Routing Guide (LERG) data.

4.2.3. Power Investment

Definition: The wire center investment required for rectifiers, battery strings, back-up generators and various distributing frames, as a function of switch line size.

Default Values:

Lines	Investment Required
0	$5,000
1000	$10,000
5000	$20,000
25,000	$50,000
50,000	$250,000

Support: This is an HAI Estimate.

4.2.4. Switch Room Size

Definition: The area in square feet required for housing a switch and its related equipment.

Default Values:

Switch Room Size	
Lines	Sq. Feet of Floor Space Required
0	500
1,000	1,000
5,000	2,000
25,000	5,000
50,000	10,000

Support: Industry experience and expertise of HAI along with information taken from manufacturer product literature (e.g., Nortel DMS-500 Planner and 5ESS Switch Information Guide). Furthermore, these values are supported by discussions over the years with personnel from LECs and competitive access providers who are familiar with the size of switch rooms through installing switches and/or acquiring space for network switches.

4.2.5. Construction Costs, per Square Foot

Definition: The costs of construction of a wire center building.
Default Values:

Construction Costs per sq. ft.	
Lines	Cost/sq. ft.
0	$75
1,000	$85
5,000	$100
25,000	$125
50,000	$150

Support: This is an HAI estimate. Although cost per square foot generally decreases as building size increases, the construction cost per square foot is assumed to increase with the number of lines served to account for higher prices typically associated with greater population densities where larger switches tend to be located.

4.2.6. Land Price, per Square Foot

Definition: The land price associated with a wire center.

Default Values:

Lines	Price/sq. ft.
0	$5.00
1,000	$7.50
5,000	$10.00
25,000	$15.00
50,000	$20.00

Support: This is an HAI estimate. Land cost per square foot are assumed to increase with the number of lines served to account for higher prices typically associated with greater population densities where larger switches are located.

4.3. TRAFFIC PARAMETERS

4.3.1. Local Call Attempts

Definition : The number of yearly local call attempts, as reported to the FCC.

Default Value: Taken from ARMIS reports for the LEC being studied.

Support: 1996 ARMIS report 43-08. For non-Tier I LECs, the default value is the average per line local call attempt value for all ICOs reporting to ARMIS.

4.3.2. Call Completion Fraction

Definition: The percentage of call attempts that result in a completed call. Calls that result in a busy signal, no answer, or network blockage are all considered incomplete.

Default Value:

Call Completion Fraction
0.7

Support: Bell Communications Research, *LATA Switching Systems Generic Requirements*, Section 17: Traffic Capacity and Environment, TR-TSY-000517, Issue 3, March 1989. This number is a composite of the results shown in table 17.6-B.

4.3.3. IntraLATA Calls Completed

Definition : The number of yearly intraLATA completed call attempts, as reported to the FCC.

Default Value: Taken from 1996 ARMIS reports for the LEC being studied.

Support: 1996 ARMIS report 43-08. For non-Tier I LECs, the default value is the average per line IntraLATA calls completed value for all ICOs reporting to ARMIS.

4.3.4. InterLATA Intrastate Calls Completed

Definition : The number of yearly interLATA intrastate completed call attempts, as reported to the FCC.

Default Value: Taken from 1996 ARMIS reports for the LEC being studied.

Support: 1996 ARMIS report 43-08. For non-Tier I LECs, the default value is the average per line interLATA intrastate calls completed value for all ICOs reporting to ARMIS.

4.3.5. InterLATA Interstate Calls Completed

Definition : The number of yearly interLATA interstate completed call attempts, as reported to the FCC.

Default Value: Taken from 1996 ARMIS reports for the LEC being studied.

Support: 1996 ARMIS report 43-08. For non-Tier I LECs, the default value is the average per line interLATA interstate calls completed value for all ICOs reporting to ARMIS.

4.3.6. Local DEMs, Thousands

Definition : The number of yearly local Dial Equipment Minutes (DEMs), as reported to the FCC.

Default Value: Taken from FCC reports for the LEC being studied.

Support: See FCC Monitoring Report, Docket No. 87-339, May 1995, Table 4.15.

4.3.7. Intrastate DEMs, Thousands

Definition: The number of yearly intrastate DEMs, as reported to the FCC.

Default Value: Taken from FCC reports for the LEC being studied.

Support: See FCC Monitoring Report, Docket No. 87-339, May 1995, Table 4.16.

4.3.8. Interstate DEMs, Thousands

Definition: The number of yearly interstate DEMs, as reported to the FCC.

Default Value: Taken from FCC reports for the LEC being studied.

Support: See FCC Monitoring Report, Docket No. 87-339, May 1995, Table 4.17.

4.3.9. Local Business/Residential DEMs Ratio

Definition: The ratio of local Business DEMs per line to local Residential DEMs per line

Default Value:

Local Bus / Res DEMs Ratio
1.1

Support: This is an HAI estimate, based on consultations with AT&T and MCI subject matter experts.

4.3.10. Intrastate Business/Residential DEMs

Definition: The ratio of intrastate Business DEMs per line to intrastate Residential DEMs per line

Default Value:

Intrastate Bus / Res DEMs Ratio
2

Support: This is an HAI estimate, based on consultations with AT&T and MCI subject matter experts.

4.3.11. Interstate Business/Residential DEMs

Definition: The ratio of interstate Business DEMs per line to interstate Residential DEMs per line

Default Value:

Interstate Bus / Res DEMs Ratio
3

Support: This is an HAI estimate, based on consultations with AT&T and MCI subject matter experts.

4.3.12. Busy Hour Fraction of Daily Usage

Definition: The percentage of daily usage that occurs during the busy hour.

Default Value:

Busy Hour Fraction of Daily Usage
0.10

Support: AT&T Capacity Cost Study.[40]

4.3.13. Annual to Daily Usage Reduction Factor

Definition: The effective number of business days in a year, used to concentrate annual usage into a fewer number of days as a step in determining busy hour usage.

Default Value:

Annual to Daily Usage Reduction Factor
270

Support: The AT&T Capacity Cost Study uses an annual to daily usage reduction factor of 264 days.[41]

[40] Blake, V.A., Flynn, P.V., Jennings, F.B., AT&T Bell Laboratories, *"A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, June 20, 1990, p.10. Filed in CC Docket No. 90-132.

[41] Blake, V.A., Flynn, P.V., Jennings, F.B., AT&T Bell Laboratories, *"A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth"*, June 20, 1990, p.10. Filed in CC Docket No. 90-132.

4.3.14. Holding Time Multipliers, Residential/Business

Definition: The potential modification to the average call "holding time" (i.e., duration) to reflect Internet use or other causes, expressed as a multiplier of the holding time associated with ordinary residential or business telephone calls.

Default Values:

Holding time multipliers	
Residential	**Business**
1.0	1.0

Support: The purpose of this parameter is to allow users to study the impact of increasing the offered load on the network. The default value of 1 means the load is that estimated from DEMs.

4.3.15. Call Attempts, Busy Hour (BHCA), Residential/Business

Definition: The number of call attempts originated per residential and business subscriber during the busy hour.

Default Values:

Busy Hour Call Attempts	
Residential	**Business**
1.3	3.5

Support: Bell Communications Research, *LATA Switching Systems Generic Requirements*, Section 17: Traffic Capacity and Environment, TR-TSY-000517, Issue 3, March 1989. This number is a composite of the results shown in table 17.6 C-G.

4.4. INTEROFFICE INVESTMENT

4.4.1. Transmission Terminal Investment

Definition: The investment in 1) the fully-equipped add-drop multiplexer (ADM) that extracts/inserts signals into OC-48 or OC-3 fiber rings, and are needed in each wire center to connect the wire center to the interoffice fiber ring; and 2) the fully-equipped OC-3/DS-1 terminal multiplexers required to interface to the OC-48 ADM and to provide point to point circuits between on-ring wire centers and end offices not connected directly to a fiber ring. The "Investment per 7 DS-1" figure is the amount by which the investment in OC-3s is reduced for each unit of 7 DS-1s below full capacity of the OC-3. See the figure in Appendix A.

Default Values:

Transmission Terminal Investment			
OC-48 ADM, Installed		OC-3/DS-1 ADM/Terminal Multiplexer, Installed	Investment per 7 DS-1s
48 DS-3s	12 DS-3s	84 DS-1s	7 DS-1s
$50,000	$40,000	$26,000	$500

Support: Industry experience and expertise of HAI, supplemented by consultations with telecommunications equipment suppliers.

4.4.2. Number of Fibers

Definition: The assumed fiber cross-section, or number of fibers in a cable, in an interoffice fiber ring and point to point connection.

Default Value:

Number of Fibers
24

Support: The default value is consistent with common practices within the telecommunications industry and reflects the engineering judgment of HAI Model developers.

4.4.3. Pigtail Investment

Definition: The cost of the short fiber connectors that attach the interoffice ring fibers to the wire center transmission equipment via a patch panel.

Default Value:

Pigtail Investment
$60 each

Support: A public source estimates the cost of pigtails at $75.00 per fiber. See, Reed, David P., *Residential Fiber Optic Networks and Engineering and Economic Analysis*, Artech House, Inc., 1992, p.93. The lower amount reflects an HAI estimate of price trends since that figure was published.

4.4.4 Optical Distribution Panel

Definition: The cost of the physical fiber patch panel used to connect 24 fibers to the transmission equipment.

Default Value:

Optical Distribution Panel
$1,000

Support: The cost for an installed fiber optic patch panel, including splicing of the fibers to pigtails, was estimated by a team of experienced outside plant experts who have contracted for such installations. A fiber optic patch panel contains no electronic or moving parts, but allows for the physical cross connection of fiber pigtails.

4.4.5. EF&I, per Hour

Definition: The per-hour cost for the "engineered, furnished, and installed" activities for equipment in each wire center associated with the interoffice fiber ring, such as the "pigtails" and patch panels to which the transmission equipment is connected.

Default Value:

EF&I
$55 per hour

Support: This is a fully loaded labor rate used for the most sophisticated technicians. It includes basic wages and benefits, Social Security, Relief & Pensions, management supervision, overtime, exempt material and motor vehicle loadings. A team of experienced outside plant experts estimated this value.

4.4.6. EF&I, Units

Definition: The number of hours required to install the equipment associated with the interoffice transmission system (see EF&I, per hour, above) in a wire center.

Default Value:

EF&I, units
32 hours

Support: This amount of labor was estimated by a team of experienced engineering experts. It includes the labor hours to install and test the transport equipment involved in interoffice facilities.

4.4.7. Regenerator Investment, Installed

Definition: The installed cost of an OC-48 optical regenerator.

Default Value:

Regenerator Investment, Installed
$15,000

Support: This approximation was obtained from a representative of a major fiber optic multiplexer manufacturer at Supercom '96, in June 1996 in Dallas, Texas.

Current fiber multiplexers readily operate at distance beyond 40 miles between a laser transmitter and a laser receiver. Where span distances exceed the recommended default of 40 miles, a regenerator is required. Significantly different from a fiber optic multiplexer that combines large numbers of low speed signals into an extremely high speed laser driven device using Time Division Multiplexing, a regenerator simply receives a high speed laser pulse, determines whether each individual laser pulse is an "on" or "off" condition, and triggers a laser to fire a signal in an identical pattern.

An OC-48 regenerator is a single shelf device, no more than 10½ inches high by 21½ inches wide by 12 inches deep. Installation is normally done in a central office environment by simply screwing it onto an existing frame, providing a standard CO power connection, and attaching the fiber pigtails. The default value assumes installation in an existing central office along the route, and including costs for material, engineering, and installation.

4.4.8. Regenerator Spacing, Miles

Definition: The distance between digital signal regenerators in the interoffice fiber optics transmission system.

Default Value:

Regenerator Spacing
40 miles

Support: Based on field experience of maximum distance before fiber regeneration is necessary. This number is conservatively low compared to Fujitsu product literature, which indicates a maximum regenerator spacing of 110km, or approximately 69 miles[42] (with post- and pre-amp).

4.4.9. Channel Bank Investment, per 24 Lines

Definition: The investment in voice grade to DS-1 multiplexers in wire centers required for some special access circuits.

[42] Futjitsu Network Communications, Inc. product sheet for Flash™-192 multiplexer, "Typical Optical Span Lengths SMF Fiber {Single Mode Fiber} 110 km (with post- and pre-amp)."

Default Value:

Channel Bank Investment, per 24 lines
$5,000

Support: Industry experience and expertise of HAI, supplemented by consultations with telecommunications equipment suppliers.

4.4.10. Fraction of SA Lines Requiring Multiplexing

Definition: The percentage of special access circuits that require voice grade to DS-1 multiplexing in the wire center in order to be carried on the interoffice transmission system. This parameter is for use in conjunction with a study of the cost of special access circuits.

Default Value:

Fraction of SA Lines Requiring Multiplexing
0.0

Support: The default value of zero is appropriate for the existing set of UNEs, which do not include a special access UNE.

4.4.11. Digital Cross Connect System, Installed, per DS-3

Definition: The investment required for a digital cross connect system that interfaces DS-1 signals between switches and OC-3 multiplexers, expressed on a per DS-3 (672 DS-0) basis.

Default Value:

Digital Cross Connect System, Installed, per DS-3
$30,000

Support: Industry experience and expertise of HAI, supplemented by consultations with telecommunications equipment suppliers.

4.4.12. Transmission Terminal Fill (DS-0 level)

Definition: The fraction of maximum DS-0 circuit capacity that can actually be utilized in ADMs, DS-1 to OC-3 multiplexers, and channel banks.

Default Value:

Transmission Terminal Fill (DS-0 level)
0.90

Support: Based on outside plant subject matter expert judgment.

4.4.13. Interoffice Fiber Cable Investment per Foot, Installed

Definition: The installed cost per foot of interoffice fiber cable, assuming a 24-fiber cable.

Default Value:

Interoffice Fiber Cable Investment, Installed, per foot
$1.79

Support: *{NOTE: The discussion in Section 3.4.2. [Fiber Feeder] is reproduced here for ease of use.}*

Outside plant planning engineers have commonly assumed that the cost of cable material can be represented as an a + bx straight line graph. In fact, Bellcore Planning tools, EFRAP I, EFRAP II, and LEIS:PLAN have had the engineer develop such an a + bx equation to represent the cost of cable. As technology, manufacturing methods, and competition have advanced, the price of cable has been reduced. While 10 years ago, the cost of fiber cable was typically $0.50 + $0.10 per fiber per foot, and as recently as 4 years ago was typically $0.30 + $0.05 per fiber per foot as represented in HM 5.0a, extensive deployment of fiber, especially by CATV companies has driven the cost of fiber even lower.

The Rural Utilities Service ("RUS") supplied Dr. David Gabel (on behalf of NRRI[43]) with a substantial amount of data from actual contracts. That data is available from the NRRI Website at http://www.nrri.ohio-state.edu/. An analysis of data involving fiber cable was performed to obtain the new default values recommended for HAI 5.1

71 of 1,505 observations were excluded from the analysis (32 observations with zero footage quantities, 10 observations with zero total cost, 23 observations containing labor only without any material, 3 observations of cables with 0-3 fibers, and 3 observations with costs far outside reasonable bounds, e.g., 24-fiber cable with material cost greater than a 216-fiber cable). The remaining 1,434 observations (1,028 buried, 243 aerial, and 163 underground) were analyzed to produce the new default values for installed fiber cable.

The analysis of 1,434 observations provided an a + bx result of $1.00 per foot plus $.032 per fiber-foot.

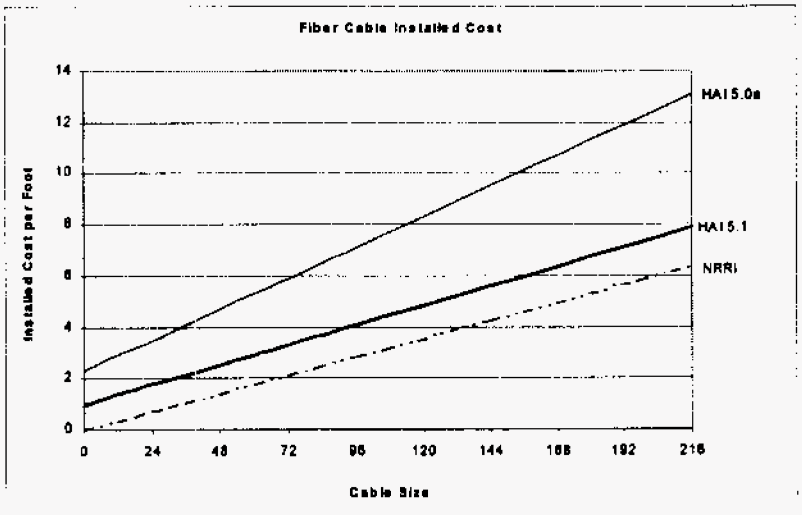
Splicing Engineering and Direct Labor are included in the cost of the Remote Terminal Installations, and the Central Office Installations, since field splicing is unnecessary with fiber cable pulls that are as long as 35,000 feet between splices.

The NRRI analysis recognized that the fixed component included structure costs, or partial structure costs for buried and underground installations. NRRI then excluded the fixed component of fiber cable costs. In contrast to that approach, this analysis normalized buried data to remove the cost of buried structure, and underground data was normalized to remove the cost of innerduct structure[44]. Engineering costs were assumed to be $0.04/ft. (2,000 ft./hr. @ $75/hr.), which is simpler than copper engineering because tasks involve route layout with construction forces reporting "as built" conditions.

[43] National Regulatory Research Institute.

[44] Buried fixed cost per foot was reduced by $0.88, and underground fixed cost per foot was reduced by $0.62. Installed costs per foot were as follows: Buried = $0.97 + $0.030/fiber; Aerial = $0.88 + $0.037/fiber; Underground = $1.02 + $0.032/fiber; Average all types = $0.96 + $0.032/fiber.

The following chart represents the default values used in the model HAI ver. 5.1, plus a comparison with HAI ver. 5.0a and the NRRI study.



4.4.14. Number of Strands per ADM

Definition: The number of interoffice fiber strands connected to the ADM in each wire center.
Default Value:

Number of Strands per ADM
4

Support: This is the standard number of strands required by an ADM. It provides for redundant transmission in both directions around the interoffice fiber ring.

4.4.15. Interoffice Structure Percentages

Definition: The relative amounts of different structure types supporting interoffice transmission facilities. Aerial cable is attached to telephone poles or buildings, buried cable is laid directly in the earth, and underground cable runs through underground conduit. Aerial and buried percentages are entered by the user; the underground fraction is then computed.

Default Values:

Structure Percentages		
Aerial	Buried	Underground
20%	60%	20%

Support: These are average figures that reflect the judgment of a team of outside plant experts regarding the appropriate mix of density zones applicable to interoffice transmission facilities.

4.4.16. Transport Placement

Definition: The cost of fiber cable structures used in the interoffice transmission system.

