HAI Model

Release 5.3

Inputs Portfolio

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1. OVERVIEW

This draft document contains descriptions of the user-adjustable inputs to the HAI Model, version 5.3 ("HM 5.3"), the default values assigned to the inputs, and the rationales and supporting evidence for these default values. The inputs and assumptions in HM 5.3 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 HM 5.3[1] The HM 5.3 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 some 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. Furthermore, in particular state proceedings where it is utilized, the Model often benefits from information specific to the jurisdiction and company in question. Such information may take the form of regulatory mandates as to the values certain input parameters should have assigned, information obtained from the ILEC's own cost studies, and/or information obtained from the ILEC during the discovery process.

The inputs used in the HAI Model are subject to frequent review by the Model's developers and their advisors, particularly for the set of inputs that have a major impact on the results. These reviews consider new evidence that has come to light since the parameter values were last changed. The evidence may take the form of specific public information that has become available, of general trends and directions in the industry tracked by the HAI development team, and/or of general impressions about parameters formed in the course of participating in proceedings. Where such data suggest parameter values should change, they have been changed. Where the data suggest the existing values fall within the range of current values, they have typically not been modified. This document will continue to evolve as more documented sources are found to support the input values and assumptions.

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

Organization of Material:

Material is generally organized in this binder in the same order as default values appear in Model Input screens in HM 5.3.

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

2. CABLE INVESTMENT

2.1 COPPER CABLE MATERIAL INVESTMENT PER FOOT AND PER PAIR-FOOT

Definition: The delivered price per foot for copper cables of various sizes (pair counts), broken out separately for aerial, buried, and underground cable. The copper investment per pair-foot is an average installed cost for copper feeder cable that is used in estimating comparative life-cycle costs for copper vs. fiber feeder.

Default Values:

Copper Cable, Material $/foot				
Cable		**Material Cost/foot**		
Size	Gauge	Aerial	Buried	Underground
4200	26	$15.14	$16.08	$14.05
3600	26	$12.97	$13.79	$12.13
3000	26	$10.81	$11.49	$10.23
2400	26	$8.23	$9.19	$8.28
1800	26	$6.63	$7.16	$6.33
1200	26	$4.48	$5.32	$4.41
900	26	$3.45	$3.56	$3.39
600	26	$2.47	$2.76	$2.27
400	26	$1.69	$1.75	$1.51
200	26	$1.31	$1.17	$1.05
100	24	$0.72	$0.62	$0.52
50	24	$0.45	$0.35	$0.26
25	24	$0.29	$0.21	$0.13
12	24	$0.29	$0.21	$0.13
6	24	$0.29	$0.21	$0.13
Installed Copper Feeder Investment per Pair-foot				
$0.0055				

Support: The source for these copper cable material inputs is Florida PSC Order No. PSC-99-0068-FOF, pages 149-155. Although thicker 24-gauge wire is not required for transmission reasons, use of this more expensive cable for cable sizes of 200 pairs and smaller prevents 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.

2.2 COPPER CABLE ENGINEERING FACTORS

Definition: Factors involved in calculating the cost of engineering copper cables.

Default Value:

OSP Engineering Labor Rate & Productivity for Copper Cable		
Function	**Parameter**	
Length of OSP engineer's work day	8.0	hours per day
OSP engineering labor rate per hour	$60.00	per hour
OSP engineering cable layout productivity	10,000	feet per day
Minutes per splice engineered	30.0	minutes per splice
Minutes per 300 copper pairs engineered	15.0	minutes per 300 pairs

Support: It is well known in the industry that the two key components of engineering productivity are the number of feet of cable engineered per day, and the efforts required to engineer copper splice points. Based on experience, it is typical for an engineer to engineer approximately two miles of cable in a day, to designate a splice location in half an hour, and to take approximately 15 minutes to designate which wire pairs coming into a splice should be joined with which wire pairs are exiting a splice at a rate of 300 pairs per 15 minute interval.

2.3 COPPER CABLE INSTALLATION FACTORS

Definition: Factors involved in calculating the cost of installing (placing and splicing) copper cables, broken out separately, where appropriate, for aerial, buried, and underground cable.

Default Value:

OSP Technician Labor Rate & Productivity for Copper Cable		
Function	**Parameter**	
Length of OSP technician's work day	8.0	hours per day
OSP technician labor rate per hour	$60.00	per hour
Cable placing crew size	2.0	technicians per crew
Cable splicing crew size – aerial & buried	1.0	Technicians per splicing crew
Cable splicing crew size – underground	2.0	Technicians per splicing crew
Splicing set up and closure time (hours)	2.0	Hours
Splicing rate (pairs joined per hour)	300	pairs joined per hour

OSP Technician Labor Rate & Productivity for Copper Cable			
Function	**Aerial**	**Buried**	**Underground**
Copper Cable Placing Rates (ft. per day)	5,000	8,000	3,600
Average Distance between copper splices (ft.)	1,000	2,000	600

Support:
Cable placing crews are generally made up of two technicians. Cable splicing crews normally consist of two technicians in an underground manhole environment, or one technician in an aerial or buried environment. It normally requires two hours to set up and close a splice case that contains the wires joined using high production 25-pair modules that are snapped together to form the splice. Copper cable splicing can be performed at a rate of 300 to 500 pairs per hour. Support for that splicing rate can be found in Appendix C of the FCC Inputs Order[2], in a letter from AMP Corporation, and in discovery information from Bell South.

[2] *See* Federal-State Joint Board on Universal Service, CC Docket No. 96-45 and Forward-Looking Mechanism for High Cost Support for Non-Rural LECs, CC Docket No. 97-160, Tenth Report and Order: Adopted: October 21, 1999 and Released: November 2, 1999. Also see, Federal-State Joint Board on Universal Service, Fifth Report and Order, CC Docket Nos. 96-45, 97-160, Adopted: October 22, 1998 and Released: October 28, 1998 ("FCC Inputs Order").

The aerial copper cable placing rate represents a reasonably expected placement of 20 to 33 aerial sections (pole-to-pole) per day using high production cable placing trucks and well trained technicians. The underground copper cable placing rate represents a reasonable rate of placing six 600-foot (between manholes) sections per work day using high production underground placing rigs and well trained technicians. The input for placing buried cable is conservatively low, because placing buried cable in an open trench is usually performed at no extra cost by buried structure contractors, or is part of the plow cable operation which does not require separate costs for cable placement.

2.4 FIBER CABLE MATERIAL INVESTMENT PER FOOT AND PER STRAND-FOOT

Definition: The delivered price per foot for fiber cables of various sizes (strand counts), broken out separately for aerial, buried, and underground cable. The fiber investment per strand-foot is used in estimating comparative life-cycle costs for copper vs. fiber feeder.

Default Value:

Fiber Cable, Material $/foot			
Cable Size	**Material Cost/foot**		
Size	Aerial	Buried	Underground
288	$8.51	$8.51	$8.51
216	$6.42	$6.42	$6.42
144	$4.30	$4.30	$4.30
96	$2.97	$2.97	$2.97
72	$2.30	$2.30	$2.30
48	$1.60	$1.60	$1.60
36	$1.12	$1.12	$1.12
24	$0.89	$0.89	$0.89
12	$0.59	$0.59	$0.59
6	$0.36	$0.36	$0.36
Installed Fiber Investment per Strand-Foot			
$0.03			

Support: The source for these fiber cable material inputs is Florida PSC Order No. PSC-99-0068-FOF, pages 147-149.