Default Values:

Transport Placement, per foot	
Buried	Conduit
$1.77	$16.40

Support: Structures closer to the central office are normally shared with feeder cable. Additional structures at the end of feeder routes may be required to complete an interoffice transport path. Since distances farther from the central office normally involve lower density zones, average structure costs appropriate for lower density zones are reflected in the default values. A default value for Buried representing the lower density zones is used, while a conservatively higher value is used for Conduit, representing the default value expected in a 850-2,550 line per square mile density zone.

4.4.17. Buried Sheath Addition

Definition: The cost of dual sheathing for additional mechanical protection of fiber interoffice transport cable.

Default Value:

Buried Sheath Addition
$0.20 per foot

Support: *{NOTE: The discussion in Section 3.2.3. [Fiber Feeder] is reproduced here for ease of use.}*

Incremental cost for mechanical sheath protection on fiber optic cable is a constant per foot, rather than the ratio factor used for copper cable, because fiber sheath is approximately ½ inch in diameter, regardless of the number of fiber strands contained in the sheath. The incremental per foot cost was estimated by a team of experienced outside plant experts who have purchased millions of feet of fiber optic cable.

4.4.18. Interoffice Conduit, Cost and Number of Tubes

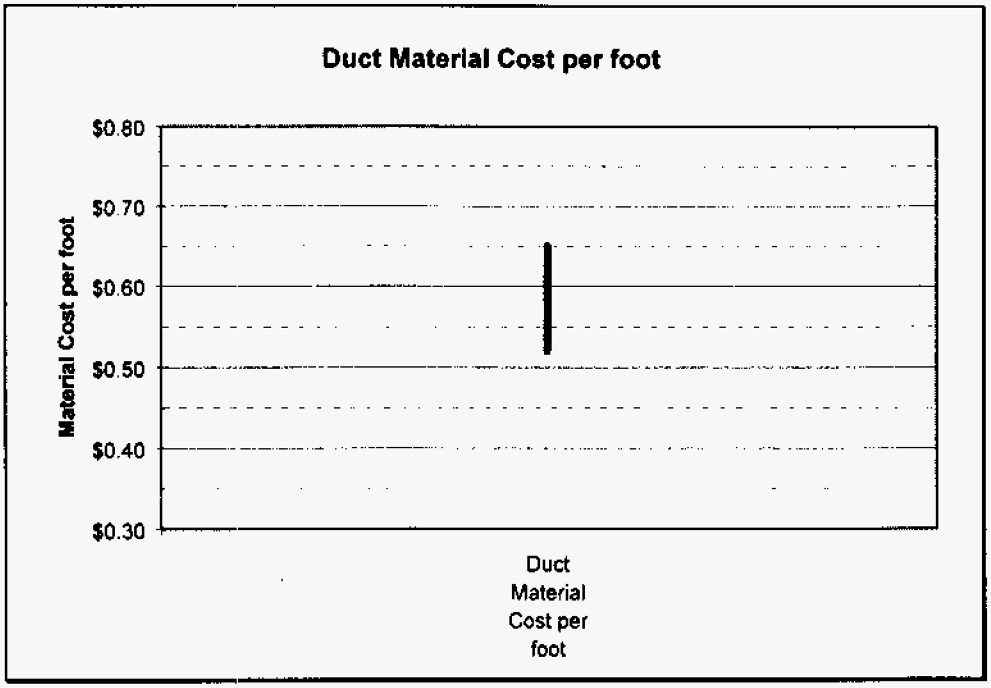
Definition: The cost per foot for interoffice fiber cable conduit, and the number of spare tubes (conduit) placed per route.

Default Values:

Interoffice Conduit, Cost and Number of Tubes	
Cost	Spare Tubes per Route
$0.60 per foot	1

Support: *{NOTE: The discussions in Sections 2.4.3. and 2.4.4. [Distribution] are reproduced here for ease of use.}*

Conduit Cost per foot:
Several suppliers were contacted for material prices. Results are shown below.



The labor to place conduit in trenches is included in the cost of the trench, not in the conduit cost.

Under the Model's assumptions, a relatively few copper cables serving short distances (e.g., less than 9,000 ft. feeder cable length), and one or more fiber cables to serve longer distances, will be needed. Since the number of cables in each of the four feeder routes is relatively small, the predominant cost is that of the trench, plus the material cost of a few additional 4" PVC conduit pipes. No additional allowance is necessary for stabilizing the conduit in the trench.

Spare Tubes per Route:
"A major advantage of using conduits is the ability to reuse cable spaces without costly excavation by removing smaller, older cables and replacing them with larger cables or fiber facilities. Some companies reserve vacant ducts for maintenance purposes."[45] Version 5.1 of the HAI Model provides one spare maintenance duct (as default) in each conduit run. In addition, if there is also a fiber feeder cable along with a copper feeder cable in the run, an additional maintenance duct (as a default) is provided in each conduit run to facilitate a fiber cable replacement at the same time a copper cable replacement may be required.

4.4.19. Pullbox Spacing

Definition: Spacing between pullboxes in the interoffice portion of the network.

[45] Bellcore, BOC Notes on the Networks - 1997, p. 12-46.

Default Value:

Pullbox Spacing
2,000 feet

Support: *{NOTE: The discussion in Section 3.2.2. [Feeder] is reproduced here for ease of use.}*

Unlike copper manhole spacing, the spacing for fiber pullboxes is based on the practice of coiling spare fiber (slack) within pullboxes to facilitate repair in the event the cable is cut or otherwise impacted. Fiber feeder pullbox spacing is not a function of the cable reel lengths, but rather a function of length of cable placed. The standard practice during the cable placement process is to provide for 5 percent excess cable to facilitate subsurface relocation, lessen potential damage from impact on cable, or provide for ease of cable splicing when cable is cut or damaged.[46] It is common practice for outside plant engineers to require approximately 2 slack boxes per mile.

4.4.20. Pullbox Investment

Definition: Investment per fiber pullbox in the interoffice portion of the network.

Default Value:

Pullbox Investment
$500

Support: *{NOTE: The discussion in Section 3.7. [Fiber Feeder] is reproduced here for ease of use.}*

The information was received verbally from a Vice President of PenCell Corporation at their Supercom '96 booth. He stated a price of approximately $280 for one of their larger boxes, without a large corporate purchase discount. Including installation, HM 5.1 uses a default value of $500.

4.4.21. Pole Spacing, Interoffice

Definition: Spacing between poles supporting aerial interoffice fiber cable.

Default Value:

Pole Spacing, Interoffice
150 feet

Support: This is a representative figure accounting for the mix of density zones applicable to interoffice transmission facilities.

4.4.22. Interoffice Pole Material and Labor

Definition: The installed cost of a 40' Class 4 treated southern pine pole.

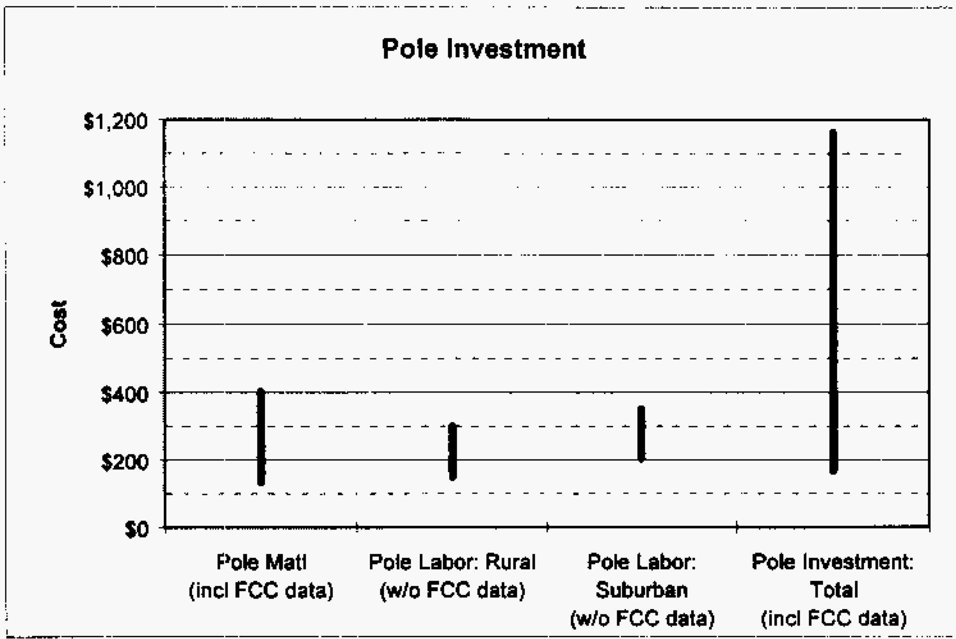
[46] CommScope, *Cable Construction Manual, 4th Edition*, p. 75.

Default Values:

Pole Investment	
Materials	$201
Labor	$216
Total	*$417*

***Support:** {NOTE: The discussion in Section 2.4.1. [Distribution] is reproduced here for ease of use. Refer to Section 2.4.1. [Distribution] for material, labor and total pole investment as depicted in a compilation of pole data charts that has recently been filed by large telephone companies with the FCC.}*

Pole investment is a function of the material and labor costs of placing a pole. Costs include periodic down-guys and anchors. Utility poles can be purchased and installed by employees of ILECs, but are frequently placed by contractors. Several sources revealed the following information on prices.



The exempt material load on direct labor includes ancillary material not considered by FCC Part 32 as a unit of plant. That includes items such as downguys and anchors that are already included in the pole placement labor cost. The steel strand run between poles is likewise an exempt material item, charged to the aerial cable account. The cost of steel strands is not included in the cost of poles; it is included in the installed cost of aerial cable.

4.4.23. Fraction of Interoffice Structure Common with Feeder

Definition: The percentage of structure supporting interoffice transport facilities that is also shared by feeder facilities, expressed as a fraction of the smaller of the interoffice and feeder investment for each of the three types of facilities (i.e., aerial, buried and underground are treated separately in calculating the amount of sharing).

Default Value:

Fraction of Interoffice Structure Common with Feeder
.75

Support: Interoffice transport facilities will almost always follow feeder routes which radiate from each central office. Typically only a small distance between adjacent wire centers is not traversed by a feeder route; for this distance, structure is appropriately assigned exclusively to interoffice transport. In the opinion of a team of outside plant engineers, the additional structure required exclusively for interoffice transport is no more than 25 percent of the distance. Therefore, 75 percent of the interoffice route is assumed by the HM 5.1 to be shared with feeder cables.

4.4.24. Interoffice Structure Sharing Fraction

Definition: The fraction of investment in interoffice poles and trenching that is assigned to ILECs. The remainder is attributed to other utilities/carriers.

Default Values:

Fraction of Interoffice Structure Assigned to Telephone		
Aerial	Buried	Underground
.33	.33	.33

Support: The structure sharing with other utilities covered by this parameter involves the portion of interoffice structure that is not shared with feeder cable. Sharing with other utilities is assumed to include at least two other occupants of the structure. Candidates for sharing include electrical power, CATV, competitive long distance carriers, competitive local access providers, municipal services and others. See also Appendix B.

4.5. TRANSMISSION PARAMETERS

4.5.1. Operator Traffic Fraction

Definition: Fraction of traffic that requires operator assistance. This assistance can be automated or manual (see Operator Intervention Fraction in the Operator Systems section below). These fractions may be varied by switch line size if the user has access to such information, in order to reflect possible differences between traffic characteristics for different demographic situations, such as a lower incidence of operator-assisted traffic in rural areas where smaller switches are typically deployed

Default Value:

Operator Traffic Fraction	
Line size	**Fraction**
0-1,000	0.02
1,000-10,000	0.02
10,000-40,000	0.02
40,000+	0.02

Support: Industry experience and expertise of HAI.

4.5.2. Total Interoffice Traffic Fraction

Definition: The fraction of all calls that are completed on a switch other than the originating switch, as opposed to calls completed within a single switch. These fractions may be varied by switch line size if the user has access to such information, in order to reflect possible differences between traffic characteristics for different demographic situations, such as a lower incidence of interoffice calls in rural areas where smaller switches are typically deployed.

Default Value:

Total Interoffice Traffic Fraction	
Line size	**Fraction**
0-1,000	0.65
1,000-10,000	0.65
10,000-40,000	0.65
40,000+	0.65

Support: According to *Engineering and Operations in the Bell System*, Table 4-5, p. 125, the most recent information source found to date, the percentage of calls that are interoffice calls ranges from 34 percent for rural areas to 69 percent for urban areas. Assuming weightings according to the typical number of lines per wire center for each environment (urban, suburban, rural), these figures suggest an overall interoffice traffic fraction of approximately 65 percent.

4.5.3. Maximum Trunk Occupancy, CCS

Definition: The maximum utilization of a trunk during the busy hour.

Default Value:

Maximum Trunk Occupancy, CCS
27.5

Support: AT&T Capacity Cost Study.[47]

4.5.4. Trunk Port Investment, per End

Definition: Per-trunk equivalent investment in switch trunk port at each end of a trunk.

Default Value:

Trunk Investment, per end
$100

Support: AT&T Capacity Cost Study.[48] HAI judgment is that $100 is for the switch port itself.

4.5.5. Direct-Routed Fraction of Local Interoffice Traffic

Definition: The amount of local interoffice traffic that is directly routed between originating and terminating end offices as opposed to being routed via a tandem switch. These fractions may be varied by switch line size, if the user has access to such information, in order to reflect possible differences between traffic characteristics for different demographic situations, such as a higher incidence of traffic routed via tandem switches in rural areas where smaller switches are typically deployed.

Default Value:

Direct-Routed Fraction of Local Interoffice	
Line size	Fraction
0-1,000	0.98
1,000-10,000	0.98
10,000-40,000	0.98
40,000+	0.98

Support: The direct routed fraction of local interoffice is based on data filed by the LECs in response to an FCC data request issued in Docket 80-286: *In the Matter of Amendment of Part 36 of the Commission's*

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[47] Blake, et al., "A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p.4.

[48] Blake, et al., "A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth,", p. 7.

Rules and Establishment of a Joint Board, Docket 80-286, Order, December 1, 1994, 9 FCC Rcd 7962 (1994). See Universal Service Fund Data Request, File 1 of 4, page 8 of 11, 9 FCC Rcd 7962, 7976.

4.5.6. Tandem-Routed Fraction of Total IntraLATA Toll Traffic

Definition: Fraction of intraLATA toll calls that are routed through a tandem. These fractions may be varied by switch line size, if the user has access to such information, in order to reflect possible differences between traffic characteristics for different demographic situations, such as a higher incidence of trandem-routed traffic in rural areas where smaller switches are typically deployed.

Default Value:

Tandem-Routed Fraction of Total IntraLATA Toll Traffic	
Line size	**Fraction**
0-1,000	0.20
1,000-10,000	0.20
10,000-40,000	0.20
40,000+	0.20

Support: The tandem routed fraction of total intraLATA toll traffic is based on data filed by the LECs in response to an FCC data request issued in Docket 80-286: *In the Matter of Amendment of Part 36 of the Commission's Rules and Establishment of a Joint Board*, Docket 80-286, Order, December 1, 1994, 9 FCC Rcd 7962 (1994). See Universal Service Fund Data Request, File 1 of 4, page 8 of 11, 9 FCC Rcd 7962, 7976.

4.5.7. Tandem-Routed Fraction of Total InterLATA Traffic

Definition: Fraction of interLATA (IXC access) calls that are routed through a tandem instead of directly to the IXC. These fractions may be varied by switch line size, if the user has access to such information, in order to reflect possible differences between traffic characteristics for different demographic situations, such as a higher incidence of trandem-routed traffic in rural areas where smaller switches are typically deployed.

Default Value:

Tandem-Routed Fraction of Total InterLATA Traffic	
Line size	**Fraction**
0-1,000	0.20
1,000-10,000	0.20
10,000-40,000	0.20
40,000+	0.20

Support: The tandem routed fraction of total interLATA traffic is based on data filed by the LECs in response to an FCC data request issued in Docket 80-286: *In the Matter of Amendment of Part 36 of the Commission's Rules and Establishment of a Joint Board*, Docket 80-286, Order, December 1, 1994, 9 FCC Rcd 7962 (1994). See Universal Service Fund Data Request, File 1 of 4, page 8 of 11, 9 FCC Rcd 7962, 7976.

4.5.8. POPs per Tandem Location

Definition: The number of IXC points of presence requiring an entrance facility, per LEC tandem.

Default Value:

POPs per Tandem Location
5

Support: An assumption that envisions POPs for three principal IXCs plus two smaller carriers associated with each LEC tandem.

4.5.9. Threshold Value for Off-Ring Wire Centers

Definition: The threshold value, in lines, that determines whether a wire center should be included in ring calculations and therefore be a candidate to appear on (that is, be directly connected to) a ring. Wire centers whose size falls below the threshold will not be appear on a ring, but will be connected via a redundant point-point link to the tandem switch or via a redundant "spur" to the nearest wire center that is on a ring. Transmission equipment in such cases consists of terminal multiplexers and not ADMs. This parameter only applies to companies that own and operate a local tandem switch.

Default Value:

Threshold Value for Off-Ring Wire Centers, total lines
1

Support: By setting this value to 1, all switches are candidates for being part of a ring. The algorithm that calculates ring configurations includes a test to ensure it is economic to incur the cost of terminal equipment required to be on the ring. Therefore, no other arbitrary limitation is required, although it is still provided to study the effect of an ILEC imposing such a limitation.

4.5.10. Remote-Host Fraction of Interoffice Traffic

Definition: Fraction of local direct traffic assumed to flow from a remote to its host switch.

Default Value:

Remote – Host Fraction of Interoffice Traffic, Remote
0.10

Support: Based on HAI judgment.

4.5.11. Host-Remote Fraction of Interoffice Traffic

Definition: Fraction of local direct traffic assumed to flow from a host to its remotes.

Default Value:

Host – Remote Fraction of Interoffice Traffic, Host
0.05

Support: Based on HAI judgment.

4.5.12. Maximum Nodes per Ring

Definition: Maximum number of ADMs that are permitted on a single ring.

Default Value:

Maximum Nodes per Ring
16

Support: Buffering and other internal delays in add/drop multiplexers (ADMs) ultimately limit the number of ADMs that can constitute a SONET ring. A 16-node limit is a typical value.[49]

4.5.13. Ring Transiting Traffic Factor

Definition: An estimated factor, representing the fraction of traffic that flows from one ring to another by way of a third, or "transit," ring.

Default Value:

Ring Transiting Traffic Factor
0.40

Support: Based on HAI judgement of the amount of traffic between wire centers on different rings versus total interoffice traffic and the number of rings that must be transited between the originating and terminating wire center.

[49] Fujitsu, Network Design Features, FJTU-320-560-100, Issue 3, Revision 1, December 1995, p.11.

4.5.14. Intertandem Fraction of Tandem Trunks

Definition: A factor used to estimate the number of additional tandem trunks required to carry intertandem traffic.

Default Value:

Intertandem Fraction of Tandem trunks
0.10

Support: Based on HAI judgement.

4.6. TANDEM SWITCHING

4.6.1. Real Time Limit, BHCA

Definition: The maximum number of BHCA a tandem switch can process.

Default Value:

Real Time Limit, BHCA
750,000

Support: Industry experience and expertise of HAI. These numbers are well within the range of the BHCA limitations NORTEL supplies in its Web site. See 4.1.1.

4.6.2. Port Limit, Trunks

Definition: The maximum number of trunks that can be terminated on a tandem switch.

Default Value:

Port Limit, Trunks
100,000

Support: AT&T Updated Capacity Cost Study.[50]

4.6.3. Tandem Common Equipment Investment

Definition: The amount of investment in common equipment for a large tandem switch. Common Equipment is the hardware and software that is present in the tandem in addition to the trunk terminations themselves. The cost of a tandem is estimated by the HAI Model as the cost of common equipment plus an investment per trunk terminated on the tandem.

Default Value:

Tandem Common Equipment Investment
$1,000,000

Support: AT&T Capacity Cost Study.[51]

4.6.4. Maximum Trunk Fill (Port Occupancy)

Definition: The fraction of the maximum number of trunk ports on a tandem switch that can be utilized.

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[50] Brand, T.L., Hallas, G.A., et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", April 19, 1995, p. 9.

[51] Blake, et. al., "A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p.9.

Default Value:

Maximum Trunk Fill (port occupancy)
0.90

Support: This is an HAI estimate, based on consultations with AT&T and MCI subject matter experts.

4.6.5. Maximum Tandem Real Time Occupancy

Definition: The fraction of the total capacity (expresses as the real time limit, BHCA) a tandem switch is allowed to carry before an additional switch is provided.

Default Value:

Maximum Tandem Real Time Occupancy
0.9

Support: Bell Communications Research, *LATA Switching Systems Generic Requirements*, Section 17: Traffic Capacity and Environment, TR-TSY-000517, Issue 3, March 1989, figure 17.5-1, p. 17-24.

4.6.6. Tandem Common Equipment Intercept Factor

Definition: The multiplier of the common equipment investment input that gives the common equipment cost for the smallest tandem switch, allowing scaling of tandem switching investment according to trunk requirements.

Default Value:

Tandem Common Equipment Intercept Factor
0.50

Support: Value selected to allow tandem common equipment investment to range from $500,000 to $1,000,000 which is the appropriate range based on expertise of HAI.

4.6.7. Entrance Facility Distance from Serving Wire Center & IXC POP

Definition: Average length of trunks connecting an IXC POP with the wire center that serves it.

Default Value:

Entrance Facility Distance from Serving Wire Center & IXC POP
0.5 miles

Support: Value selected in recognition of the fact that IXCs typically locate POPs close to the serving wire center to avoid long cable runs.

4.7. SIGNALING

4.7.1. STP Link Capacity

Definition: The maximum number of signaling links that can be terminated on a given STP pair.

Default Value:

STP Link Capacity
720

Support: AT&T Updated Capacity Cost Study.[52]

4.7.2. STP Maximum Fill

Definition: The fraction of maximum links (as stated by the STP link capacity input) that the model assumes can be utilized before it adds another STP pair.

Default Value:

STP Maximum Fill
0.80

Support: The STP maximum fill factor is based on HAI engineering judgment and is consistent with maximum link/port fill levels throughout HM 5.1.

4.7.3. STP Maximum Common Equipment Investment, per Pair

Definition: The cost to purchase and install a pair of maximum-sized STPs.

Default Value:

STP Maximum Common Equipment Investment, per pair
$5,000,000

Support: AT&T Updated Capacity Cost Study.[53]

4.7.4. STP Minimum Common Equipment Investment, per Pair

Definition: The minimum investment for a minimum-capacity STP, i.e.: the fixed investment for an STP pair that serves a minimum number of links.

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[52] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 26.

[53] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth",p. 26.

Default Value:

STP Minimum Common Equipment Investment, per pair
$1,000,000

Support: It is necessary to allow the scaling of STP common equipment for smaller STPs that in some configuration are sufficient for local exchange carriers. The minimum STP common equipment investment cost is an HAI judgment of the lower end of the range of common equipment investment.

4.7.5. Link Termination, Both Ends

Definition: The investment required for the transmission equipment that terminates both ends of an SS7 signaling link.

Default Value:

Link Termination, Both Ends
$900

Support: AT&T Updated Capacity Cost Study.[54]

4.7.6. Signaling Link Bit Rate

Definition: The rate at which bits are transmitted over an SS7 signaling link.

Default Value:

Signaling Link Bit Rate
56,000 bits per second

Support: The AT&T Updated Capacity Cost Study, and an SS7 network industry standard.[55]

4.7.7. Link Occupancy

Definition: The fraction of the maximum bit rate that can be sustained on an SS7 signaling link.

Default Value:

Link Occupancy
0.40

Support: AT&T Updated Capacity Cost Study.[56]

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[54] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 26.

[55] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 25.

4.7.8. C Link Cross-Section

Definition: The number of C-links in each segment connecting a mated STP pair.

Default Value:

C Link Cross-Section
24

Support: The input was derived assuming the 56 kbps signaling links between STPs are normally transported in a DS-1 signal, whose capacity is 24 DS-0s.

4.7.9. ISUP Messages per Interoffice BHCA

Definition: The number of Integrated Services Digital Network User Part (ISUP) messages associated with each interoffice telephone call attempt. Switches send to each other ISUP messages over the SS7 network to negotiate the establishment of a telephone connection.

Default Value:

ISUP messages per Interoffice BHCA
6

Support: AT&T Updated Capacity Cost Study.[57]

4.7.10. ISUP Message Length, Bytes

Definition: The average number of bytes in each ISUP (ISDN User Part) message.

Default Value:

ISUP Message Length
25 bytes

Support: Bellcore Technical Reference TR-NWT-000317, Appendix A, shows that 25 bytes per message is a conservatively high figure. Northern Telecom's DMS-STP product/service information booklet shows an average ISUP message length of 25 bytes.[58] Therefore a default value of 25 average bytes per message is appropriate for use in the HAI Model.

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[56] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 24.

[57] Brand, at al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 25.

[58] Northern Telecom, DMS-STP Planner 1995, Product/Service Information, 57005.16, Issue 1, April, 1995, p.13.

4.7.11. TCAP Messages per Transaction

Definition: The number of Transaction Capabilities Application Part (TCAP) messages required per Service Control Point (SCP) database query. A TCAP message is a message between a switch and a database that is necessary to provide the switch with additional information prior to setting up a call or completing a call.

Default Value:

TCAP Messages per Transaction
2

Support: AT&T Updated Capacity Cost Study.[59]

4.7.12. TCAP Message Length, Bytes

Definition: The average length of a TCAP message.

Default Value:

TCAP Message Length
100 bytes

Support: Bellcore Technical Reference TR-NWT-000317, Appendix A, shows that 100 bytes per message is a conservatively high figure. Northern Telecom's DMS-STP product/service information booklet shows an average TCAP message length of 85 bytes.[60]

4.7.13. Fraction of BHCA Requiring TCAP

Definition: The percentage of BHCAs that require a database query, and thus generate TCAP messages.

Default Value:

Fraction of BHCA Requiring TCAP
0.10

Support: The AT&T Updated Capacity Cost Study assumes that 50% of all calls require a database query, but that is not an appropriate number to use in the HM because a substantial fraction of IXC calls are toll-free (800) calls.[61] When reduced to reflect the fact that a large majority of calls handled by the LECs are local calls that do not require such a database query, the 50% would be less than 10%; HAI has used the 10% default as a conservatively high estimate.

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[59] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 25.

[60] DMS-STP Planner 1995, p.13.

[61] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 25.

4.7.14. SCP Investment per Transaction per Second

Definition: The investment in the SCP associated with database queries, or transactions, stated as the investment required per transaction per second. For example, if the default of $20,000 is assumed, an SCP required to handle 100 transactions per second would require a 2 million dollar ($20,000 times 100) investment.

Default Value:

SCP Investment per Transaction, per Second
$20,000

Support: AT&T Updated Capacity Cost Study uses a default value of $30,000 from the 1990 study, but notes that this is "conservatively high because of the industry's advances in this area and the resulting decrease in technology costs since the 1990 study."[62] The default value used in the HM represents the judgment of HAI as to the reduction of such processing costs since then.

[62] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 27.

4.8. OS AND PUBLIC TELEPHONE

4.8.1. Investment per Operator Position

Definition: The investment per computer required for each operator position.

Default Value:

Investment per Operator Position
$6,400

Support: Based on AT&T experience in the long distance business.

4.8.2. Maximum Utilization per Position, CCS

Definition: The estimated maximum number of CCS that one operator position can handle during the busy hour.

Default Value:

Maximum Utilization per Position
32 CCS

Support: Industry experience and expertise of HAI in conjunction with subject matter experts.

4.8.3. Operator Intervention Factor

Definition: The percentage of all operator-assisted calls that require manual operator intervention, expressed as 1 out of every N calls, where N is the value of the input. Given the default values for operator-assisted calls, this parameter means that 1/10, or 10%, of the assisted calls actually require manual intervention of an operator, as opposed to *automated* operator assistance for credit card verification, etc.

Default Value:

Operator Intervention Factor
10

Support: Industry experience and expertise of HAI.

4.8.4. Public Telephone Equipment Investment per Station

Definition: The weighted average cost of a public telephone and pedestal (coin/non-coin and indoor/outdoor).

Default Value:

Public Telephone Equipment Investment, per Station
$760

Support: New England Incremental Cost Study.[63]

[63] New England Telephone Company, "1993 New Hampshire Incremental Cost Study", p. 90.

4.9. ICO PARAMETERS

4.9.1. ICO STP Investment, per Line

Definition: The surrogate value for equivalent per line investment in STPs by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

ICO STP Investment per Line
$5.50

Support: The average STP investment per line estimated by the HAI Model for all states, with 20 percent added to reflect the higher cost a small ICO is likely to encounter.

4.9.2. ICO Local Tandem Investment, per Line

Definition: The surrogate value for the per line investment in a local tandem switch by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO Local Tandem Investment
$1.90

Support: The average local tandem investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.3. ICO OS Tandem Investment, per Line

Definition: The surrogate value for the per line investment in an Operator Services tandem switch by a small independent telephone company (ICO),that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO OS Tandem Investment
$0.80

Support: The average OS tandem investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.4. ICO SCP Investment, per Line

Definition: The surrogate value for the per line investment in a SCP by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO SCP Investment
$2.50

Support: The average SCP investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.5. ICO STP/SCP Wire Center Investment, per Line

Definition: The surrogate value for the per line investment in an STP/SCP wire center by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line STP / SCP Wire Center Investment
$0.40

Support: The average STP/SCP wire center investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.6. ICO Local Tandem Wire Center Investment, per Line

Definition: The surrogate value for the per line investment in a local tandem wire center by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO Local Tandem Wire Center Investment
$2.50

Support: The average local tandem wire center investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.7. ICO OS Tandem Wire Center Investment, per Line

Definition: The surrogate value for the per line investment in a operator services tandem wire center by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO OS Tandem Wire Center Investment
$1.00

Support: The average OS tandem wire center investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.8. ICO C-Link / Tandem A-Link Investment, per Line

Definition: The surrogate value for the per line investment in a C-link / tandem A-link by a small independent telephone company (ICO), that is used in lieu of calculating it directly in the model.

Default Value:

Per Line ICO C-Link / Tandem A-Link Investment
$0.30

Support: The average C-Link / tandem A-link investment per line from the HAI Model, with 20 percent added to reflect the higher cost a small ICO is likely to encounter, due to its character of use.

4.9.9. Equivalent Facility Investment per DS0, Constant Term

Definition: The constant term, A, in the per-DS0 surrogate facilities investment by an ICO for dedicated circuits between an end office and tandem switch belonging to the BOC (or other large LEC) on which the ICO relies for interoffice connectivity.

The Model computes the explicit investment required for facilities and terminal equipment connecting the ICO wire center with the nearest BOC (or other large LEC) wire center, then separately compute a per-DS0 equivalent facilities investment in BOC/LEC dedicated circuits between the BOC/LEC wire center and tandem in the form A + B • (Miles from BOC/LEC wire center to tandem). This parameter is the "A" term, while Section 4.9.10 specifies the "B" term. See also Section 4.9.11 for related terminal equipment investment.

Default Value:

Equivalent Facility Investment per DS0, Constant Term
$138.08

Support: The default value is the nationwide average BOC investment in the dedicated transport UNE (part of transport network elements) as calculated by the Model. Alternatively, the user can input the state-specific value that results from running the model for the BOC (or other large LEC) in question.

4.9.10. Equivalent Facility Investment per DS0, Slope Term

Definition: The slope term, B, in the per-DS0 surrogate facilities investment by an ICO for dedicated circuits between an end office and tandem switch belonging to the BOC (or other large LEC) on which the ICO relies for interoffice connectivity.

The Model computes the explicit investment required for facilities and terminal equipment connecting the ICO wire center with the nearest BOC (or other large LEC) wire center, then separately compute a per-DS0 equivalent facilities investment in BOC/LEC dedicated circuits between the BOC/LEC wire center and tandem in the form A + B • (Miles from BOC/LEC wire center to tandem). This parameter is the "B" term, while Section 4.9.9 specifies the "A" term. See also Section 4.9.11 for related terminal equipment investment..

Default Value:

Equivalent Facility Investment per DS0, Slope Term
$0

Support: This parameter is set to $0 because the related constant term (discussed in Section 4.9.9) bears the entire cost of these facilities in the default case.

4.9.11. Equivalent Terminal Investment per DS0

Definition: The per-DS0 surrogate investment by a small ICO for terminal equipment used on dedicated circuits between an end office and tandem switch belonging to the BOC (or other large LEC) on which the ICO relies for interoffice connectivity.

Default Value:

Equivalent Terminal Investment per DS0
$111.62

Support: In addition to the equivalent facilities investment incurred by an ICO for the BOC end office to tandem dedicated circuits, the model uses this parameter to separately compute a per-DS0 equivalent investment in the terminal equipment used on the dedicated circuits. The default value is the nationwide average BOC investment in the dedicated transmission terminal UNE (part of transport network elements) as calculated by the Model. Alternatively, the user can input the state-specific value that results from running the model for the BOC in question.

4.10. HOST – REMOTE ASSIGNMENT

4.10.1. Host – Remote CLLI Assignments

Definition: An input form consisting of parameters that allow the user to specify the set of host and remote wire centers, and establish the relationships between remotes and their serving host, using the CLLI codes of the respective switches. In the default mode, host and remote relationships are defined per the LERG and are included in the database such that they appear as pre-defined (default) selections in the user interface. The user may create a scenario and change any of the default host-remote relationships.

Default Value:

Host – Remote CLLI Assignments
Host-remote relationships defined per LERG

Support: These parameters are provided to give the user the means to establish host-remote relationships different than those specified in the LERG.

4.10.2. Host – Remote Assignment Enable

Definition: An option that, if enabled, instructs the model to perform switching calculations based on the host-remote relationships defined by Parameter 4.10.1. If enabled, 1) the investment in host/remote combinations are distributed equally among all lines served by the combination, 2) the cost of umbilical trunks between remotes and hosts is modeled explicitly, and 3) the host and remotes will be connected on a local SONET ring. If disabled, the Model uses the price of an "amalgamated host-remote-standalone switch set using the parameters described in Sections 4.1.9 and 4.1.10, and does not carry out the steps described in the previous sentence.

Default Value:

Host – Remote Assignment Enable
Enabled

Support: Prior users of the Model have most often enabled the host-remote assignment capability, and doing so is consistent with the requirements specified by the FCC.

4.11. HOST - REMOTE INVESTMENT4.11.1. Line Sizes

Definition: The line size designations used to specify the fixed and per line components of the total switch investments for stand alone, host and remote switches. The line sizes define ranges of switch sizes over which the corresponding switch investment components, specified in Section 4.11.2, apply .

Default Values:

Line Size
0
640
5,000
10,000

Support: The line size ranges resulting from these default values, for instance, 0 to 640 lines, are considered by subject matter experts to be ranges within which the constant and per-line switch investment components are approximately fixed. Those components may, however, change from one range to the next (See default values in Section 4.11.2).

4.11.2. Fixed and per Line Investments

Definition: The fixed and per line investments included in the function that calculates the total switching investment as a function of switch line size for host, remote, and stand alone switches, expressed separately for BOCs and large independents and for small independents. The total investment function for each type of switch and each type of telephone company is assumed to have the form A + B • L, where A is the fixed investment, B is the per-line investment, and L is the number of lines.

Default Values:

Fixed and per Line Investments for Standalone, Host and Remote Switches						
BOCs and Large ICOs						
Line Size	Standalone fixed investment	Host fixed investment	Remote fixed investment	Standalone per line investment	Host per line investment	Remote per line investment
0	$175,000	$183,750	$10,000	$75	$75	$85
640	$175,000	$183,750	$55,000	$75	$75	$83
5,000	$175,000	$183,750	$70,000	$75	$75	$85
10,000	$475,000	$498,750	$225,000	$73	$73	$70
Small ICOs						
Line Size	Standalone fixed investment	Host fixed investment	Remote fixed investment	Standalone per line investment	Host per line investment	Remote per line investment
0	$300,001	$315,001	$17,143	$129	$129	$146
640	$300,001	$315,001	$94,286	$129	$129	$141
5,000	$300,001	$315,001	$120,000	$129	$129	$146
10,000	$814,289	$855,003	$385,716	$124	$124	$120

Support: The default values are assembled on a forward-looking basis and are derived from a forced amalgam of host, remote and standalone switch investments. This system of derived costs does not reflect a detailed analysis of prices. The default values are computed from an amalgamated process, whereby the three categories of switch investments are derived as a function of three representative curves, generated by separate line size, and when considered together yield the same result as the cost function for amalgamated switches.

5. EXPENSE

5.1. COST OF CAPITAL AND CAPITAL STRUCTURE

Definition: The capital cost structure, including the debt/equity ratio, cost of debt, and return on equity, that makes up the overall cost of capital.

Default Values:

Cost of Capital	
Debt percent	0.450
Cost of debt	0.077
Cost of equity	0.119
Weighted average Cost of capital	0.1001

Support: Based on FCC-approved cost of capital methodology using 1996 financial data and AT&T and MCI-sponsored DCF and CAPM analyses calculating the RBOCs' cost of capital. See, for example, "Statement of Matthew I. Kahal Concerning Cost of Capital," In the Matter of Rate of Return Prescription for Local Exchange Carriers," File No. AAD95-172, March 11, 1996. See also AT&T ex parte filing of February 12, 1997, "Estimating the Cost of Capital of Local Telephone Companies for the Provision of Network Elements," by Bradford Cornell, September, 1996.