2.5 FIBER CABLE ENGINEERING FACTORS

Definition: Factors involved in calculating the cost of engineering fiber cables.

Default Value:

OSP Engineering Labor Rate & Productivity for Fiber Cable		
Function	Parameter	
Length of OSP engineer's work day	8.0	hours per day
OSP engineering labor rate per hour	$60.00	per hour
OSP engineering cable layout productivity	10,000	feet per day
Minutes per splice engineered	10.0	Minutes per splice
Minutes per 12 fiber strands engineered	3.0	Minutes per 12 strands

Support:
It is well known in the industry that the two key components of engineering productivity are the number of feet of cable engineered per day, and the efforts required to engineer fiber splice points. Fiber cable is much simpler to engineer than copper cable, primarily because maximum reel lengths allow a great deal of latitude in placing and splicing instructions to technicians. Based on experience, it is typical for an engineer to engineer approximately two miles of fiber cable in a day, and to designate a splice location in approximately 10 minutes. Fiber splices are much smaller than copper splices, and there is considerably more leeway in where they are placed. Since fibers joined in a splice are frequently planned in groups of 12 fibers, it takes approximately 3 minutes to designate which fibers coming into a splice should be joined with which fibers are exiting a splice.

2.6 FIBER CABLE INSTALLATION FACTORS

Definition: Factors involved in calculating the cost of installing (placing and splicing) fiber cables, broken out separately, where appropriate, for aerial, buried, and underground cable.

Default Value:

OSP Technician Labor Rate & Productivity for Fiber Cable		
Function	**Parameter**	
Length of OSP technician's work day	8.0	hours per day
OSP technician labor rate per hour	$60.00	per hour
Cable placing crew size	2.0	technicians per crew
Cable splicing crew size – aerial & buried	1.0	technicians per splicing crew
Cable splicing crew size – underground	2.0	technicians per splicing crew
Splicing set up and closure time (hours)	2.0	hours
Splicing rate minutes per fiber strand joined	5.0	minutes per fiber strand joined

Function	**Aerial**	**Buried**	**Underground**
Fiber Cable Placing Rates (ft. per day)	8,000	8,000	8,000
Average Distance between fiber splices (ft.)	6,000	6,000	6,000

Support:
HM 5.3 conservatively uses the same technician productivity for fiber splice setup and closure as for copper. The splicing rate at 5 minutes per fiber is readily achieved by typical fiber splicing crews using automated fusion fiber splicing tools. Average distance between splices is much greater for fiber cable than copper cable, because short reel lengths are never an issue. A fiber splice every 6,000 feet is typical.

Placing fiber cable is much more rapid than placing copper cable for two reasons. First, the cable reel lengths are extremely long – up to 35,000 feet on one reel, compared to, for example the maximum copper cable reel length for a 4200-pair copper cable of 810 feet.[3] Second, fiber cable is extremely lightweight, at approximately 100 pounds per 1,000 feet. A placing rate of 8,000 feet per day is typical. It is common for contract fiber placing crews to place 8,000 to 10,000 feet of fiber cable per day.

3. DISTRIBUTION

3.1 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

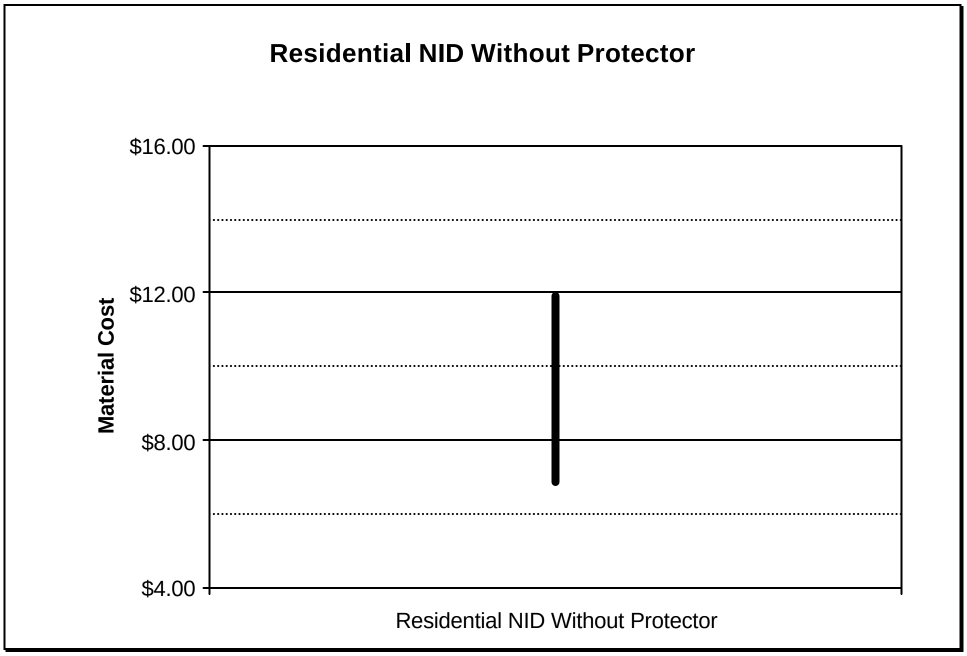
Support:

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.

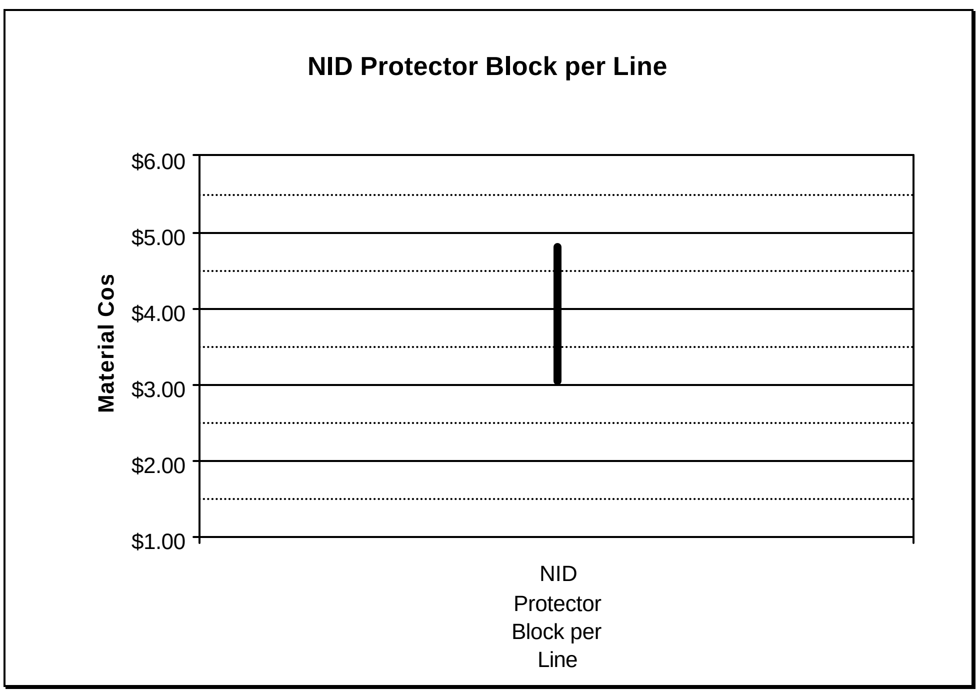
Price quotes for material were received from several sources. Results were as follows:

[3] See, for example Lucent, *AT&T Outside Plant Engineering Handbook*, August 1994, p. 14-10.



b) NID Protector Block per Line

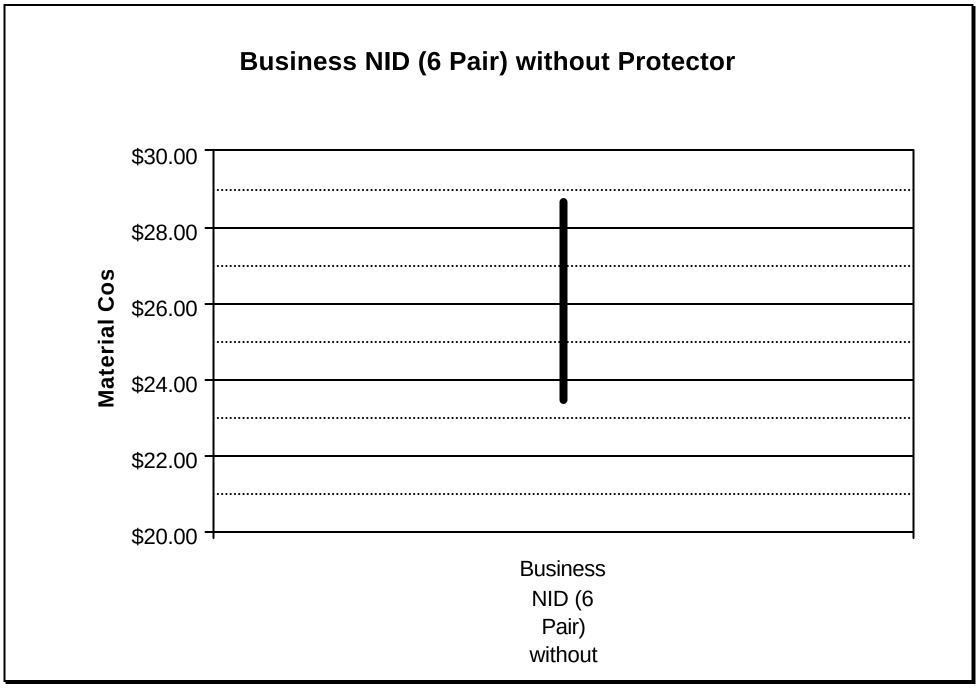
Price quotes for material were received from several sources. Results were as follows:



c) Business NID - No Protector

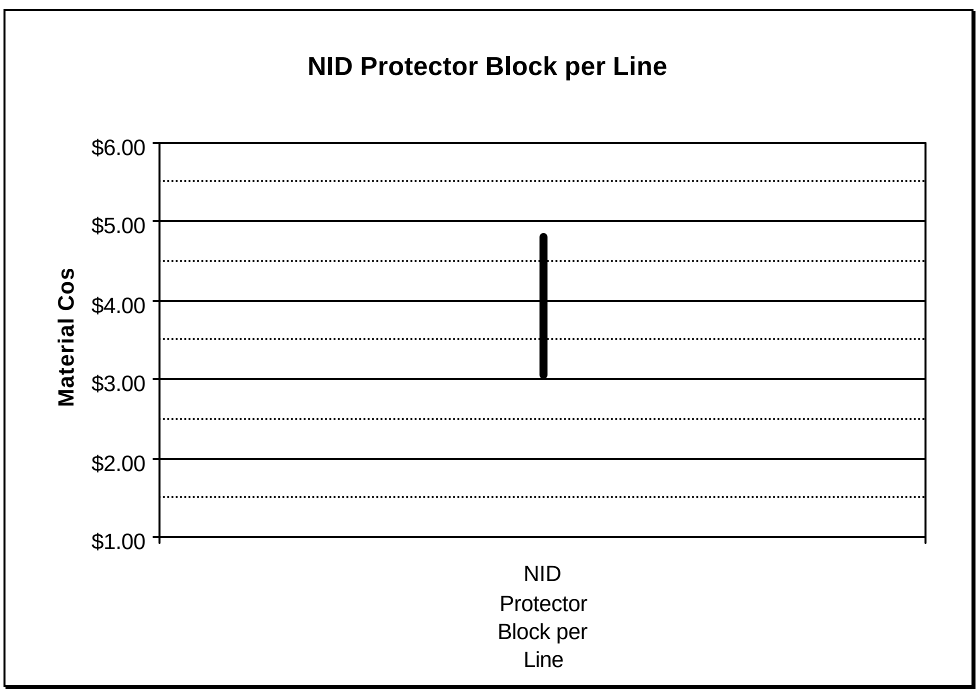
The labor estimate assumes a crew installing network interface devices throughout a neighborhood (in coordination with the installation of drops, terminals, and distribution cables). A work time of 25 minutes was used, based on the opinion of a team of outside plant experts. A loaded labor rate of $35 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.

3.2. DROP

3.2.1. 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 5.3 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 5.3 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.[4]

3.2.2. 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.

[4] Telcordia Technologies, Inc., *Telcordia Notes on the Networks*, Issue 4, November, 2000 ("*Notes on the Network")*, 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.

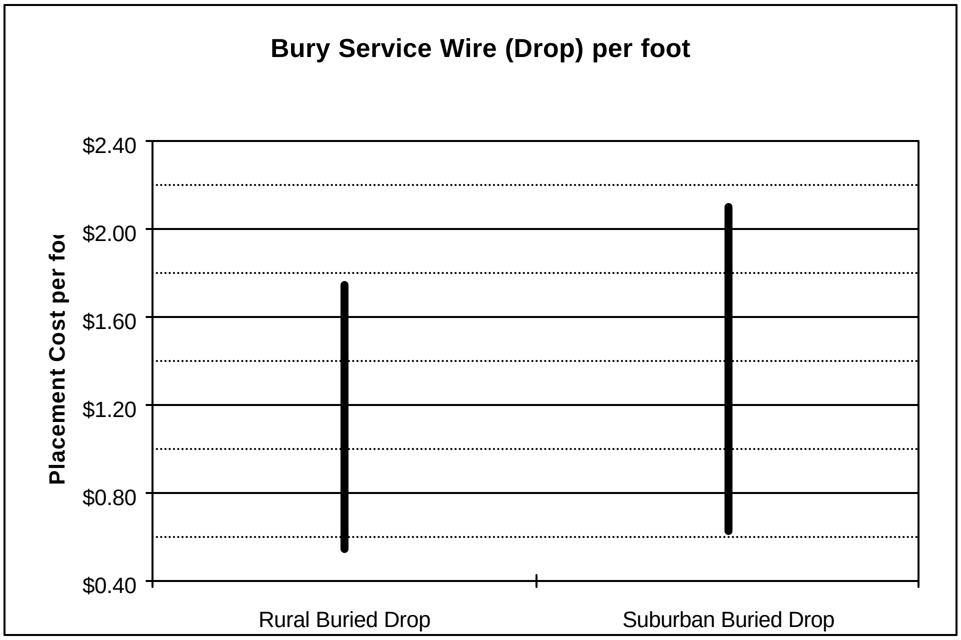
Aerial Drop Placement				
Density Zone	**Aerial Drop Length (ft.)**	**Installation Time (min.)**	**Direct Loaded Labor Rate $/hr.**	**Aerial Total**
0-5	150	40	$35	$23.33
5-100	150	40	$35	$23.33
100-200	100	30	$35	$17.50
200-650	100	30	$35	$17.50
650-850	50	20	$35	$11.67
850-2,550	50	20	$35	$11.67
2,550-5,000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

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 5.3 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:



3.2.3. 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 5.3 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.