Note, more recently available data indicate that the appropriate cost of capital to be significantly less than the default 10.01% figure used here. See, Submission of AT&T Corp. and MCI Worldcom, Inc., in CC Docket No. 98-166, "Prescribing the Authorized Unitary Rate of Return for Interstate Services of Local Exchange Carriers," filed, March 16, 1999.

5.2. DEPRECIATION AND NET SALVAGE

Definition: The economic life and net salvage value of various network plant categories.

Default Values:

Plant Type	Economic Life	Net Salvage %
motor vehicles	8.24	11.21
garage work equipment	12.22	-10.71
other work equipment	13.04	3.21
buildings	46.93	1.87
furniture	15.92	6.88
office support equipment	10.78	6.91
company comm. Equipment	7.40	3.76
general purpose computers	6.12	3.73
digital electronic switching	16.17	2.97
operator systems	9.41	-0.82
digital circuit equipment	10.24	-1.69
public telephone term. Equipment	7.60	7.97
poles	30.25	-89.98
aerial cable, metallic	20.61	-23.03
aerial cable, non metallic	26.14	-17.53
underground cable, metallic	25.00	-18.26
underground cable, non metallic	26.45	-14.58
buried cable, metallic	21.57	-8.39
buried cable, non metallic	25.91	-8.58
intrabuilding cable, metallic	18.18	-15.74
intrabuilding cable, non metallic	26.11	-10.52
conduit systems	56.19	-10.34

Support: The default values are the weighted average set of projected depreciation lives, and net salvage percentages, coming from 76 LEC study areas including all the BOCs, SNET, Cincinnati Bell, and numerous GTE and United companies. Weighting is based on total lines per operating company. The projected lives and salvage values are determined in a triennial review process involving each state PUC, the FCC, and the LEC to establish unique state-and-operating-company-specific depreciation schedules. See, FCC Public Notice D.A. #'s 95-1635, 93-970, 96-1175, 94-856, 95-1712. NID, SAI, and drop lives are assumed to be 19.00 years, with no net salvage.

5.3. EXPENSE ASSIGNMENT

Definition: The fraction of certain categories of indirect expenses, including the loop component of general support, as well as network operations, other taxes, and variable overhead, that are assigned to loop UNEs (distribution, concentrator, feeder and NID), and thus to universal service, on a per-line basis, rather than the default assignment based on the relative proportions of the direct costs associated with these UNEs.

Default Value

Expense Assignment	Percent to be assigned per line
General Support Loops	
Furniture – Capital Costs	0 %
Furniture – Expenses	0 %
Office Equipment – Capital Costs	0 %
Office Equipment – Expenses	0 %
General Purpose Computer – Capital Costs	0 %
General Purpose Computer – Expenses	0 %
Motor Vehicles – Capital Costs	0 %
Motor Vehicles – Expenses	0 %
Buildings – Capital Costs	0 %
Buildings – Expenses	0 %
Garage Work Equipment – Capital Costs	0 %
Garage Work Equipment – Expenses	0 %
Other Work Equipment – Capital Costs	0 %
Other Work Equipment – Expenses	0 %
Network Operations	0 %
Other Taxes	0 %
Variable Overhead	0 %

Support: the default assumption is that these costs are most appropriately assigned in proportion to the identified direct costs, not on a per-line basis.

5.4. STRUCTURE SHARING FRACTIONS

Definition: The fraction of investment in distribution and feeder poles and trenching that is assigned to LECs. The remainder is attributed to other utilities/carriers.

Default Values:

Structure Percent Assigned to Telephone Company						
	Distribution			Feeder		
Density Zone	Aerial	Buried	Underground	Aerial	Buried	Underground
0-5	.50	.33	1.00	.50	.40	.50
5-100	.33	.33	.50	.33	.40	.50
100-200	.25	.33	.50	.25	.40	.40
200-650	.25	.33	.50	.25	.40	.33
650-850	.25	.33	.40	.25	.40	.33
850-2,550	.25	.33	.33	.25	.40	.33
2,550-5,000	.25	.33	.33	.25	.40	.33
5,000-10,000	.25	.33	.33	.25	.40	.33
10,000+	.25	.33	.33	.25	.40	.33

Support: Industry experience and expertise of HAI and outside plant engineers; Montgomery County, MD Subdivision Regulations Policy Relating to Grants of Location for New Conduit Network for the Provision of Commercial Telecommunications Services; Monthly Financial Statements of the Southern California Joint Pole Committee; Conversations with representatives of local utility companies. See the structure sharing discussion in Appendix B.

5.5. OTHER EXPENSE INPUTS

5.5.1. Income Tax Rate

Definition: The combined federal and state income tax rate on earnings paid by a telephone company.

Default Value:

Income Tax Rate
39.25%

Support: Based on a nationwide average of composite federal and state tax rates.

5.5.2. Corporate Overhead Factor

Definition: Forward-looking corporate overhead costs, expressed as a fraction of the sum of all capital costs and operations expenses calculated by the model.

Default Value:

Overhead Factor
10.4%

Support: Based on data from AT&T's Form M. See, also earlier ex parte submission by AT&T dated March 18, 1997 and Appendix C.

5.5.3. Other Taxes Factor

Definition: Operating taxes (primarily gross receipts and property taxes) paid by a telephone company in addition to federal and state income taxes.

Default Value:

Other Taxes Factor
5%

Support: This is the average for all Tier I LECs, expressed as a percentage of total revenue. Revenue and tax data are taken from the 1996 ARMIS report 43-03. See, also Appendix B.

5.5.4. Billing/Bill Inquiry per Line per Month

Definition:

The cost of bill generation and billing inquiries for end users, expressed as an amount per line per month.

Default Value:

Billing / Bill Inquiry per line per month
$1.22

Support: Based on data found in the New England Incremental Cost Study, section for billing and bill inquiry where unit costs are developed. This study uses marginal costing techniques, rather than TSLRIC. Therefore, billing/bill inquiry-specific fixed costs were added to conform with TSLRIC principles.[64]

To compute this value from the NET study, the base monthly cost for residential access lines is divided by the base demand (lines) for both bill inquiry (p. 122) and bill production (p. 126). The resulting per-line values are added together to arrive at the total billing/bill inquiry cost per line per month.

5.5.5. Directory Listing per Line per Month

Definition: The monthly cost of creating and maintaining white pages listings on a per line, per month basis for Universal Service Fund purposes.

Default Value:

Directory Listing per line per month
$0.00

Support: Because the FCC and Joint Board have determined that white pages listings are not an element of supported Universal Service, this value is set to default to zero. HAI estimates that the cost of maintaining a white page listing per line is $0.15 per month.

5.5.6. Forward-Looking Network Operations Factor

Definition: The forward-looking factor applied to a specific category of expenses reported in ARMIS called Network Operations. The factor is expressed as the percentage of current ARMIS-reported Network Operations costs per line.

Default Value:

Forward Looking Network Operations Factor
50%

Support: ARMIS-based network operations expenses are -- by definition -- a function of telephone company embedded costs. As reported, these costs are artificially high because they reflect antiquated systems and practices that are more costly than the modern equipment and practices that the HAI Model assumes will be installed on a forward-looking basis. Furthermore, today's costs do not reflect much of the substantial savings opportunities posed by new technologies, such as new management network standards, intranets, and the like. See Appendix D for a more detailed discussion of the savings opportunities associated with network operations.

[64] New England Telephone Company, *"1993 New Hampshire Incremental Cost Study"*, p. 122, 126.

5.5.7. Alternative Central Office Switching Expense Factor

Definition: The expense to investment ratio for digital switching equipment, used as an alternative to the ARMIS expense ratio, reflecting forward looking rather than embedded costs. Thus, this factor multiplies the calculated investment in digital switching in order to determine the monthly expense associated with digital switching. This factor is not intended to capture the cost of software upgrades to the switch, as all switching software is part of the capital value inputs to HM 5.1.

Default Value:

Alternative Central Office Switching Expense Factor
2.69%

Support: New England Incremental Cost Study.[65]

5.5.8. Alternative Circuit Equipment Factor

Definition: The expense to investment ratio for all circuit equipment (as categorized by LECs in their ARMIS reports), used as an alternative to the ARMIS expense ratio to reflect forward looking rather than embedded costs.

Default Value:

Alternative Circuit Equipment Factor
0.0153

Support: New England Incremental Cost Study.[66]

5.5.9. End Office Non Line-Port Cost Fraction

Definition: The fraction of the total investment in digital switching that is assumed to be not related to the connection of lines to the switch.

Default Value:

End Office Non Line-Port Cost Fraction
70%

Support: This factor is an HAI estimate of the average over several different switching technologies.

[65] New England Telephone Company, "1993 New Hampshire Incremental Cost Study", p. 394

[66] New England Telephone Company, "1993 New Hampshire Incremental Cost Study", p. 394

5.5.10. Monthly LNP Cost, per Line

Definition: The estimated cost of permanent Local Number Portability (LNP), expressed on a per-line, per-month basis, including the costs of implementing and maintaining the service. This is included in the USF calculations only, not the UNE rates, because it will be included in the definition of universal service once the service is implemented.

Default Value:

Per Line Monthly LNP Cost
$0.25

Support: This estimate is based on an ex parte submission by AT&T to the FCC in CC Docket No. 95-116, dated May 22, 1996.

5.5.11. Carrier-Carrier Customer Service, per Line, per Year

Definition: The yearly amount of customer operations expense associated with the provision of unbundled network elements by the LECs to carriers who purchase those elements.

Default Value:

Carrier-Carrier Customer Service per line
$1.69

Support: This calculation is based on data drawn from LEC ARMIS accounts 7150, 7170, 7190 and 7270 reported by all Tier I LECs in 1996. To calculate this charge, the amounts shown for each Tier 1 LEC in the referenced accounts are summed across the accounts and across all LECs, divided by the number of access lines reported by those LECs in order to express the result on a per-line basis, and multiplied by 70% to reflect forward-looking efficiencies in the provision of network elements. See, also Appendix C.

5.5.12. NID Expense, per Line, per Year

Definition: The estimated annual NID expense on a per line basis, based on an analysis of ARMIS data modified to reflect forward-looking costs. This is for the NID only, not the drop wire, which is included in the ARMIS cable and wire account.

Default Value:

NID Expense per line per year
$1.00

Support: The opinion of outside plant experts indicate a failure rate of less than 0.25 per 100 lines per month, or 3 percent per year. At a replacement cost of $29, this would yield an annual cost of $0.87. Therefore, the current default value is conservatively high.

5.5.13. DS-0/DS-1 Terminal Factor

Definition: The computed ratio for terminal investment per DS-0 when provided in a DS-0 level signal, to terminal investment per DS-0 when provided in a DS-1 level signal

Default Value:

DS-0 / DS-1 Terminal Factor
12.4

Support:, This ratio is based on default transmission terminal investments specified in Section 4.4.1.

5.5.14. DS-1/DS-3 Terminal Factor

Definition: The computed ratio for terminal investment per DS-0 when provided in a DS-1 level signal, to terminal investment per DS-0 when provided in a DS-3 level signal.

Default Value:

DS-1 / DS-3 Terminal Factor
9.9

Support: This ratio is based on default transmission terminal investments specified in Section 4.4.1.

5.5.15. Average Lines per Business Location

Definition: The average number of business lines per business location, used to calculate NID and drop cost. This parameter should be set the same as 2.2.5.

Default Value:

Average Business Lines per Location
4

Support: *{NOTE: The discussion in Section 2.2.5. [Distribution] is reproduced here for ease of use.}*

The number of lines per business location estimated by HAI is based on data in the *1995 Common Carrier Statistics* and the *1995 Statistical Abstract of the United States.*

5.5.16. Average Trunk Utilization

Definition: The 24 hour average utilization of an interoffice trunk.

Default Value:

Average Trunk Utilization
0.30

Support: AT&T Capacity Cost Study.[67]

[67] Blake, et al., "A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p.4.

6. EXCAVATION AND RESTORATION

6.1. UNDERGROUND EXCAVATION

Definition: The cost per foot to dig a trench in connection with building an underground conduit system to facilitate the placement of underground cables. Cutting the surface, placing the 4" PVC conduit pipes, backfilling the trench with appropriately screened fill, and restoring surface conditions is covered in the following section titled, "Underground Restoration Cost per Foot". These two sections do not include the material cost of the PVC conduit pipe, which is covered under "Conduit Material Investment per foot", and is affected by the number of cables placed in a conduit run, and the number of "Spare tubes per Route."

Default Values:

Underground Excavation Costs per Foot						
Density	Normal Trenching		Backhoe		Hand Trench	
Range	Fraction	Per Foot	Fraction	Per Foot	Fraction	Per Foot
0-5	54%	$1.90	45%	$3.00	1%	$5.00
5-100	54%	$1.90	45%	$3.00	1%	$5.00
100-200	54%	$1.90	45%	$3.00	1%	$5.00
200-650	52%	$1.90	45%	$3.00	3%	$5.00
650-850	52%	$1.95	45%	$3.00	3%	$5.00
850-2,550	50%	$2.15	45%	$3.00	5%	$5.00
2,550-5,000	35%	$2.15	55%	$3.00	10%	$5.00
5,000-10,000	23%	$6.00	67%	$20.00	10%	$10.00
10,000+	16%	$6.00	72%	$30.00	12%	$18.00

Note: Fraction % for Normal Trenching is the fraction remaining after subtracting Backhoe % & Trench %.

Support: See discussion in Section 6.2.

6.2. UNDERGROUND RESTORATION

Definition: The cost per foot to cut the surface, place the 4" PVC conduit pipes, backfill the trench with appropriately screened fill, and restore surface conditions. Digging a trench in connection with building an underground conduit system to facilitate the placement of underground cables is covered in the preceding section titled, "Underground Excavation Cost per Foot". These two sections do not include the material cost of the PVC conduit pipe, which is covered under "Conduit Material Investment per foot", and is affected by the number of cables placed in a conduit run, and the number of "Spare tubes per Route."

Default Values:

Underground Restoration Costs per Foot													
	Cut/Restore Asphalt		Cut/Restore Concrete		Cut/Restore Sod		Simple Backfill		Conduit Placement & Stabilization			
Density Range	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Pave-ment/ft	Frac-tion	Dirt/ft
0-5	55%	$6.00	10%	$9.00	1%	$1.00	34%	$0.15	65%	$5.00	35%	$1.00
5-100	55%	$6.00	10%	$9.00	1%	$1.00	34%	$0.15	65%	$5.00	35%	$1.00
100-200	55%	$6.00	10%	$9.00	1%	$1.00	34%	$0.15	65%	$5.00	35%	$1.00
200-650	65%	$6.00	10%	$9.00	3%	$1.00	22%	$0.15	75%	$5.00	25%	$1.00
650-850	70%	$6.00	10%	$9.00	4%	$1.00	16%	$0.15	80%	$5.00	20%	$1.00
850-2,550	75%	$6.00	10%	$9.00	6%	$1.00	9%	$0.15	85%	$9.00	15%	$4.00
2,550-5,000	75%	$6.00	15%	$9.00	4%	$1.00	6%	$0.15	90%	$13.00	10%	$11.00
5,000-10,000	80%	$18.00	15%	$21.00	2%	$1.00	3%	$0.15	95%	$17.00	5%	$12.00
10,000+	82%	$30.00	16%	$36.00	0%	$1.00	2%	$0.15	98%	$20.00	2%	$16.00

Note: Fraction % for Simple Backfill is the fraction remaining after subtracting Asphalt % & Concrete % & Sod %.
Fraction % for Conduit Placement & Stabilization for Pavement is Asphalt % + Concrete %.
Fraction % for Conduit Placement & Stabilization for Dirt is Sod % + Simple Backfill %.

Support: The costs reflect a mixture of different types of placement activities.

Note: Use of underground conduit structure for distribution should be infrequent, especially in the lower density zones. Although use of conduit for distribution cable in lower density zones is not expected, default prices are shown, should a user elect to change parameters for percent underground, aerial, and buried structure allowed by the HM 5.1 model structure.

Excavation and restoral costs are significantly higher in the two highest density zones to care for working within congested subsurface facility conditions, handling traffic control, work hour restrictions, concrete encasement of ducts, and atypical trench depths.

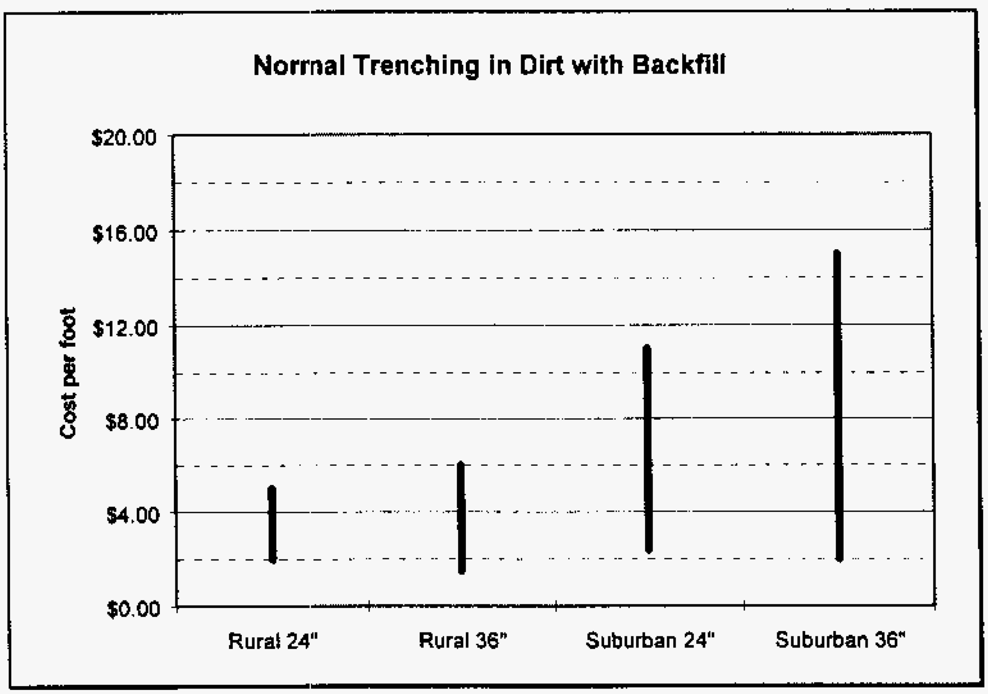
A compound weighted cost for conduit excavation, placement and restoral can be calculated by multiplying the individual columns shown above and in the immediately preceding section, "Underground Excavation Costs per Foot". Performing such calculations using the default values shown would provide the following composite costs by density zone.

The percentages for Underground Excavation Costs total to 100%, for Restoration (Asphalt + Concrete + Sod + Simple Backfill) total to 100%, and for Conduit Placement & Stabilization total to 100%, since each is a discrete function.