3.2.4. 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 - Verizon		
Density Zone	**Aerial**	**Buried**
0-5	.43	.57
5-100	.43	.57
100-200	.43	.57
200-650	.43	.57
650-850	.43	.57
850-2,550	.43	.57
2,550-5,000	.48	.52
5,000-10,000	.65	.35
10,000+	.85	.15

Support: HM 5.3 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 3.5), including any building and riser cable that may be present in the upper two density zones.

3.2.5. 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*.

3.2.6. Aerial and Buried Terminal and Splice per Line

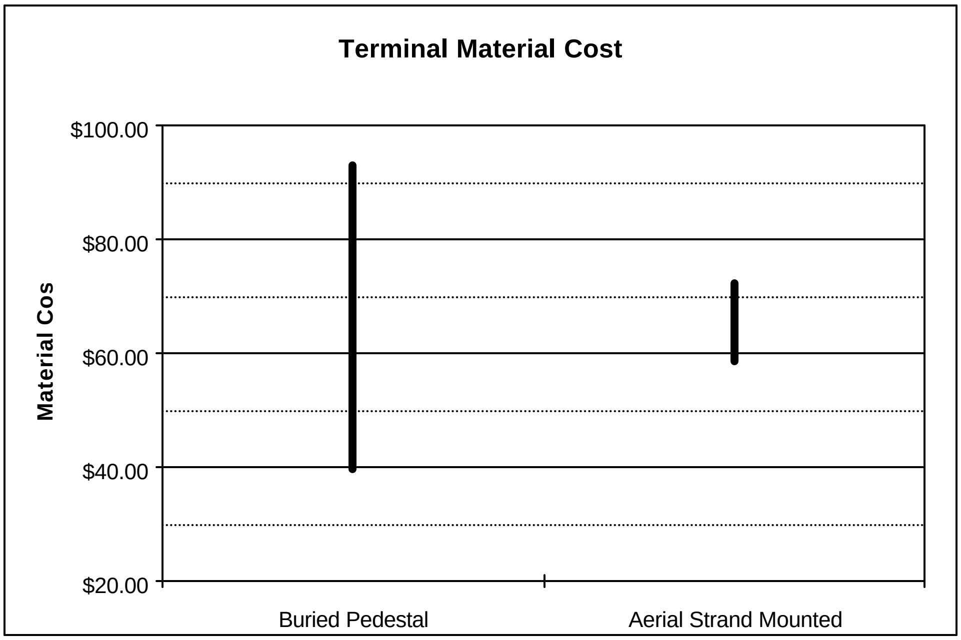
Definition: The installed cost per line for the terminal and splice that connect the drop to the distribution cable.

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 5.3 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:



The prices used are similar to those determined by the FCC for six- and twelve-pair terminals in its examination of information and data submitted by large telephone companies and Rural Utilities service contract data.

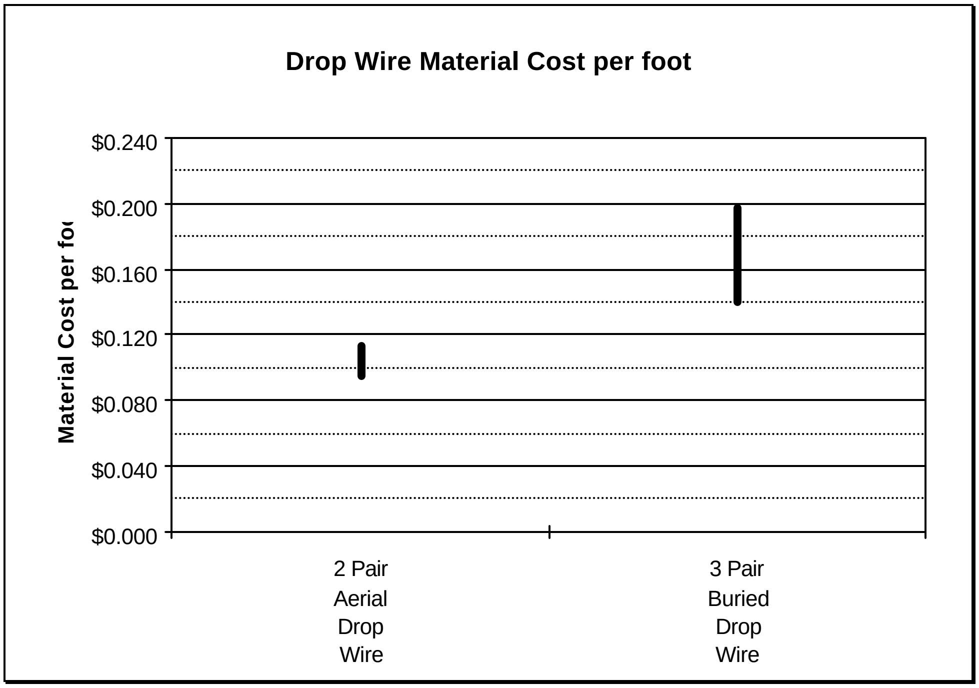
3.2.7. Drop Cable Investment, per Foot and Pairs per Drop

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:



3.3 RISER CABLE INVESTMENT

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 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.

3.4. POLES AND CONDUIT

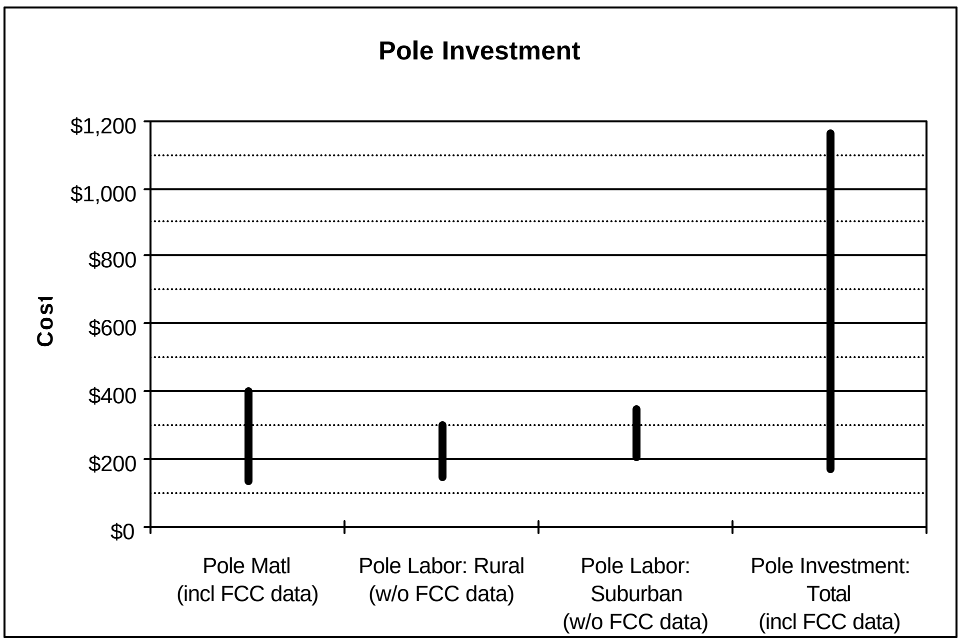
3.4.1. Pole Investment

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

Default Values:

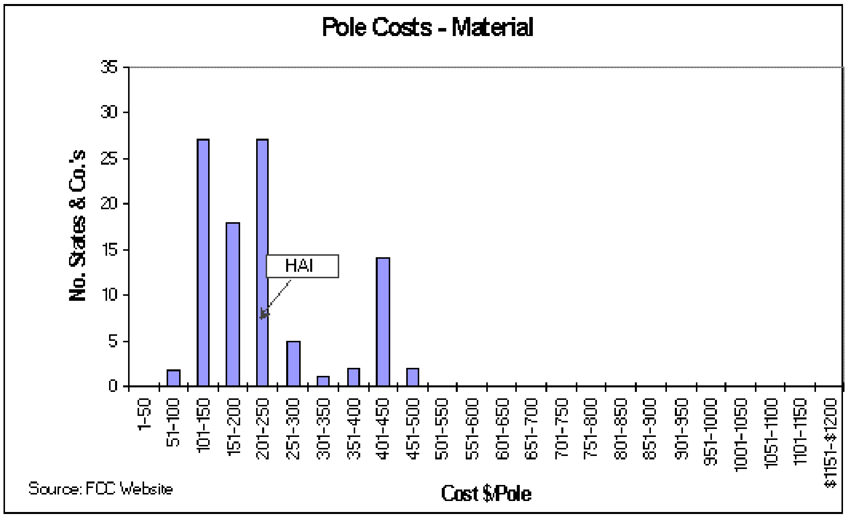
Pole Investment	
Materials	$201
Labor	$216
Total	*$417*

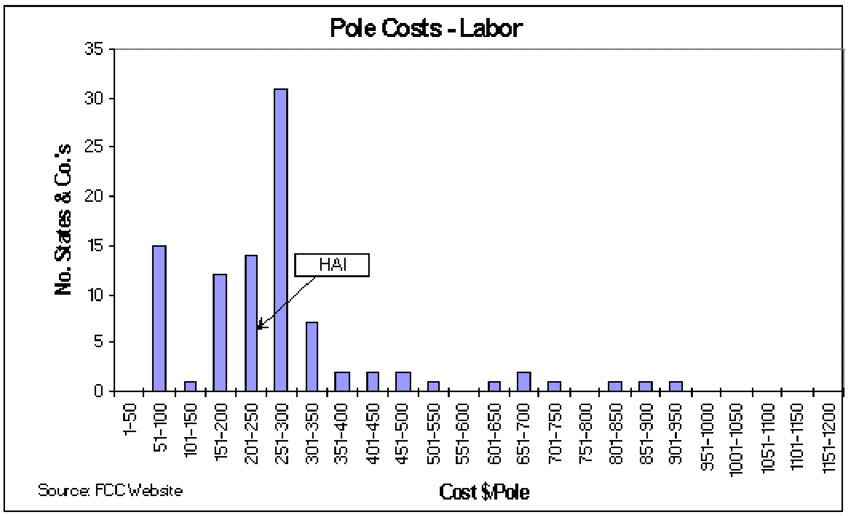
Support: Pole investment is a function of the material and labor costs of placing a pole. Costs include periodic down-guys and anchors. Utility poles can be purchased and installed by employees of ILECs, but are frequently placed by contractors. Several sources revealed the following information on prices.

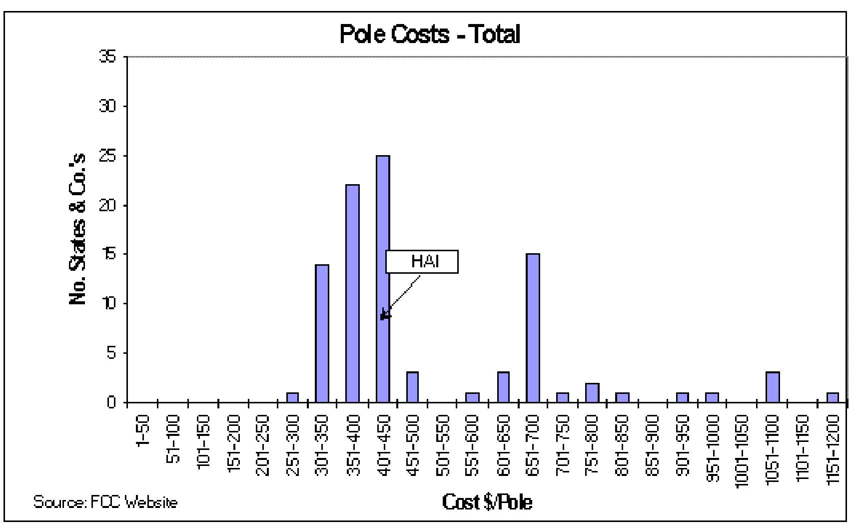


Pole data has also been recently filed by large telephone companies with the FCC.[5] A compilation of that information is shown below:

[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
35
30
25
20
15
10
5
0
HAI
1-50
51-100
101-150
151-200
201-250
251-300
301-350
351-400
401-450
451-500
501-550
551-600
601-650
651-700
701-750
751-800
801-850
851-900
901-950
951-1000
1001-1050
1051-1100
1101-1150
$1151-$1200
Source: FCC Website
Cost $/Pole


Pole Costs - Labor
No. States & Co.'s
35
30
25
20
15
10
5
0
HAI
1-50
51-100
101-150
151-200
201-250
251-300
301-350
351-400
401-450
451-500
501-550
551-600
601-650
651-700
701-750
751-800
801-850
851-900
901-950
951-1000
1001-1050
1051-1100
1101-1150
1151-1200
Source: FCC Website
Cost $/Pole


Pole Costs - Total
No. States & Co.'s
35
30
25
20
15
10
5
0
HAI
1-50
51-100
101-150
151-200
201-250
251-300
301-350
351-400
401-450
451-500
501-550
551-600
601-650
651-700
701-750
751-800
801-850
851-900
901-950
951-1000
1001-1050
1051-1100
1101-1150
1151-1200
Source: FCC Website
Cost $/Pole

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.