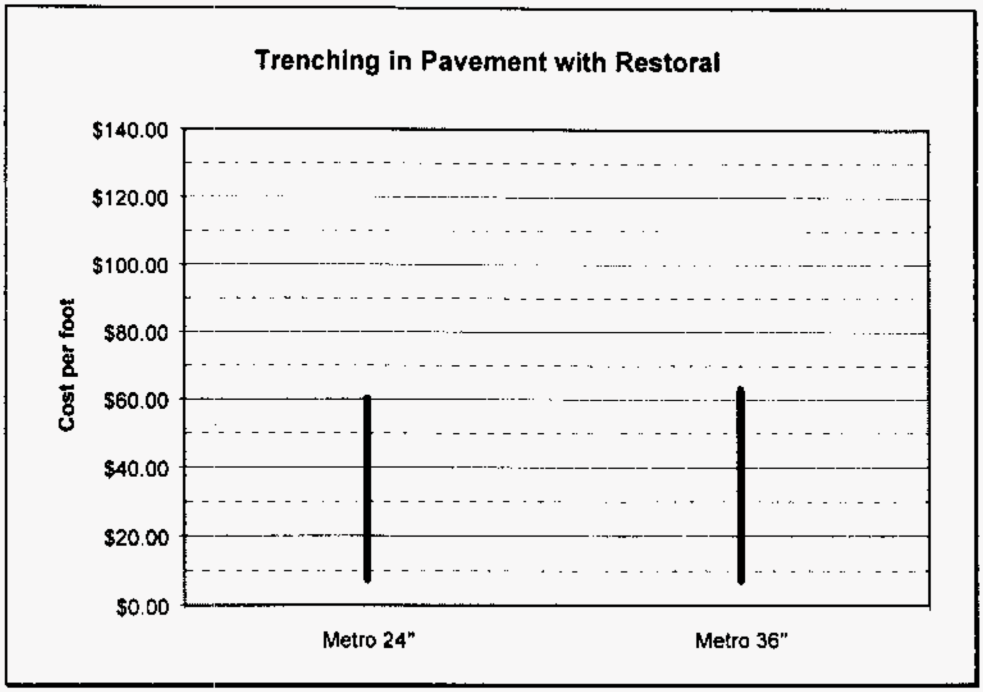
Underground Excavation, Restoration, and Conduit Placement Cost per Foot	
Density Zone	Cost Per Foot
0-5	$10.29
5-100	$10.29
100-200	$10.29
200-650	$11.35
650-850	$11.88
850-2,550	$16.40
2,550-5,000	$21.60
5,000-10,000	$50.10
10,000+	$75.00

Costs for various trenching methods were estimated by a team of experienced outside plant experts. Additional information was obtained from printed resources[68]. Still other information was provided by several contractors who routinely perform excavation, conduit, and manhole placement work for telephone companies. Results of those inquiries are revealed in the following charts. Note that this survey demonstrates that costs do not vary significantly between buried placements at 24" underground versus 36" underground. Therefore the HAI Model assumes an average placement depth ranging from 24" to 36", averaging 30".

Conduit placement cost is essentially the same, whether the conduit is used to house distribution cable, feeder cable, interoffice cable, or other telecommunication carrier cable, including CATV.



[68] Martin D. Kiley and Marques Allyn, eds., *1997 National Construction Estimator 45th Edition*, pp. 12-15.


Trenching in Pavement with Restoral
$140.00
$120.00
$100.00
$80.00
$60.00
$40.00
$20.00
$0.00
Cost per foot
Metro 24"
Metro 36"

6.3. BURIED EXCAVATION

Definition: The cost per foot to dig a trench to allow buried placement of cables, or the plowing of one or more cables into the earth using a single or multiple sheath plow.

Default Values:

Buried Excavation Costs per Foot												
	Plow		Normal Trench		Backhoe		Hand Trench		Bore Cable		Push Pipe/ Pull Cable	
Density Range	Fraction	Per Foot	Fraction	Per Foot	Fraction	Per Foot	Fraction	Per Foot	Fraction	Per Foot	Fraction	Per Foot
0-5	60%	$0.80	*28%*	$1.90	10%	$3.00	0%	$5.00	0%	$11.00	2 %	$6.00
5-100	60%	$0.80	*28%*	$1.90	10%	$3.00	0%	$5.00	0%	$11.00	2%	$6.00
100-200	60%	$0.80	*28%*	$1.90	10%	$3.00	0%	$5.00	0%	$11.00	2%	$6.00
200-650	50%	$0.80	*37%*	$1.90	10%	$3.00	1%	$5.00	0%	$11.00	2%	$6.00
650-850	35%	$0.80	*51%*	$1.95	10%	$3.00	2%	$5.00	0%	$11.00	2%	$6.00
850-2,550	20%	$1.20	*59%*	$2.15	10%	$3.00	4%	$5.00	3%	$11.00	4%	$6.00
2,550-5,000	0%	$1.20	*76%*	$2.15	10%	$3.00	5%	$5.00	4%	$11.00	5%	$6.00
5,000-10,000	0%	$1.20	*73%*	$6.00	10%	$20.00	6%	$10.00	5%	$11.00	6%	$6.00
10,000+	0%	$1.20	*54%*	$15.00	25%	$30.00	10%	$18.00	5%	$18.00	6%	$24.00

Note: Fraction % for Normal Trenching is the fraction remaining after subtracting Plow %, Backhoe %, Hand Trench %, Bore Cable % and Push Pipe / Pull Cable % from 100%.

Support: See discussion in Section 6.4.

6.4. BURIED INSTALLATION AND RESTORATION

Definition: The cost per foot to push pipe under pavement , or the costs per foot to cut the surface, place cable in a trench, backfill the trench with appropriately screened fill, and restore surface conditions. Digging a trench in connection with placing buried cable is covered in the preceding section titled, "Buried Excavation Cost per Foot".

Default Values:

Buried Installation and Restoration Costs per Foot									
	Cut/Restore Asphalt		Cut/Restore Concrete		Cut/Restore Sod		Simple Backfill		Restoral Not Req'd
Density Range	Fraction	Per Foot	Fraction	Per Foot	Fraction	Per Foot	Fraction	Per Foot	Fraction
0-5	3%	$6.00	1%	$9.00	2%	$1.00	32%	$0.15	62%
5-100	3%	$6.00	1%	$9.00	2%	$1.00	32%	$0.15	62%
100-200	3%	$6.00	1%	$9.00	2%	$1.00	32%	$0.15	62%
200-650	3%	$6.00	1%	$9.00	2%	$1.00	42%	$0.15	52%
650-850	3%	$6.00	1%	$9.00	2%	$1.00	57%	$0.15	37%
850-2,550	5%	$6.00	3%	$9.00	35%	$1.00	30%	$0.15	27%
2,550-5,000	8%	$6.00	5%	$9.00	35%	$1.00	43%	$0.15	9%
5,000-10,000	18%	$18.00	8%	$21.00	11%	$1.00	52%	$0.15	11%
10,000+	60%	$30.00	20%	$36.00	5%	$1.00	4%	$0.15	11%

Note: Note: Restoral is not required for plowing, boring, or pushing pipe & pulling cable. Fraction for Simple Backfill is the fraction remaining after subtracting the Restoral Not Required fraction and the cut/restore activities fractions from 100%.

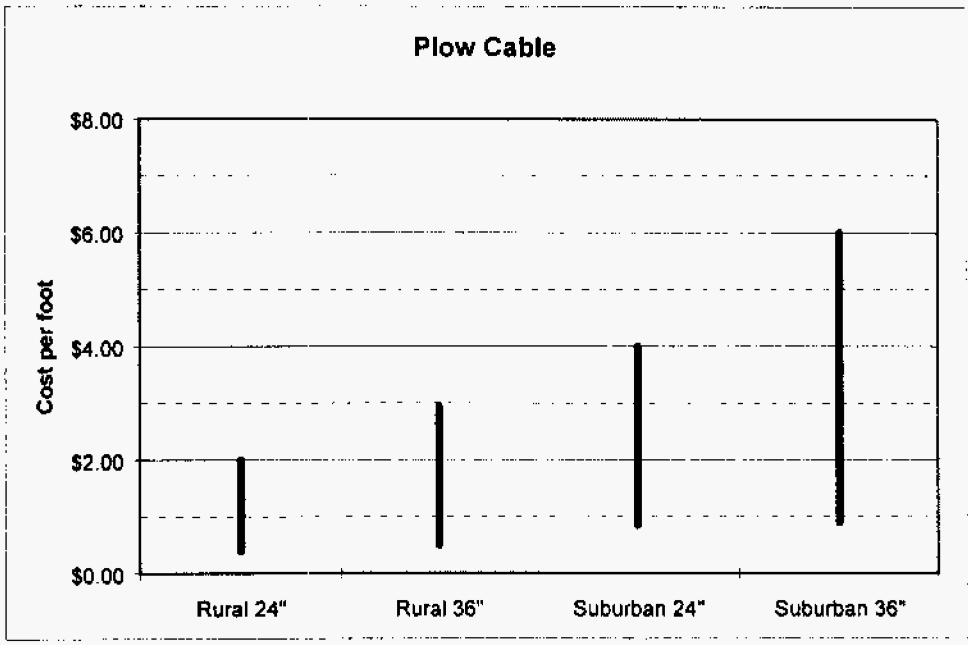
Support:
The costs reflect a mixture of different types of placement activities.

Excavation and restoral costs are significantly higher in the two highest density zones to care for working within congested subsurface facility conditions, handling traffic control, work hour restrictions, and atypical trench depths.

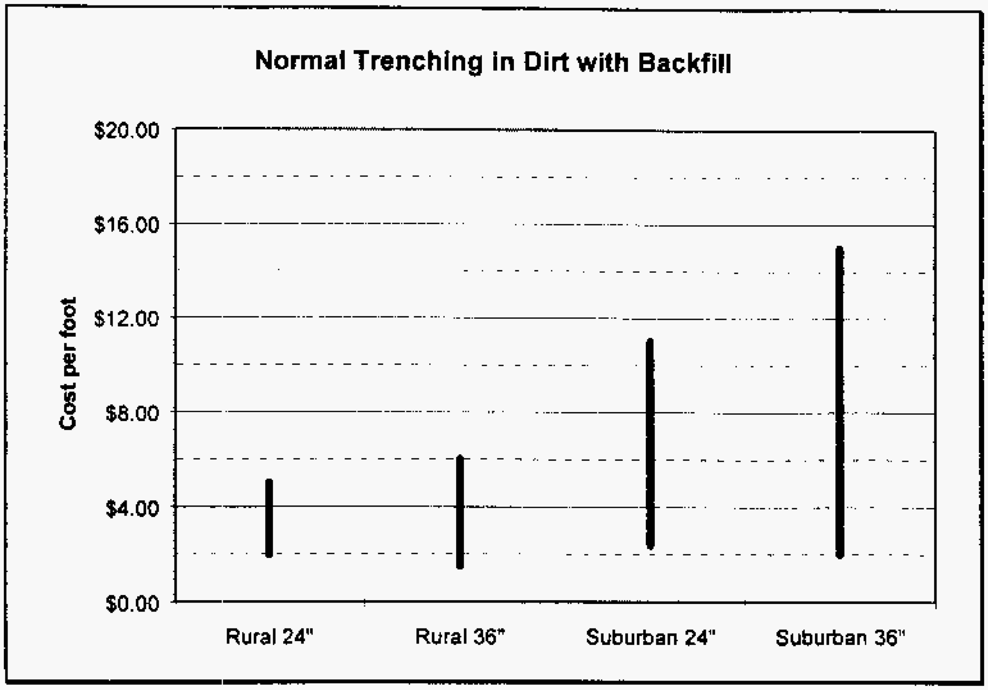
A compound weighted cost for conduit excavation, placement and restoral can be calculated by multiplying the individual columns shown above and in the immediately preceding section, "Buried Excavation Costs per Foot". Performing such calculations using the default values shown would provide the following composite costs by density zone.

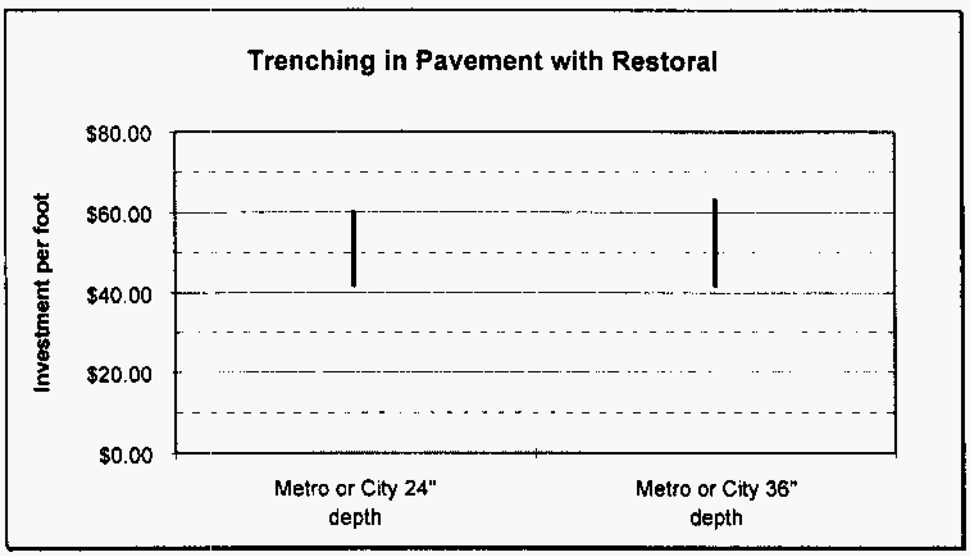
Buried Excavation, Installation, and Restoration Cost per Foot	
Density Zone	Cost Per Foot
0-5	$1.77
5-100	$1.77
100-200	$1.77
200-650	$1.93
650-850	$2.17
850-2,550	$3.54
2,550-5,000	$4.27
5,000-10,000	$13.00
10,000+	$45.00

Costs for various excavation methods were estimated by a team of experienced outside plant experts. Additional information was obtained from printed resources[69]. Still other information was provided by several contractors who routinely perform excavation, conduit, and manhole placement work for telephone companies. Results of those inquiries are revealed in the following charts. Note that this survey demonstrates that costs do not vary significantly between buried placements at 24" underground versus 36" underground. Therefore the HAI Model assumes an average placement depth ranging from 24" to 36", averaging 30".



[69] Martin D. Kiley and Marques Allyn, eds., *1997 National Construction Estimator 45th Edition*, pp. 12-15.


Normal Trenching in Dirt with Backfill
Cost per foot
$20.00
$16.00
$12.00
$8.00
$4.00
$0.00
Rural 24"
Rural 36"
Suburban 24"
Suburban 36"


Trenching in Pavement with Restoral
Investment per foot
$80.00
$60.00
$40.00
$20.00
$0.00
Metro or City 24" depth
Metro or City 36" depth

6.5. SURFACE TEXTURE MULTIPLIER

Definition: The increase in placement cost attributable to the soil condition in a main cluster and its associated outlier clusters, expressed as a multiplier of a fraction of all buried or underground structure excavation components in the clusters. The multiplier appears in the "Effect" column, and the fraction appears in the "Fraction of Cluster Affected" column. The surface conditions are determined from the CBG to which the clusters belong. The table lists effects in alphabetical order by Texture Code.

Default Values:

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.00		Blank
1.00	1.00	BY	Bouldery
1.00	1.00	BY-COS	Bouldery Coarse Sand
1.00	1.00	BY-FSL	Bouldery & Fine Sandy Loam
1.00	1.00	BY-L	Bouldery & Loam
1.00	1.00	BY-LS	Bouldery & Sandy Loam
1.00	1.00	BY-SICL	Bouldery & Silty Clay Loam
1.00	1.00	BY-SL	Bouldery & Sandy Loam
1.00	1.10	BYV	Very Bouldery
1.00	1.10	BYV-FSL	Very Bouldery & Fine Sandy Loam
1.00	1.10	BYV-L	Very Bouldery & Loamy
1.00	1.10	BYV-LS	Very Bouldery & Loamy Sand
1.00	1.10	BYV-SIL	Very Bouldery & Silt
1.00	1.10	BYV-SL	Very Bouldery & Sandy Loam
1.00	1.30	BYX	Extremely Bouldery
1.00	1.30	BYX-FSL	Extremely Bouldery & Fine Sandy Loam
1.00	1.30	BYX-L	Extremely Bouldery & Loamy
1.00	1.30	BYX-SIL	Extremely Bouldery & Silt Loam
1.00	1.30	BYX-SL	Extremely Bouldery & Sandy Loam
1.00	1.00	C	Clay
1.00	1.00	CB	Cobbly
1.00	1.00	CB-C	Cobbly & Clay
1.00	1.00	CB-CL	Cobbly & Clay Loam
1.00	1.00	CB-COSL	Cobbly & Coarse Sandy Loam
1.00	1.10	CB-FS	Cobbly & Fine Sand
1.00	1.10	CB-FSL	Cobbly & Fine Sandy Loam
1.00	1.00	CB-L	Cobbly & Loamy
1.00	1.00	CB-LCOS	Cobbly & Loamy Coarse Sand
1.00	1.00	CB-LS	Cobbly & Loamy Sand
1.00	1.10	CB-S	Cobbly & Sand
1.00	1.00	CB-SCL	Cobbly & Sandy Clay Loam
1.00	1.00	CB-SICL	Cobbly & Silty Clay Loam
1.00	1.00	CB-SIL	Cobbly & Silt Loam
1.00	1.10	CB-SL	Cobbly & Sandy Loam
1.00	1.00	CBA	Angular Cobbly

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.10	CBA-FSL	Angular Cobbly & Fine Sandy Loam
1.00	1.20	CBV	Very Cobbly
1.00	1.20	CBV-C	Very Cobbly & Clay
1.00	1.20	CBV-CL	Very Cobbly & Clay Loam
1.00	1.20	CBV-FSL	Very Cobbly & Fine Sandy Loam
1.00	1.20	CBV-L	Very Cobbly & Loamy
1.00	1.20	CBV-LFS	Very Cobbly & Fine Loamy Sand
1.00	1.20	CBV-LS	Very Cobbly & Loamy Sand
1.00	1.20	CBV-MUCK	Very Cobbly & Muck
1.00	1.20	CBV-SCL	Very Cobbly & Sandy Clay Loam
1.00	1.20	CBV-SIL	Very Cobbly & Silt
1.00	1.20	CBV-SL	Very Cobbly & Sandy Loam
1.00	1.20	CBV-VFS	Very Cobbly & Very Fine Sand
1.00	1.20	CBX	Extremely Cobbly
1.00	1.20	CBX-CL	Extremely Cobbly & Clay
1.00	1.20	CBX-L	Extremely Cobbly Loam
1.00	1.20	CBX-SIL	Extremely Cobbly & Silt
1.00	1.20	CBX-SL	Extremely Cobbly &Sandy Loam
1.00	1.30	CBX-VFSL	Extremely Cobbly Very Fine Sandy Loam
1.00	1.00	CE	Coprogenous Earth
1.00	1.00	CIND	Cinders
1.00	1.00	CL	Clay Loam
1.00	1.30	CM	Cemented
1.00	1.00	CN	Channery
1.00	1.00	CN-CL	Channery & Clay Loam
1.00	1.10	CN-FSL	Channery & Fine Sandy Loam
1.00	1.00	CN-L	Channery & Loam
1.00	1.00	CN-SICL	Channery & Silty Clay Loam
1.00	1.00	CN-SIL	Channery & Silty Loam
1.00	1.00	CN-SL	Channery & Sandy Loam
1.00	1.00	CNV	Very Channery
1.00	1.00	CNV-CL	Very Channery & Clay
1.00	1.00	CNV-L	Very Channery & Loam
1.00	1.00	CNV-SCL	Channery & Sandy Clay Loam
1.00	1.00	CNV-SIL	Very Channery & Silty Loam
1.00	1.00	CNV-SL	Very Channery & Sandy Loam
1.00	1.00	CNX	Extremely Channery
1.00	1.00	CNX-SL	Extremely Channery & Sandy Loam
1.00	1.00	COS	Coarse Sand
1.00	1.00	COSL	Coarse Sandy Loam
1.00	1.20	CR	Cherty
1.00	1.20	CR-L	Cherty & Loam
1.00	1.20	CR-SICL	Cherty & Silty Clay Loam
1.00	1.20	CR-SIL	Cherty & Silty Loam
1.00	1.20	CR-SL	Cherty & Sandy Loam

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.20	CRC	Coarse Cherty
1.00	1.20	CRV	Very Cherty
1.00	1.20	CRV-L	Very Cherty & Loam
1.00	1.20	CRV-SIL	Very Cherty & Silty Loam
1.00	1.30	CRX	Extremely Cherty
1.00	1.30	CRX-SIL	Extremely Cherty & Silty Loam
1.00	1.00	DE	Diatomaceous Earth
1.00	1.00	FB	Fibric Material
1.00	1.00	FINE	Fine
1.00	1.00	FL	Flaggy
1.00	1.10	FL-FSL	Flaggy & Fine Sandy Loam
1.00	1.00	FL-L	Flaggy & Loam
1.00	1.00	FL-SIC	Flaggy & Silty Clay
1.00	1.00	FL-SICL	Flaggy & Silty Clay Loam
1.00	1.00	FL-SIL	Flaggy & Silty Loam
1.00	1.00	FL-SL	Flaggy & Sandy Loam
1.00	1.10	FLV	Very Flaggy
1.00	1.10	FLV-COSL	Very Flaggy & Coarse Sandy Loam
1.00	1.10	FLV-L	Very Flaggy & Loam
1.00	1.10	FLV-SICL	Very Flaggy & Silty Clay Loam
1.00	1.10	FLV-SL	Very Flaggy & Sandy Loam
1.00	1.10	FLX	Extremely Flaggy
1.00	1.10	FLX-L	Extremely Flaggy & Loamy
1.00	1.00	FRAG	Fragmental Material
1.00	1.10	FS	Fine Sand
1.00	1.10	FSL	Fine Sandy Loam
1.00	1.00	G	Gravel
1.00	1.00	GR	Gravelly
1.00	1.00	GR-C	Gravel & Clay
1.00	1.00	GR-CL	Gravel & Clay Loam
1.00	1.00	GR-COS	Gravel & Coarse Sand
1.00	1.00	GR-COSL	Gravel & Coarse Sandy Loam
1.00	1.00	GR-FS	Gravel & Fine Sand
1.00	1.00	GR-FSL	Gravel & Fine Sandy Loam
1.00	1.00	GR-L	Gravel & Loam
1.00	1.00	GR-LCOS	Gravel & Loamy Coarse Sand
1.00	1.10	GR-LFS	Gravel & Loamy Fine Sand
1.00	1.00	GR-LS	Gravel & Loamy Sand
1.00	1.00	GR-MUCK	Gravel & Muck
1.00	1.00	GR-S	Gravel & Sand
1.00	1.00	GR-SCL	Gravel & Sandy Clay Loam
1.00	1.00	GR-SIC	Gravel & Silty Clay
1.00	1.00	GR-SICL	Gravel & Silty Clay Loam
1.00	1.00	GR-SIL	Gravel & Silty Loam
1.00	1.00	GR-SL	Gravel & Sandy Loam

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.10	GR-VFSL	Gravel & Very Fine Sandy Loam
1.00	1.00	GRC	Coarse Gravelly
1.00	1.00	GRF	Fine Gravel
1.00	1.00	GRF-SIL	Fine Gravel Silty Loam
1.00	1.00	GRV	Very Gravelly
1.00	1.00	GRV-CL	Very gravelly & Clay Loam
1.00	1.00	GRV-COS	Very Gravelly & coarse Sand
1.00	1.00	GRV-COSL	Very Gravelly & coarse Sandy Loam
1.00	1.00	GRV-FSL	Very Gravelly & Fine Sandy Loam
1.00	1.00	GRV-L	Very Gravelly & Loam
1.00	1.00	GRV-LCOS	Very Gravelly & Loamy Coarse Sand
1.00	1.00	GRV-LS	Very Gravelly & Loamy Sand
1.00	1.00	GRV-S	Very Gravelly & Sand
1.00	1.00	GRV-SCL	Very Gravelly & Sandy Clay Loam
1.00	1.00	GRV-SICL	Very Gravelly & Silty Clay Loam
1.00	1.00	GRV-SIL	Very Gravelly & Silt
1.00	1.00	GRV-SL	Very Gravelly & Sandy Loam
1.00	1.00	GRV-VFS	Very Gravelly & Very Fine Sand
1.00	1.00	GRV-VFSL	Very Gravelly & Very Fine Sandy Loam
1.00	1.10	GRX	Extremely Gravelly
1.00	1.10	GRX-CL	Extremely Gravelly & Coarse Loam
1.00	1.10	GRX-COS	Extremely Gravelly & Coarse Sand
1.00	1.10	GRX-COSL	Extremely Gravelly & Coarse Sandy Loam
1.00	1.10	GRX-FSL	Extremely Gravelly & Fine Sand Loam
1.00	1.10	GRX-L	Extremely Gravelly & Loam
1.00	1.10	GRX-LCOS	Extremely Gravelly & Loamy Coarse
1.00	1.10	GRX-LS	Extremely Gravelly & Loamy Sand
1.00	1.10	GRX-S	Extremely Gravelly & Sand
1.00	1.10	GRX-SIL	Extremely Gravelly & Silty Loam
1.00	1.10	GRX-SL	Extremely Gravelly & Sandy Loam
1.00	1.20	GYP	Gypsiferous Material
1.00	1.00	HM	Hemic Material
1.00	1.50	ICE	Ice or Frozen Soil
1.00	1.20	IND	Indurated
1.00	1.00	L	Loam
1.00	1.00	LCOS	Loamy Coarse Sand
1.00	1.10	LFS	Loamy Fine Sand
1.00	1.00	LS	Loamy Sand
1.00	1.00	LVFS	Loamy Very Fine Sand
1.00	1.00	MARL	Marl
1.00	1.00	MEDIUM coarse	Medium Coarse
1.00	1.00	MK	Mucky
1.00	1.00	MK-C	Mucky Clay
1.00	1.00	MK-CL	Mucky Clay Loam
1.00	1.00	MK-FS	Muck & Fine Sand

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.00	MK-FSL	Muck & Fine Sandy Loam
1.00	1.00	MK-L	Mucky Loam
1.00	1.00	MK-LFS	Mucky Loamy Fine Sand
1.00	1.00	MK-LS	Mucky Loamy Sand
1.00	1.00	MK-S	Muck & Sand
1.00	1.00	MK-SI	Mucky & Silty
1.00	1.00	MK-SICL	Mucky & Silty Clay Loam
1.00	1.00	MK-SIL	Mucky Silt
1.00	1.00	MK-SL	Mucky & Sandy Loam
1.00	1.00	MK-VFSL	Mucky & Very Fine Sandy Loam
1.00	1.00	MPT	Mucky Peat
1.00	1.00	MUCK	Muck
1.00	1.00	PEAT	Peat
1.00	1.00	PT	Peaty
1.00	1.50	RB	Rubbly
1.00	1.50	RB-FSL	Rubbly Fine Sandy Loam
1.00	1.00	S	Sand
1.00	1.00	SC	Sandy Clay
1.00	1.00	SCL	Sandy Clay Loam
1.00	1.00	SG	Sand & Gravel
1.00	1.00	SH	Shaly
1.00	1.00	SH-CL	Shaly & Clay
1.00	1.00	SH-L	Shale & Loam
1.00	1.00	SH-SICL	Shaly & Silty Clay Loam
1.00	1.00	SH-SIL	Shaly & Silt Loam
1.00	1.50	SHV	Very Shaly
1.00	1.50	SHV-CL	Very Shaly & Clay Loam
1.00	2.00	SHX	Extremely Shaly
1.00	1.00	SI	Silt
1.00	1.00	SIC	Silty Clay
1.00	1.00	SICL	Silty Clay Loam
1.00	1.00	SIL	Silt Loam
1.00	1.00	SL	Sandy Loam
1.00	1.00	SP	Sapric Material
1.00	1.00	SR	Stratified
1.00	1.00	ST	Stony
1.00	1.00	ST-C	Stony & Clay
1.00	1.00	ST-CL	Stony & Clay Loam
1.00	1.00	ST-COSL	Stony & Coarse Sandy Loam
1.00	1.10	ST-FSL	Stony & Fine Sandy Loam
1.00	1.00	ST-L	Stony & Loamy
1.00	1.00	ST-LCOS	Stony & Loamy Coarse Sand
1.00	1.10	ST-LFS	Stony & Loamy Fine Sand
1.00	1.00	ST-LS	Stony & Loamy Sand
1.00	1.00	ST-SIC	Stony & Silty Clay

Fraction Cluster Affected	Effect	Texture	Description of Texture
1.00	1.00	ST-SICL	Stony & Silty Clay Loam
1.00	1.00	ST-SIL	Stony & Silt Loam
1.00	1.00	ST-SL	Stony & Sandy Loam
1.00	1.10	ST-VFSL	Stony & Sandy Very Fine Silty Loam
1.00	1.20	STV	Very Stony
1.00	1.20	STV-C	Very Stony & Clay
1.00	1.20	STV-CL	Very Stony & Clay Loam
1.00	1.20	STV-FSL	Very Stony & Fine Sandy Loam
1.00	1.20	STV-L	Very Stony & Loamy
1.00	1.20	STV-LFS	Very Stony & Loamy Fine Sand
1.00	1.20	STV-LS	Very Stony & Loamy Sand
1.00	1.20	STV-MPT	Very Stony & Mucky Peat
1.00	1.20	STV-MUCK	Very Stony & Muck
1.00	1.20	STV-SICL	Very Stony & Silty Clay Loam
1.00	1.20	STV-SIL	Very Stony & Silty Loam
1.00	1.20	STV-SL	Very Stony & Sandy Loam
1.00	1.20	STV-VFSL	Very Stony & Very Fine Sandy Loam
1.00	1.30	STX	Extremely Stony
1.00	1.30	STX-C	Extremely Stony & Clay
1.00	1.30	STX-CL	Extremely Stony & Clay Loam
1.00	1.30	STX-COS	Extremely Stony & Coarse Sand
1.00	1.30	STX-COSL	Extremely Stony & Coarse Sand Loam
1.00	1.30	STX-FSL	Extremely Stony & Fine Sandy Loam
1.00	1.30	STX-L	Extremely Stony & Loamy
1.00	1.30	STX-LCOS	Extremely Stony & Loamy Coarse Sand
1.00	1.30	STX-LS	Extremely Stony & Loamy Sand
1.00	1.30	STX-MUCK	Extremely Stony & Muck
1.00	1.30	STX-SIC	Extremely Stony & Silty Clay
1.00	1.30	STX-SICL	Extremely Stony & Silty Clay Loam
1.00	1.30	STX-SIL	Extremely Stony & Silty Loam
1.00	1.30	STX-SL	Extremely Stony & Sandy Loam
1.00	1.30	STX-VFSL	Extremely Stony & Very Fine Sandy Loam
1.00	3.00	SY	Slaty
1.00	3.00	SY-L	Slaty & Loam
1.00	3.00	SY-SIL	Slaty & Silty Loam
1.00	3.50	SYV	Very Slaty
1.00	4.00	SYX	Extremely Slaty
1.00	1.00	UNK	Unknown
1.00	2.00	UWB	Unweathered Bedrock
1.00	1.00	VAR	Variable
1.00	1.00	VFS	Very Fine Sand
1.00	1.00	VFSL	Very Fine Sandy loam
1.00	3.00	WB	Weathered Bedrock

Support: Discussions with excavation contractors who routinely perform work in a variety of soil conditions are reflected in the default difficulty factors listed above. Difficulty factors range from 1.00, or no additional effect, to as high as 4.0, or 400% as much as normal.

Although an engineer would normally modify plans to avoid difficult soil textures where possible, and although it is likely that population is located in portions of a CBG where conditions are less severe than is the average throughout the CBG, HM 5.1 has taken the conservative approach of assuming that the difficult terrain factors would affect 100% of the cluster.

7. REGIONAL LABOR ADJUSTMENT FACTORS

Definition: Factors that adjust a specific portion of certain investments by a labor factor adjustment that account for regional differences in the availability of trained labor, union contracts, and cost of living factors. Both the portions of different categories of investments that are affected and the size of adjustment are included as parameters.

Default Value:

Regional Labor Adjustment Factor	
Factor	1.0

Regional Labor Adjustment Factor Fraction of Installed Investment Affected	
Contractor Trenching	.125
Telco Construction – Copper	.164
Telco Construction – Fiber	.364
Telco I&M – NID & Drop	.571
Pole Placing	.518

Support: Different areas of the country are known to experience variations in wages paid to technicians, depending on availability of trained labor, union contracts, and cost of living factors. The adjustment applies only to that portion of installed costs pertaining to salaries. It does not apply to loading factors such as exempt material, construction machinery, motor vehicles, leases and rentals of special tools and work equipment, welfare, pension, unemployment insurance, workers compensation insurance, liability insurance, general contractor overheads, subcontractor overheads, and taxable and non-taxable fringe benefits.

The portions of various kinds of network investment affected by the adjustment are determined as follows. For heavy construction of outside plant cable, the model assumes a fully loaded direct labor cost of $55.00 per hour for a placing or splicing technician who receives pay of $20 per hour. For copper feeder and copper distribution cable, the HAI Model assumes that this fully loaded direct labor component accounts for 45% of the investment.

Because $20 is 36.4% of the fully loaded $55 per hour figure, the effect of the Regional Labor Adjustment Factor is 0.364 x .45, or 16.4% of the installed cost of copper cable. Therefore, the labor adjustment factor is applied to 16.4% of the installed cost of copper cable.

The labor adjustment factor also applies to pole labor, NID installation, conduit and buried placement, and drop installation. In the feeder plant, the factor applies to manhole and pullbox installation as well as to cable and other structure components.

Contract labor is used for buried trenching, conduit trenching, and manhole/pullbox excavation. Contract labor (vs. equipment + other charges) is 25% of total contractor cost. Direct salaries are 50% of the "labor & benefits" cost. The fraction of investment that represents labor cost for these items, and is, therefore, subject to the regional labor adjustment factor, is 0.25 times 0.50, or 0.125 of the trenching and excavation costs.

Once the adjustment factors are determined in this fashion, the factor is multiplied by the corresponding unit cost to determine the amount of investment affected by the adjustment. This amount is then multiplied by the specific regional labor adjustment factor to determine the modified investment. For instance, if buried installation trenching per foot is normally $1.77, the adjustment factor of 0.125 applied to this amount is $0.2213. If the regional adjustment was 1.07 (e.g., California), the increased installation cost is 0.07 times $0.2213, or $0.015.

Application of Regional Labor Adjustment Factor on Buried Installation			
Density Zone	Buried Installation per Foot	Labor Content Affected	Investment Affected per Foot
0-5	$1.77	0.125	$0.2213
5-100	$1.77	0.125	$0.2213
100-200	$1.77	0.125	$0.2213
200-650	$1.93	0.125	$0.2413
650-850	$2.17	0.125	$0.2713
850-2,550	$3.54	0.125	$0.4425
2,550-5,000	$4.27	0.125	$0.5338
5,000-10,000	$13.00	0.125	$1.6250
10,000+	$45.00	0.125	$5.6250

Application of Regional Labor Adjustment Factor on Conduit Installation			
Density Zone	Conduit Installation per Foot	Labor Content Affected	Investment Affected per Foot
0-5	$10.29	0.125	$1.2863
5-100	$10.29	0.125	$1.2863
100-200	$10.29	0.125	$1.2863
200-650	$11.35	0.125	$1.4188
650-850	$11.38	0.125	$1.4225
850-2,550	$16.40	0.125	$2.0500
2,550-5,000	$21.60	0.125	$2.7000
5,000-10,000	$50.10	0.125	$6.2625
10,000+	$75.00	0.125	$9.3750

Application of Regional Labor Adjustment Factor on Manhole Installation			
Density Zone	Manhole Excavation & Backfill	Labor Content Affected	Investment Affected per Manhole
0-5	$2,800	0.125	$350
5-100	$2,800	0.125	$350
100-200	$2,800	0.125	$350
200-650	$2,800	0.125	$350
650-850	$3,200	0.125	$400
850-2,550	$3,500	0.125	$438
2,550-5,000	$3,500	0.125	$438
5,000-10,000	$5,000	0.125	$625
10,000+	$5,000	0.125	$625

Application of Regional Labor Adjustment Factor on Fiber Pullbox Installation			
Density Zone	Pullbox Excavation & Backfill	Labor Content Affected	Investment Affected per Pullbox
0-5	$220	0.125	$27.50
5-100	$220	0.125	$27.50
100-200	$220	0.125	$27.50
200-650	$220	0.125	$27.50
650-850	$220	0.125	$27.50
850-2,550	$220	0.125	$27.50
2,550-5,000	$220	0.125	$27.50
5,000-10,000	$220	0.125	$27.50
10,000+	$220	0.125	$27.50

Application of Regional Labor Adjustment Factor on Copper Distribution Cable Installation			
Copper Distribution Cable Size	Installed Copper Distribution Cost	Labor Content Affected	Investment Affected per Foot
2,400	$20.00	0.164	$3.28
1,800	$16.00	0.164	$2.62
1,200	$12.00	0.164	$1.97
900	$10.00	0.164	$1.64
600	$7.75	0.164	$1.27
400	$6.00	0.164	$0.98
200	$4.25	0.164	$0.70
100	$2.50	0.164	$0.41
50	$1.63	0.164	$0.27
25	$1.19	0.164	$0.20
12	$0.76	0.164	$0.12
6	$0.63	0.164	$0.10