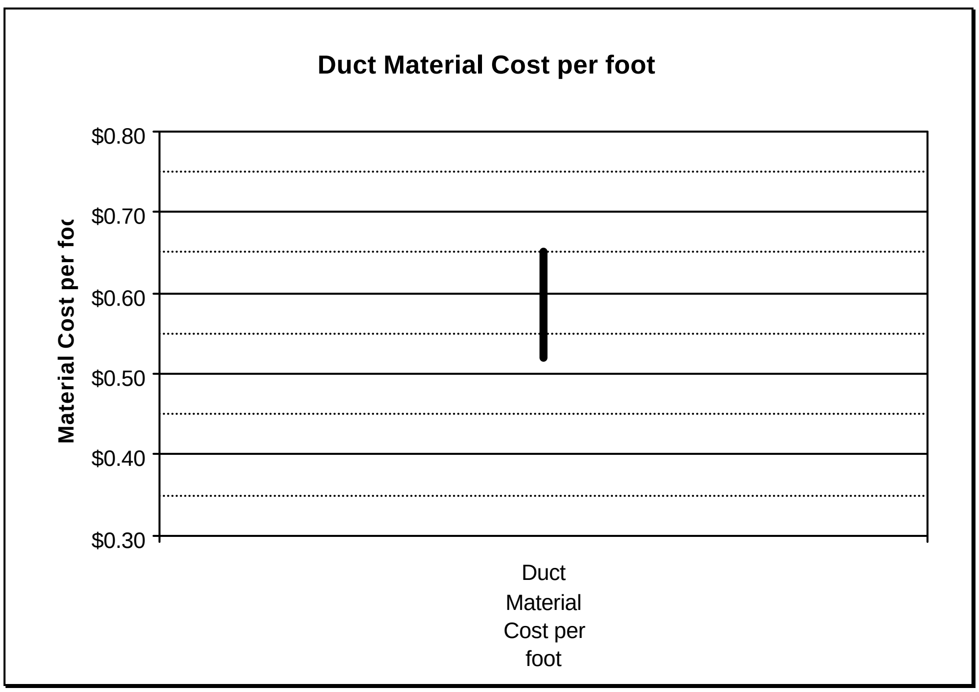
3.4.2. Conduit Material Investment per Foot

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.

3.4.3. 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 5.3 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] *Notes on the Networks* , p. 12-46.

3.5. 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. HM 5.3 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 built into the copper and fiber buried cable costs discussed in Section 1. The total investment in buried structure is a function of total route mileage, the fraction of buried structure, 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 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.

[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 5.3 this portion of “aerial” structure does not include poles.

3.5.1 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 3.5.2, 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."[8]

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 5.3 accounts for drop wire separately; drop wire is not considered part of aerial cable in HM 5.3. 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 5.3 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 ¶ 3.5.3.). Use of that parameter removes pole costs from such cable investment calculations.

Buried Cable:

Default values in HM 5.3 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.

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

[8] *Notes on the Network*, p. 12-45.

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.

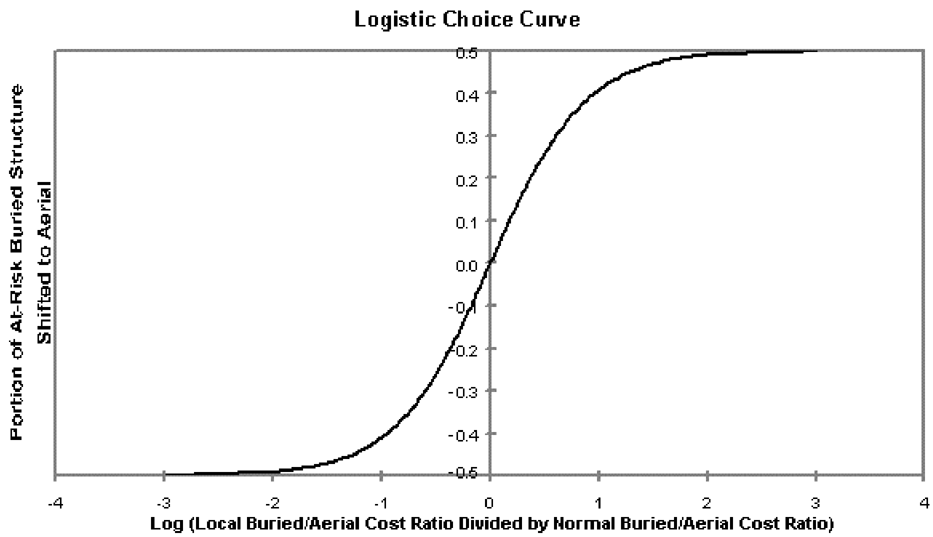
There may be rare exceptions where distribution cable from a SAI is so long that it requires an underground splicing chamber (manhole). Sometimes feeder cable will be extended, via a lateral, into a SAI, and distribution pairs in the same feeder stub will run back into the same manhole for further routing 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.

3.5.2 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 5.3 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 - Verizon				
Density Zone	Aerial/Block /Building Cable	Buried Cable	Underground Cable (calculated)	Buried Fraction Available for Shift
0-5	.43	.57	0	.75
5-100	.43	.57	0	.75
100-200	.43	.57	0	.75
200-650	.43	.57	0	.75
650-850	.43	.57	0	.75
850-2,550	.43	.57	0	.75
2,550-5,000	.43	.52	.05	.75
5,000-10,000	.50	.35	.15	-
10,000+	.50	.15	.35	-

Support: A review of ILEC ARMIS data filed with the FCC is reviewed prior to setting a range of structure percentages shown above. In addition, since shifting of structure type from buried to aerial, or vice versa is permitted, HM 5.3 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, HM 5.3 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 judgment 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.

3.5.3. 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 3.5.1 will yield the fraction of aerial structure requiring poles. For instance, in the highest density zone, the default fraction of aerial cable (parameter 3.5.1) is .50, while in the table below, the default fraction of block/building cable is .30, so in this density zone, poles are applied to .50 minus .30, or .20, 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	.10
10,000+	.30

Support: HM 5.3 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 (block cable), or can consist of Intrabuilding Network (cable (riser cable) inside elevator shafts or other pathways inside a building. 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 5.3 conservatively assumes that the ILEC will own all building riser cable, as well as distribution cable attached to the outside walls of buildings.

HM 5.3 applies 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. 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.

3.6. CABLE SIZING FACTORS AND POLE SPACING

3.6.1. 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: HM 5.3 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.[9] 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.[10]

- 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.

- 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.

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9 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.

10 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.

In general, the level of spare capacity provided by the default value of 75% in HM 5.3 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 5.3 default values for the distribution cable sizing factors are conservatively low from an economic costing standpoint.

3.6.2. 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.[11] 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."[12]

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

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

3.7. GEOLOGY AND POPULATION CLUSTERS

3.7.1. 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 5.3 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 3.7.2 through 3.7.5. 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 5.3 instead treats the effect of difficult soil conditions as a multiplier of placement cost – see Parameter 7.5, Surface Texture Multiplier. Therefore, the distribution distance multiplier is set to 1.0.

3.7.2. 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 5.3 imposes additional costs.