Application of Regional Labor Adjustment Factor on Copper Riser Cable Installation			
Copper Distribution Cable Size	Installed Copper Distribution Cost	Labor Content Affected	Investment Affected per Foot
2,400	$25.00	0.164	$4.10
1,800	$20.00	0.164	$3.28
1,200	$15.00	0.164	$2.46
900	$12.50	0.164	$2.05
600	$10.00	0.164	$1.64
400	$7.50	0.164	$1.23
200	$5.30	0.164	$0.87
100	$3.15	0.164	$0.52
50	$2.05	0.164	$0.34
25	$1.50	0.164	$0.25
12	$0.95	0.164	$0.16
6	$0.80	0.164	$0.13

Application of Regional Labor Adjustment Factor on Copper Feeder Cable Installation			
Copper Feeder Cable Size	Installed Copper Feeder Cost	Labor Content Affected	Investment Affected per Foot
4,200	$29.00	0.164	$4.76
3,600	$26.00	0.164	$4.26
3,000	$23.00	0.164	$3.77
2,400	$20.00	0.164	$3.28
1,800	$16.00	0.164	$2.62
1,200	$12.00	0.164	$1.97
900	$10.00	0.164	$1.64
600	$7.75	0.164	$1.27
400	$6.00	0.164	$0.98
200	$4.25	0.164	$0.70
100	$2.50	0.164	$0.41

Application of Regional Labor Adjustment Factor on Fiber Feeder Cable Installation				
Fiber Feeder Cable Size	Installed Fiber Feeder Cost	Labor Content Affected	Factor	Investment Affected per Foot
216	$13.10	$2.00	0.364	$0.73
144	$9.50	$2.00	0.364	$0.73
96	$7.10	$2.00	0.364	$0.73
72	$5.90	$2.00	0.364	$0.73
60	$5.30	$2.00	0.364	$0.73
48	$4.70	$2.00	0.364	$0.73
36	$4.10	$2.00	0.364	$0.73
24	$3.50	$2.00	0.364	$0.73
18	$3.20	$2.00	0.364	$0.73
12	$2.90	$2.00	0.364	$0.73

Application of Regional Labor Adjustment Factor on Outdoor SAI Installation			
Outdoor SAI Total Pairs Terminated	Installed Outdoor SAI	Labor Content Affected	Investment Affected per Outdoor SAI
7,200	$10,000	0.164	$1,640
5,400	$8,200	0.164	$1,345
3,600	$6,000	0.164	$984
2,400	$4,300	0.164	$705
1,800	$3,400	0.164	$558
1,200	$2,400	0.164	$394
900	$1,900	0.164	$312
600	$1,400	0.164	$230
400	$1,000	0.164	$164
200	$600	0.164	$98
100	$350	0.164	$57
50	$250	0.164	$41

Application of Regional Labor Adjustment Factor on Indoor SAI Installation			
Indoor SAI Distribution Cable Size	Installed Indoor SAI	Labor Content Affected	Investment Affected per Indoor SAI
7,200	$3,456	0.164	$567
5,400	$2,592	0.164	$425
3,600	$1,728	0.164	$283
2,400	$1,152	0.164	$189
1,800	$864	0.164	$142
1,200	$576	0.164	$94
900	$432	0.164	$71
600	$288	0.164	$47
400	$192	0.164	$31
200	$96	0.164	$16
100	$48	0.164	$8
50	$48	0.164	$8

Telco Installation & Repair labor (Drop & NID installation): Regional Labor Adjustment Factor applies to $20 of the $35 loaded labor rate (exclusive of exempt material loadings).

Application of Regional Labor Adjustment Factor on NID Installation			
Type of NID	NID Basic Labor	Labor Content Affected	Investment Affected per NID
Residence	$15.00	0.571	$8.57
Business	$15.00	0.571	$8.57

Application of Regional Labor Adjustment Factor on Aerial Drop Installation			
Density Zone	Installed Aerial Drop	Labor Content Affected	Investment Affected per Drop
0-5	$23.33	0.571	$13.33
5-100	$23.33	0.571	$13.33
100-200	$17.50	0.571	$10.00
200-650	$17.50	0.571	$10.00
650-850	$11.67	0.571	$6.67
850-2,550	$11.67	0.571	$6.67
2,550-5,000	$11.67	0.571	$6.67
5,000-10,000	$11.67	0.571	$6.67
10,000+	$11.67	0.571	$6.67

Application of Regional Labor Adjustment Factor on Buried Drop Installation			
Density Zone	Installed Buried Drop per Foot	Labor Content Affected	Investment Affected per Drop
0-5	$0.60	0.125	$0.075
5-100	$0.60	0.125	$0.075
100-200	$0.60	0.125	$0.075
200-650	$0.60	0.125	$0.075
650-850	$0.60	0.125	$0.075
850-2,550	$0.75	0.125	$0.094
2,550-5,000	$1.13	0.125	$0.141
5,000-10,000	$1.50	0.125	$0.188
10,000+	$5.00	0.125	$0.625

Application of Regional Labor Adjustment Factor on Pole Installation			
Total Pole Investment	Pole Labor	Labor Content Affected	Investment Affected per Pole
$417	$216	0.518	$216

The following chart shows recommended default values for each state.

Regional Labor Adjustment Factor:

Direct Labor costs vary among regions in the United States. A variety of sources can be used for labor adjustment factors.[70] The following statewide labor adjustment factor indexes can be used as default values:

State	Factor[71]
Alaska	1.25
Hawaii	1.22
Massachusetts	1.09
California	1.07
Michigan	1.01
New York	1.00
New Jersey	1.00
Rhode Island	1.00
Illinois	1.00
Minnesota	0.99
Connecticut	0.98
Pennsylvania	0.97
Nevada	0.95
Washington (State)	0.92
Oregon	0.92
Delaware	0.92
Indiana	0.92
Missouri	0.90
Maryland	0.89
New Hampshire	0.86

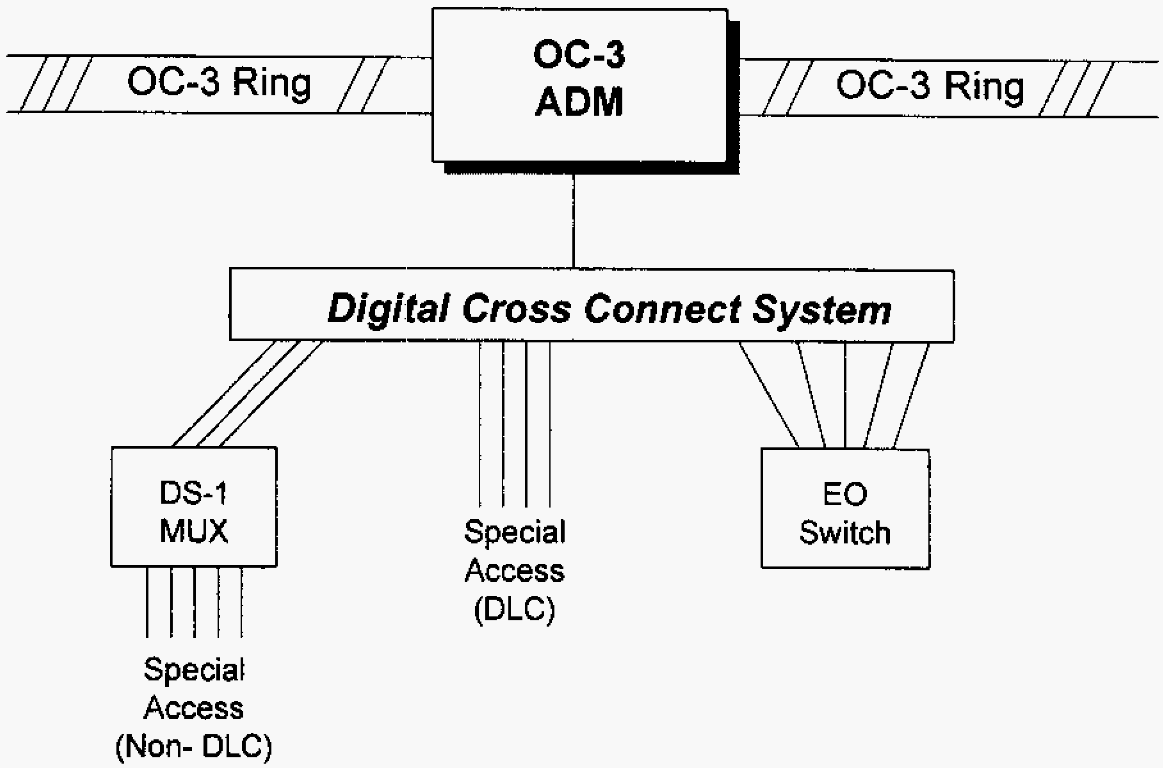
[70] See, for example, R.S. Means Company, Inc., *Square Foot Costs, 18th Annual Edition,* 1996, p.429-433.

[71] Martin D. Kiley and Marques Allyn, eds., *1997 National Construction Estimator 45th Edition*, pp. 12-15. [Normalized for New York State as 1.00]

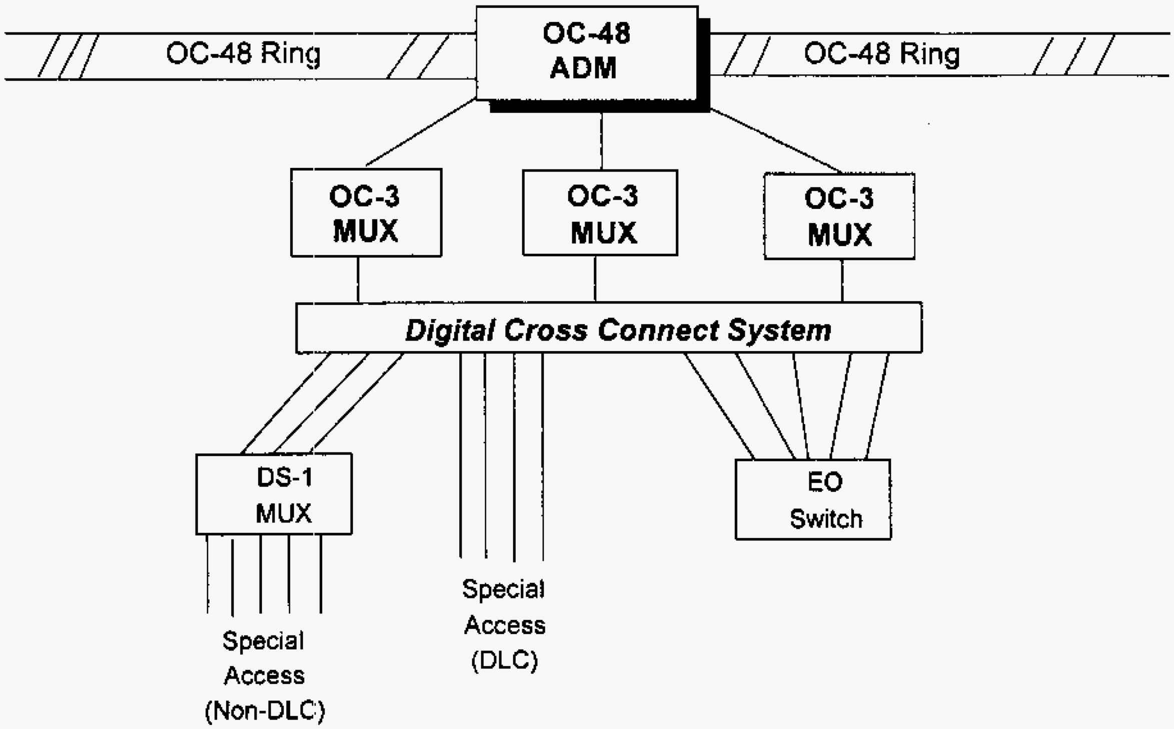
State	Factor[71]
Montana	0.85
West Virginia	0.84
Ohio	0.83
Wisconsin	0.83
Arizona	0.81
Colorado	0.77
New Mexico	0.76
Vermont	0.75
Iowa	0.74
North Dakota	0.74
Idaho	0.73
Maine	0.73
Kentucky	0.73
Louisiana	0.72
Kansas	0.71
Utah	0.71
Tennessee	0.70
Oklahoma	0.69
Florida	0.68
Virginia	0.67
Nebraska	0.65
Texas	0.65
South Dakota	0.64
Georgia	0.62
Arkansas	0.61
Wyoming	0.60
Alabama	0.58
Mississippi	0.58
South Carolina	0.55
North Carolina	0.51

APPENDIX A

Interoffice Transmission Terminal Configuration (OC-3 Fiber Ring)



Interoffice Transmission Terminal Configuration (OC-48 Fiber Ring)



APPENDIX B

Structure Shares Assigned to Incumbent Local Telephone Companies

B.1. Overview

Due to their legacy as rate-of-return regulated monopolies, LECs and other utilities have heretofore had little incentive to share their outside plant structure with other users. To share would have simply reduced the "ratebase" upon which their regulated returns were computed. But today and going forward, LECs and other utilities face far stronger economic and institutional incentives to share outside plant structure whenever it is technically feasible. There are two main reasons. First, because utilities are now more likely to either face competition or to be regulated on the basis of their prices (e.g., price caps) rather than their costs (e.g., ratebase), a LEC's own economic incentive is to share use of its investment in outside plant structure. Such arrangements permit the LEC to save substantially on its outside plant costs by spreading these costs across other utilities or users. Second, many localities now strongly encourage joint pole usage or trenching operations for conduit and buried facilities as a means of minimizing the unsightliness and/or right-of-way congestion occasioned by multiple poles, or disruptions associated with multiple trenching activities.

Because of these economic and legal incentives, not only has structure sharing recently become more common, but its incidence is likely to accelerate in the future – especially given the Federal Telecommunications Act's requirements for nondiscriminatory access to structure at economic prices.

The degree to which a LEC can benefit from structure sharing arrangements varies with the type of facility under consideration. Sharing opportunities are most limited for multiple use of the actual conduits (e.g., PVC pipe) through which cables are pulled that comprise a portion of underground structure. Because of safety concerns, excess ILEC capacity within a conduit that carries telephone cables can generally be shared only with other low-voltage users, such as cable companies, other telecommunications companies, or with municipalities or private network operators. Although the introduction of fiber optic technology has resulted in slimmer cables that have freed up extra space within existing conduits, and thus enlarged actual sharing opportunities, the HAI Model does not assume that conduit is shared because as a forward-looking model of efficient supply, it assumes that a LEC will not overbuild its conduit so as to carry excess capacity available for sharing.

Trenching costs of conduit, however, account for most of the costs associated with underground facilities – and LECs can readily share these costs with other telecommunications companies, cable companies, electric, gas or water utilities, particularly when new construction is involved. Increased CATV penetration rates and accelerated facilities based entry by CLECs into local telecommunications markets will expand further future opportunities for underground structure sharing. In addition, in high density urban areas, use of existing underground conduit is a much more economic alternative than excavating established streets and other paved areas.

Sharing of trenches used for buried cable is already the norm, especially in new housing subdivisions. In the typical case, power companies, cable companies and LECs simply place their facilities in a common trench, and share equally in the costs of trenching, backfilling and surface repair. Gas, water and sewer companies may also occupy the trench in some localities. Economic and regulatory factors are likely to increase further incentives for LECs to schedule and perform joint trenching operations in an efficient manner.

Aerial facilities offer the most extensive opportunities for sharing. The practice of sharing poles through joint ownership or monthly lease arrangements is already widespread. Indeed, the typical pole carries the facilities of at least three potential users – power companies, telephone companies and cable companies. Power companies and LECs typically share the ownership of poles through either cross-lease or condominium arrangements, or through other arrangements such as one where the telephone company and power company each own every other pole. Cable companies have commonly leased a portion of the pole space available for low voltage applications from either the telephone company or the power company. Methods of setting purchase prices and of calculating pole attachment rates generally are prescribed by federal and state regulatory authorities.

The number of parties wishing to participate in pole sharing arrangements should only increase with the advent of competition in local telecommunications markets. Economic and institutional factors strongly support reliance on pole sharing arrangements. It makes economic sense for power companies, cable companies and telephone companies to share pole space because they are all serving the same customer. Moreover, most local authorities restrict sharply the number of poles that can be placed on any particular right-of-way, thus rendering pole space a scarce resource. The Federal Telecommunications Act reinforces and regulates the market for pole space by prescribing nondiscriminatory access to poles (as well as to conduit and other rights-of-way) for any service provider that seeks access. The aerial distribution share factors displayed below capture a forward-looking view of the importance of these arrangements in an increasingly competitive local market.

B.2. Structure Sharing Parameters

The HAI Model captures the effects of structure sharing arrangements through the use of user-adjustable structure sharing parameters. These define the fraction of total required investment that will be borne by the LEC for distribution and feeder poles, and for trenching used as structure to support buried and underground telephone cables. Since best forward looking practice indicates that structure will be shared among LECs, IXCs, CAPs, cable companies, and other utilities, default structure sharing parameters are assumed to be less than one. Incumbent telephone companies, then, should be expected to bear only a portion of the forward-looking costs of placing structure, with the remainder to be assumed by other users of this structure.

The default LEC structure share percentages displayed below reflect most likely, technically feasible structure sharing arrangements. For both distribution and feeder facilities, structure share percentages vary by facility type to reflect differences in the degree to which structure associated with aerial, buried or underground facilities can reasonably be shared. Structure share parameters for aerial and underground facilities also vary by density zone to reflect the presence of more extensive sharing opportunities in urban and suburban areas. In addition, LEC shares of buried feeder structure are larger than buried distribution structure shares because a LEC's ability to share buried feeder structure with power companies is less over the relatively longer routes that differentiate feeder runs from distribution runs. This is because power companies generally do not share trenches with telephone facilities over distances exceeding 2500 ft.[72]

[72] A LEC's sharing of trenches with power companies, using random separation between cables for distances greater than 2,500 feet requires that either the telecommunications cable have no metallic components (i.e., fiber cable), or that both companies follow "Multi-Grounded Neutral" practices (use the same connection to earth ground at least every 2,500 feet).

Default Values in HM 5.1

Structure Percent Assigned to Telephone Company						
	Distribution			Feeder		
Density Zone	Aerial	Buried	Under-ground	Aerial	Buried	Under-ground
0-5	.50	.33	1.00	.50	.40	.50
5-100	.33	.33	.50	.33	.40	.50
100-200	.25	.33	.50	.25	.40	.40
200-650	.25	.33	.50	.25	.40	.33
650-850	.25	.33	.40	.25	.40	.33
850-2,550	.25	.33	.33	.25	.40	.33
2,550-5,000	.25	.33	.33	.25	.40	.33
5,000-10,000	.25	.33	.33	.25	.40	.33
10,000+	.25	.33	.33	.25	.40	.33

B.3. Support

Actual values for the default structure sharing parameters were determined through forward-looking analysis as well as assessment of the existing evidence of structure sharing arrangements. Information concerning present structure sharing practices is available through a variety of sources, as indicated in the references to this section. The HM 5.1 estimates of best forward-looking structure shares have been developed by combining this information with expert judgments regarding the technical feasibility of various sharing arrangements, and the relative strength of economic incentives to share facilities in an increasingly competitive local market. The reasoning behind the HAI Model's default structure sharing parameters is described below.

Aerial Facilities:

As noted in the overview to this section, aerial facilities (poles) are already a frequently shared form of structure, a fact that can readily be established through direct observation. For all but the two lowest density zones, the HAI Model uses default aerial structure sharing percentages that assign 25 percent of aerial structure costs to the incumbent telephone company. This assignment reflects a conservative assessment of current pole ownership patterns, the actual division of structure responsibility between high voltage (electric utility) applications and low voltage applications, and the likelihood that incumbent telephone companies will share the available low voltage space on their poles with additional attachers.[73]

ILECs and Power Companies generally have preferred to operate under "joint use," "shared use," or "joint ownership" agreements whereby responsibility for poles is divided between the ILEC and the power company, both of whom may benefit from the presence of third party attachers. New York Telephone reports, for example, that almost 63 percent of its pole inventory is jointly owned,[74] while, in the same proceeding, Niagara Mohawk Power Company reported that 58 percent of its pole inventory was jointly

[73] This sharing may be either of unused direct attachment space on the pole, or via co-lashing of other users' low voltage cables to the LEC's aerial cables. See, Direct Panel Testimony of Richard Wolf, Clay T. Whitehead, Donald Fiscella, David Peacock and Dr. Miles Bidwell on Behalf of the Electric Utilities, Case 95-C-0341: Pole Attachments, State of New York Public Service Commission, January 27, 1997.

[74] New York Telephone's Response to Interrogatory of January 22, 1997, Case 95-C-0341: Pole Attachments, State of New York Public Service Commission, January 27, 1997.

owned[75]. Financial statements of the Southern California Joint Pole Committee indicate that telephone companies hold approximately 50 percent of pole units[76]. Although proportions may vary by region or state, informed opinion of industry experts generally assign about 45 percent of poles to telephone companies. Note that both telephone companies and power companies may lease space on poles solely owned by the other.

While the responsibility for a pole may be joint, it is typically not equal. Because a power company commonly needs to use a larger amount of the space on the pole to ensure safe separation between its conductors that carry currents of different voltages (e.g., 440 volt conductors versus 220 volt conductors) and between its wires and the wires of low voltage users, the power company is typically responsible for a larger portion of pole cost than a telephone company.

Because of the prevalence of joint ownership, sharing, and leasing arrangements, it is unusual for a telephone company to use poles that are not also used by a power company. ILEC structure costs are further reduced by the presence of other attachers in the low voltage space. Perhaps the best example is cable TV. Rather than install their own facilities, CATV companies generally have leased low voltage space on poles owned by the utilities. Thus, the ILECs have been able to recover a portion of the costs of their own aerial facilities through pole attachment rental fees paid by the CATV companies. The proportion of ILEC aerial structure costs recoverable through pole attachment fees is now likely to increase still further as new service providers enter the telecommunications market.

As noted above, the other, most obvious reason for assigning a share of aerial structure costs as low as 25 percent to the ILEC is the way that the space is used on a pole. HM 5.1 assumes that ILECs install the most commonly placed pole used for joint use, a 40 foot, Class 4 pole.[77] Of the usable space on such a pole, roughly half is used by the power company which has greater needs for intercable separation. That leaves the remaining half to be shared by low voltage users, including CATV companies and competing telecommunications providers.

Thus, a) because ILECs generally already bear well less than half of aerial structure costs; b) because ILECs now face increased opportunities and incentives to recover aerial facilities costs from competing local service providers; c) because new facilities-based entrants will be obliged to use ILEC-owned structure to install their own networks; and, d) because the Telecommunications Act requires ILECs to provide nondiscriminatory access to structure as a means of promoting local competition, on a forward-looking basis, it is extremely reasonable to expect that ILECs will need, on average, to bear as little as 25 percent of the total cost of aerial structure.

Buried Facilities:

Buried structure sharing practices are more difficult to observe directly than pole sharing practices. Some insight into the degree to which buried structure is, and will be shared can be gained from prevailing municipal rules and architectural conventions governing placement of buried facilities. As mentioned in the overview, municipalities generally regulate subsurface construction. Their objectives are clear: less

[75] Direct Panel Testimony of Richard Wolf, Clay T. Whitehead, Donald Fiscella, David Peacock and Dr. Miles Bidwell on Behalf of the Electric Utilities, Case 95-C-0341: Pole Attachments, State of New York Public Service Commission, January 27, 1997. These experts also predicted that sharing of poles among six attachers would not be uncommon.

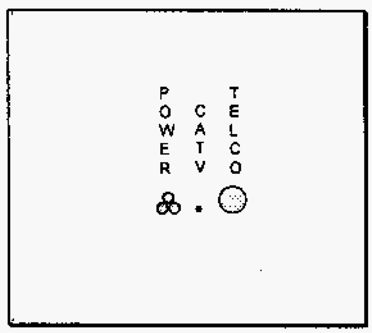
[76] " Statement of Joint Pole Units and Annual Pole Unit Changes by Regular Members", Monthly Financial Statements of the Southern California Joint Pole Committee, October, 1996.

[77] Opinion of engineering team. Also, "The Commission {FCC} found that 'the most commonly used poles are 35 and 40 feet high, ...'" {FCC CS Docket No. 97-98 NPRM dtd 3/14/97 pg. 6, and 47 C.F.R. § 1.1402(c). A pole's "class" refers to the diameter of the pole, with lower numbers representing larger diameter poles.

damage to other subsurface utilities, less cost to ratepayers, less disruption of traffic and property owners, and fewer instances of deteriorated roadways from frequent excavation and potholes.

Furthermore, since 1980, new subdivisions have usually been served with buried cable for several reasons. First, prior to 1980, cables filled with water blocking compounds had not been perfected. Thus, prior to that time, buried cable was relatively expensive and unreliable. Second, reliable splice closures of the type required for buried facilities were not the norm. And third, the public now clearly desires more out-of-sight plant for both aesthetic and safety related reasons. Contacts with telephone outside plant engineers, architects and property developers in several states confirm that in new subdivisions, builders typically not only prefer buried plant that is capable of accommodating multiple uses, but they usually dig the trenches at their own expense, and place power, telephone, and CATV cables in the trenches, if the utilities are willing to supply the materials. Thus, many buried structures are available to the LEC at no charge. The effect of such "no charge" use of developer-dug trenches reduces greatly the effective portion of total buried structure cost borne by the LEC. Note, too, that because power companies do not need to use a disproportionately large fraction of a trench – in contrast to their disproportionate use of pole space, and because certain buried telephone cables are plowed into the soil rather than placed in trenches, the HM 5.1 assumed LEC share of buried structure generally is greater than of aerial structure.

Facilities are easily placed next to each other in a trench as shown below:



Underground Facilities:

Underground plant is generally used in more dense areas, where the high cost of pavement restoration makes it attractive to place conduit in the ground to permit subsequent cable reinforcement or replacement, without the need for further excavation. Underground conduit usually is the most expensive investment per foot of structure -- with most of these costs attributable to trenching. For this reason alone, it is the most attractive for sharing.

In recent years, major cities such as New York, Boston, and Chicago have seen a large influx of conduit occupants other than the local telco. Indeed most of the new installations being performed today are cable placement for new telecommunications providers. As an example, well over 30 telecommunications providers now occupy ducts owned by Empire City Subway in New York City.[78] This trend is likely to continue as new competitors enter the local market.

[78] Empire City Subway is the subsidiary of NYNEX that operates its underground conduits in New York City.

References

Industry experience and expertise of HAI

The knowledge of AT&T and MCI outside plant engineers.

Outside Plant Consultants

Montgomery County, MD Subdivision Regulations

Policy Relating to Grants of Location for New Conduit Network for the Provision of Commercial Telecommunications Services

Monthly Financial Statements of the Southern California Joint Pole Committee.

Conversations with representatives of local utility companies.

New York Telephone's Response to Interrogatory of January 22, 1997, Case 95-C-0341: Pole Attachments, State of New York Public Service Commission, January 27, 1997.

Direct Panel Testimony of Richard Wolf, Clay T. Whitehead, Donald Fiscella, David Peacock and Dr. Miles Bidwell on Behalf of the Electric Utilities, Case 95-C-0341: Pole Attachments, State of New York Public Service Commission, January 27, 1997.

"Statement of Joint Pole Units and Annual Pole Unit Changes by Regular Members", Monthly Financial Statements of the Southern California Joint Pole Committee, October 1996.

APPENDIX C

Expenses in the HAI Model

Expense Group: Network Expenses
Explanation: Maintenance and repair of various categories of investment - outside plant (e.g., NID, drop, distribution, Service Area Interface, Circuit equipment, Feeder plant) and Central office equipment (e.g., switch)
Data Origin: New England Telephone Company Incremental Cost Study (switching and circuit operating expenses), HAI Consultant (NID), FCC 1996 ARMIS 43-03 (everything else).

6212 Digital Electronic Expense
6230 Operator Systems Expense
6232 Circuit Equipment Expense
6351 Public
6362 Other Terminal Equipment
6411 Poles
6421 Aerial Cable
6422 Underground Cable
6423 Buried Cable
6426 Intrabuilding Cable
6431 Aerial Wire
6441 Conduit Systems

Amount Determination: Expense-to-Investment ratio (NET Study, ARMIS); Dollar per Line for NID.
Application: Determine cost by multiplying Expense-to-Investment ratio times modeled investments; Determine NID cost by multiplying Dollar-per-Line times number of lines

Expense Group: Network Operations
Explanation: Network related expenses needed to manage the network but not accounted for on a plant type specific basis
Data Origin: 1996 ARMIS 43-03

6512 Provisioning Expenses
6531 Power Expenses
6532 Network Administration
6533 Testing
6534 Plant Operations Administration
6535 Engineering

Amount Determination: HAI default Network Operations Factor 50% times the embedded amount in ARMIS.
Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to UNE direct costs. Cost of "Network Administration" is allocated to traffic sensitive (i.e., switching, signaling and interoffice) UNEs only.

Expense Group: Network Support and Miscellaneous
Explanation: Miscellaneous expenses needed to support day to day operations
Data Origin: 1996 ARMIS 43-03

6112 Motor Vehicles	HAI: Network Support
6113 Aircraft	HAI: Network Support
6114 Special Purpose Vehicles	HAI: Miscellaneous
6116 Other Work Equipment	HAI: Miscellaneous

Amount Determination: In essence, embedded ARMIS levels are scaled to reflect the relative change in either cable and wire (C&W) investment for Network Support Expenses or total investment for Miscellaneous Expenses in the modeled results versus ARMIS. For example:
HAI Cost
= Embedded ARMIS Expense x (HAI C&W Inv./ARMIS C&W Inv.)
The rationale is that these costs will be lower in a forward-looking cost study.
Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to direct costs

Expense Group: Other Taxes
Explanation: Taxes paid on gross receipts and property (i.e., 7240 Other Operating Taxes)
Data Origin: HAI expert estimate of 5% is based on overall Tier 1 Company ratio of ARMIS 7240 Expenses to ARMIS Revenues.
Amount Determination: Modeled costs are grossed up by 5%.
Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to direct costs.

Expense Group: Miscellaneous
Explanation: Miscellaneous expenses needed to support day to day operations
Data Origin: 1996 ARMIS 43-03
6122 Furniture
6123 Office Equipment
6124 General Purpose Computer
6121 Buildings
Amount Determination: In essence, embedded ARMIS levels are scaled to reflect the relative change in total investment in the HAI model versus ARMIS. For example:
HAI Cost
= Embedded ARMIS Expense x (HAI Tot. Inv./ARMIS Tot. Inv.)
The rationale is that these costs will be lower in a forward-looking cost study.
Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to direct costs.

Expense Group: Carrier-to-carrier customer service
Explanation: This category includes all carrier customer-related expenses such as billing, billing inquiry, service order processing, payment and collections. End-user retail services are not included in UNE cost development.
Data Origin: 1996 ARMIS 4304 (carrier-to-carrier cost to serve IXC access service)
7150 Service Order Processing
7170 Payment and Collections
7190 Billing Inquiry
7270 Carrier Access Billing System
Amount Determination: HAI multiplies embedded amount (across Tier 1 LECs) times 70% to get $1.69 per line per year. The cost is determined by multiplying the cost per line times the number of lines. This figure includes the above business office activities, hence there is no need for a separate non-recurring charge to account for this activities. The underlying data that the UNE costs were developed from include other types of non-recurring costs outside the business office. Most of the non-recurring costs are captured in the HAI UNE estimate.
Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to direct costs.

Expense Group: Variable Overhead

Explanation: Executive, Planning and General and Administrative costs
Data Origin: 1996 ARMIS 43-03

- 6711 Executive
- 6712 Planning
- 6721 Accounting & Finance
- 6722 External Relations
- 6723 Human Resources
- 6724 Information Management
- 6725 Legal
- 6726 Procurement
- 6727 Research & Development
- 6728 Other General & Administrative

Amount Determination: HAI estimates 10.4% multiplier based on AT&T public data.

		$Mill	Source
A	Rev. Net of Settlements	36,877	Form M 1994
B	Settlement Payout	4,238	Intl Traffic Data, 1994 data
C	Gross Revenues	41,115	A + B
D	Corporate Operations	3,879	Form M 1994
E	Revenue less Corp. Op.	37,236	C - D
F	Ratio	10.4%	D/E

Application: Cost is determined by multiplying the sum of all costs by 1.104.

Expense Group: Carrier-to-carrier Uncollectibles
Explanation: Revenues not realized associated with services provided (i.e., delinquency, fraud)
Data Origin: Company-specific ratio calculated from 1996 ARMIS 4304 Uncollectibles to 1996 ARMIS Access Revenues.
Amount Determination: Modeled costs are grossed up by the uncollectible rate.
Application: Determine cost by allocating to unbundled network elements (UNEs) equiproportionally relative to direct costs.

APPENDIX D

Network Operations Reduction

No matter what area of network operations one looks at, one observes a rich set of target opportunities for cost savings. In Account 6512, Network Provisioning, new technologies such as the Telecommunications Management Network (TMN) standards, procedures, and systems, and Digital Cross-Connect Systems (DCS) provide for much more centralized access and control, and self-provisioning by customers (including, and especially, knowledgeable CLECs). Given the tiered nature of TMN, where there are element, network, service, and business layers of management, some of the advantages of TMN will redound to the benefit of plant-specific expenses, while others, associated with the network, service and business management layers, will benefit the more-general activities included in network operations The use of Electronic Data Interchange, intranet technology, and technologies such as bar coding provide substantial opportunities to reduce the costs of the inventory component of this category of accounts. On the human resources side, there is a greater emphasis on quality control in provisioning activities, reducing incipient failures in the services and elements provided.

As far as power expenses, Account 6531, digital components typically consume less power than their analog counterparts. Furthermore, centralization in other expense categories also spills over into this category, since centralization implies fewer buildings to power less of the time. Finally, due to the onset of competition in the electric power industry and the greater regulatory scrutiny of new generation resources, the industry is increasingly willing to provide price reductions to large business (and, increasingly, even residential and small business) customers. It is now quite common for firms to participate in energy programs in which, in exchange for reducing consumption during peak hours, they receive substantial discounts in the cost of power.

Network Administration, Account 6532, benefits from the deployment of SONET-based transport, because many administration activities are oriented to reacting to outages, which are lessened with the deployment of newer technologies. Testing, Account 6533, also benefits from the better monitoring and reporting capabilities provided by TMN and SONET. This can lead to more proactive, better-scheduled preventative maintenance. On the human resources side, there is a growing tendency for testing activities to be taken over by contractors, leading to lower labor costs for the ILECs. To the extent the activities are still performed by telephone company personnel, they can be performed by personnel with lower job classifications. Finally, the use of "hot spares" can reduce the need for out-of-hours dispatch and emergency restoral activities. Overall, fiber and SONET projects are often "proven in" partly on the assumption that they will produce significant operational savings.

Plant Operations and Administration, Account 6534, is likely to require fewer supervisory personnel, and more involvement by the vendors of equipment to the ILECs. For instance, as vendors take over many of the installation and ongoing maintenance activities associated with their equipment, there will be fewer ILEC engineers requiring management. The use of multi-skilled craft people will allow for fewer specialists to be sent out to address particular problems, and less supervision to manage the people that are sent out. It will, for instance, allow for greater span of control in supervisory and management ranks.

Finally, Engineering, Account 6535, will be more focused on activities associated with positioning the ILECs in a multi-entrant marketplace, less on the engineering of specific elements and services, as those activities become more automated and more in the hands of the purchasers of unbundled elements. To the extent that engineering addresses particular projects, or categories of projects, the use of better planning tools, such as the ability to geocode customer locations and sizes, will act to reduce the amount of such activities.

Additional specific reasons for adjusting the embedded level of these expenses include the following:

Recognize industry trends and the opportunities for further reductions. Network operations expenses, expressed on a per line basis, have already declined over the past several years. For the reasons described in the previous section, this trend is expected to continue as modern systems and technologies are deployed.

Eliminate incumbent LEC retail costs from the network operations expense included in the cost for unbundled network elements. A number of the sub-accounts (6533 Testing and 6534 Plant Operations Administration) include costs that are specific to retail operations that are not appropriately included in the cost calculated for unbundled network elements. A portion of the expenses booked to these sub-accounts represent activities that new entrants, rather than the incumbent LEC, will be performing. Analysis indicates that, as a conservative measure, 20% of the expenses in these two sub-accounts represent such retail activities and should be excluded. Since these two sub-accounts represent 56% of the total booked network operations expense, it is reasonable to conclude that, at a minimum, an additional 11% reduction should be applied to the historic booked levels of network operations expense.

Incorporate incumbent LEC expectations of forward-looking network operations expense levels. The Benchmark Cost Proxy Model ("BCPM"), sponsored by PacTel, Sprint, and US West, consistently calculates a level network operations expense per line that is well below historic levels and below the level calculated by the HAI Model. This projection of forward-looking network operations expenses, prepared for and advocated by three incumbent LECs, indicates that the HAI Model adjustment to the embedded levels of these expenses are appropriate and necessary (and may yield cost estimates that are conservatively high).

Minimize double counting of network operations expenses. A careful review of the way ARMIS account 6530 and the related sub-accounts (6531 Power, 6532 Network Administration, 6533 Testing, 6534 Plant Operations Administration, and 6535 Engineering) are constructed makes it clear that further adjustment is necessary to accurately produce forward-looking costs. Many of the engineering and administrative functions that are included in these accounts are recovered by the incumbent LECs through non-recurring charges. Without such an adjustment, these costs may be double-recovered through existing non-recurring charges and simultaneously through the recurring rates based on the HAI Model results. Similarly, double recovery is possible because these accounts are constructed as so-called "clearance accounts" where expenses are booked before they are assigned to a specific project. Without an adjustment, these expenses could be recovered as service or element-specific costs and as the shared costs represented by network operations expense.

INDEX