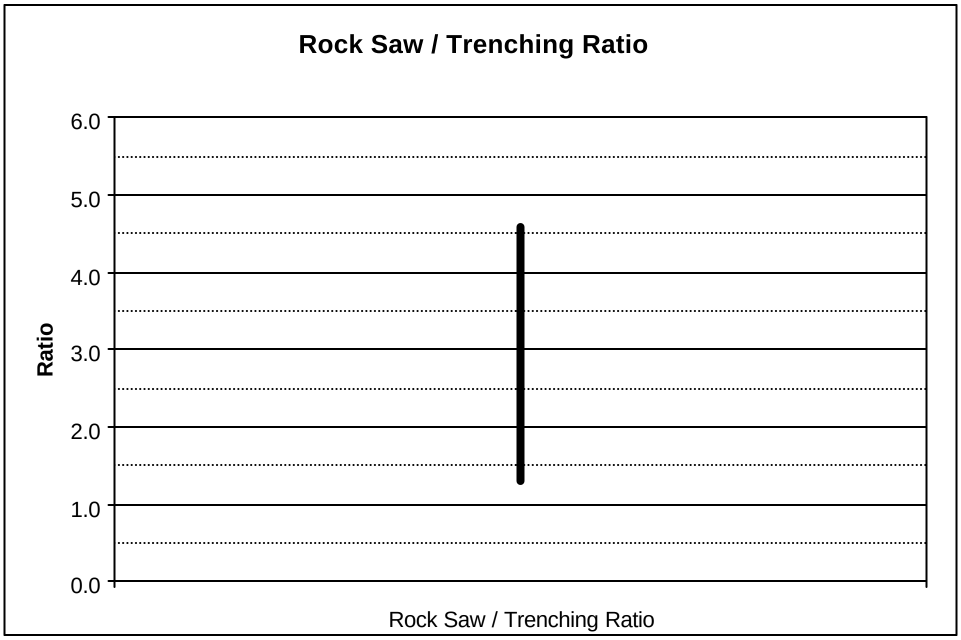
3.7.3. Hard Rock Placement Multiplier

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.



3.7.4. 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.

3.7.5. 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.

3.7.6. 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 *Notes on the Networks*, pp.12-3,-, 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. [13]

3.7.7. 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:

Feeder Steering Enable
Disabled

[13] *Notes on the Network*, p. 12-3,-4.

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 mo del will adjust the direction of a main feeder route to be closer to the more distant serving area interfaces.

3.7.8. 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.

3.7.9. 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 TNS Telecoms 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.

3.8. SAI INVESTMENT

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

Default Values:

SAI Investment		
SAI Size	**Indoor SAI**	**Outdoor SAI**
7200	$21,708	$22,481
5400	$16,618	$18,434
3600	$11,079	$13,489
2400	$7,536	$9,667
1800	$5,539	$7,644
1200	$3,993	$5,395
900	$2,770	$4,271
600	$1,996	$3,147
400	$1,331	$2,248
200	$665	$1,349
100	$333	$787
50	$220	$562

Support: Indoor Serving Area Interfaces are used inside buildings and are somewhat less expensive than Outdoor Serving Area Interfaces which require 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.

Default prices are based on the result of an FCC examination of both indoor and outdoor SAIs.

3.9. DEDICATED CIRCUIT INPUTS

3.9.1. 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.

3.9.2. 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**
0	0	0

Support: The Verizon customer location database provides explicit records for the types and locations of each loop, and HM 5.3 models the facility types required by each. Therefore, it is not necessary to provide a surrogate estimate of the equivalent amount of facilities associated with non-POTS loops, so these inputs are set to zero.

3.10 DISTRIBUTION ROUTE DISTANCE ADJUSTMENTS

3.10.1Strand 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 8.4 of the HAI Model Release 5.3 Model 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 (see the support section for the meaning of the “flag” value –999). 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	1	-999
5-100	1	-999
100-200	1	-999
200-650	1	-999
650-850	1	-999
850-2,550	1	-999
2,550-5,000	1	-999
5,000-10,000	1	-999
10,000+	1	-999

Support:

In default mode, the switch is "on," consistent with the FCC finding that the strand distance is an indicator of the correct DRD value, and the Initial Strand Multiplier is –999.[14]

The Model has a built-in calculation of the Initial Strand Multiplier by density zone. Setting the Initial Strand Multiplier value to -999 in a given density zone causes the Model to use the built-in calculation. 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. In HM 5.3, the built-in calculation sets the value to 1.0 in each density zone, which the HM 5.3 developers believe is the most appropriate value.[15]

3.10.2 Geocoded Rate

Definition: The percentage of customer locations that are successfully geocoded in each density zone, potentially used needed as a factor in a calculation of the Initial Strand Multiplier described in Section 3.10.1.

Default Values:

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

[15] In earlier versions of the model's cluster data base, the Strand Distance was based on the straight-line distance between customer locations, and a multiplier could be used to an upward adjustment to reflect the fact that cable routing is not direct. In the HM 5.3 version of the cluster database, the strand distance has been adjusted to reflect "right angle" routing between customer locations, and no further strand distance adjustment is required.

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:

This parameter is not used in HM 5.3, so it has been set to its “flag” value of –999 in each density zone.

3.11 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	0.805	0.886	0.835	0.908	0.850	0.733	0858	0.885	0.769	0.522
5-100	0.901	0.887	0.903	0.914	0.918	0.924	0.940	0.920	0.824	0.485
100-200	0.900	0.833	0.921	0.884	0.891	0.868	0.853	0.911	0.865	0.541
200-650	0.922	0.848	0.868	0.859	0.873	0.897	0.898	0.905	0.886	0.515
650-850	0.936	0.922	0.877	0.905	0.839	0.908	0.866	0.882	0.828	0.683
850-2,550	0.963	0.921	0.922	0.920	0.898	0.892	0.919	0.930	0.907	0.737
2,550-5,000	0.975	0.957	0.943	0.943	0.932	0.931	0.947	0.946	0.935	0.746
5,000-10,000	0.969	0.961	0.951	0.950	0.949	0.950	0.952	0.950	0.940	0.850
10,000+	0.958	0.960	0.951	0.951	0.959	0.959	0.952	0.927	0.930	0.945

Support: Drop structure requirements are tailored to include rate of occupancy by housing type and density zone. Occupancy is calculated using the specified number of occupied and vacant housing units reported for each Census Block Group (CBG) and Housing Type in 2000 census data. 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

3.12 HIGH CAPACITY LOOPS

3.12.1 ADSL Penetration

Definition: The number of residential and business ADSL lines as a percentage of, respectively, POTS residential lines and POTS business lines

Values: 0

Support: At the present time, ADSL cost calculations are performed in a model adjunct to HM 5.3, and thus these penetration figures are not required in the model

3.12.2 Pairs per DS-1 Loop

Definition: The number of pairs associated with a DS-1 loop

Default Value: 2

Support: While there are single-pair DS-1 services available in the marketplace, they are not nearly as extensively deployed at this time, so the model conservatively assumes two pairs are required

3.12.3 High-Capacity Optical Fraction of Total Structure

Definition: The fraction of distribution structure costs assigned to high-capacity optical loops on a route shared by fiber optics and copper loops.

Default Value: 0.50

Support: The default value causes structure costs on a distribution route shared by a copper and fiber distribution cable to be split between the two cables, and thus assigned equally to the total group of copper-based and total group of fiber-based services on the route. The HAI developers believe this is the most reasonable method of assigning shared costs.

3.12.4 Maximum High-Capacity Services on Common Route

Definition: The number of high-capacity services assumed to be on a single distribution route in a given cluster, so if there are, say, N high-capacity services in the cluster and this parameter is set to n, the number of high-capacity routes in that cluster will be set equal to N/n, rounded up.

Default Value: 4

Support: This value is based on the observation in the geocoded database that there are approximately four high-cap services per building.

3.12.5 Fiber Strands per Optical Service, incl. DS-3

Definition: The number of distribution fiber strands associated with an individual fiber service

Default Value: 4

Support: Assumes individual customers are served by a redundant pair of transmit and receive fibers, consistent with common industry practice for providing high-reliability fiber connections to customers.

3.12.6 DS-3 Wire Center Terminal Investment

Definition: The fixed and variable per-DS-3 investment in central office equipment that terminates DS-3 loops.

Default Value:

DS-3 Wire Center Terminal Investment	
Component	**Input Value**
DS-3 customer premises eqpt required	Yes
DS-3 Wire Center Terminal Investment	$99,200
Number of DS-3s served by fixed investment	36
DS-3 Wire center fill	0.90
Wire Center Terminal Variable Investment, per DS-3	$40.00

Support:
Central office/wire center labor costs are based on information in the Digital Loop Carrier section of the HIP, and on expert opinion. Such equipment may operate on a multi-node SONET ring, such that three OC-3 locations with one DS-3 service each may be readily homed on a single wire center mounted OC-3 multiplexer connected via four fibers. At least 12 OC-3 multiplexers can be mounted in a single wire center bay/rack, so costs are allocated to individual DS-3s on that basis.

Wire Center Fixed Investment per DS-3				
Central Office 12 OC-3 Multiplex Bay			**Quantity**	**Cost**
Labor Rate	$60.00	/hr.		
Engineering	8.0	hrs.	1	$480
Place frame and racks	2.0	hrs.	1	$120
Install 12 multiplexers & cabling (40 min. ea.)	8.0	hrs.	1	$480
Turn up & test 12 multiplexers (10 min. ea.)	2.0	hrs.	1	$120
Install 48 fiber patch panel and splice	6.0	hrs.	1	$360
Labor				$1,560
48-fiber patch panel	$1,340	ea.	1	$1,340
Frame and racks	$300	ea.	1	$300
OC-3 multiplexer	$8,000	ea.	12	$96,000
Material				$97,640
Wire Center Fixed Investment per DS-3				$99,200
Number of DS-3s Served By Fixed Investment (12 OC-3s @ 3 DS-3s/OC-3)				36
Allocated Wire Center Cost per DS-3 with Fill				$2,755.56

Wire Center Variable Investment per DS-3	
Component	**Input Value**
Duplex Fiber Pigtails (2 ea. @ $60) per OC-3	$120
DS-3s per OC-3	3
Wire Center Variable Investment, per DS-3	$40.00

3.12.7 DS-3 Premises Equipment

Definition: The per-customer investment in equipment and facilities required to provide a DS-3 loop to a customer at the RT/SAI and at the premises.

Default Value:

DS-3 Premises Equipment	
Component	**Input Value**
Electrical Customer Interface	TRUE
Customer premises terminal investment per DS-3	$8,799.00

Support: The checkbox for Electrical Customer Interface indicates that an optical-electrical conversion is made to hand off an electrical DS-3 to the customer. A breakdown of costs utilized to determine the default value are shown in the table that follows. Investments required for the fiber-based connection are included in the fiber terminal cost input for these services. Those investments consist of 1) a four-fiber entrance cable 100 feet long; 2) a splice of the distribution fiber cable to the entrance cable; 3) a splice within the premises that transforms the outside plant cable to a pigtail cable that provides individual connectorized fibers that can be plugged into the optical multiplexer; 4) two duplex fiber pigtails (total of four fibers); 5) an optical multiplexer; and, 6) the coaxial cable for connecting the circuit termination to the customer's equipment. The breakdown of investment costs that follows is based on estimated task times as supported in the Digital Loop Carrier section, for Engineering times, Technician times, and Material costs, with several exceptions. For the customer premises installation, those exceptions include engineering of the drop cable and multiplexer site, for which three hours is more than sufficient for the simple tasks involved; and, the placing, turn up & test of the multiplexer at the customer premises, which is based on expert opinion (Such multiplexers may be ordered for 110 volt wall outlet power, and are self-testing upon powering up the system.). The estimated cost of $40 for the coaxial cable and terminal is based on readily obtainable prices for such items from a variety of public suppliers and manufacturers.

Customer Premises Fixed Investment per DS-3				
Customer Premises	**Rate**		**Quantity**	**Cost**
OSP engineering labor rate per hour	$60.00	/hr.		
OSP engineering of drop cable & mux site	3.0	hrs.	1	$180.00
Minutes per splice engineered	10.0	min.	2	$20.00
Minutes per 4 fiber strands engineered	3.0	min.	1	$3.00
Engineering Labor				$203.00
OSP technician labor rate per hour	$60.00	/hr.		
Fiber drop cable placing time	0.5	hrs.	1	$30.00
Splicing set up and closure time (hours)	2.0	hrs.	2	$240.00
Splicing rate minutes per fiber strand joined	5.0	min.	8	$40.00
Place multiplexer, turn up & test system	1.5	hrs.	1	$90.00
Technician Labor				$400.00
Multiplexer at Customer Site	$8,000	ea.	1	$8,000.00
Duplex pigtail	$60	ea.	2	$120.00
Coaxial cable cross connect & terminal	$40	ea.	1	$40.00
4-fiber entrance cable	$0.36	/ft.	100	$36.00
Material				$8,196.00
Total Customer Premises Fixed Investment per DS-3				$8,799.00

3.12.8 DS-1 Range Extension Investment

Definition: Specifies the distribution distance beyond which additional DS-1 (HDSL) range extension equipment is required, and the per-DS-1 investment in the additional equipment

Default Value:

DS-1 Range Extension Investment	
Component	**Input Value**
Maximum DS-1 distance without range extension, ft.	12,000
DS-1 range extender investment	$2125.00

Support: Based on value used in HAI xDSL Adjunct Model for HDSL regenerator and determined by model development team, including discussions with data LEC representatives. The 12,000 ft value is a standard distance for HDSL transmission without regeneration.

3.12.9 DS-1 Wire Center Equipment

Definition: The per-DS-1 central office equipment investment for DS-1 loops carried on copper feeder cables.

Default Value:

DS-1 Wire Center Investment	
Component	**Input Value**
Wire center DS-1 shelf and common component inv, per shelf (copper feeder)	$7,035.00
Wire center DS-1 capacity per shelf (copper feeder)	84
Wire center shelf sizing factor (copper feeder)	0.9
Wire center plug-in investment per DS-1 (copper feeder)	$315.00

Support: The Wire center DS-1 shelf and common component investment per shelf (copper feeder) and the Wire center plug-in investment per DS-1 (copper feeder) investment inputs are based on expert opinions of members of the model development team, including discussions with data LEC representatives, as well as information filed by Qwest Corporation in its publicly filed DS-1 Model for ADC Soneplex equipment in the State of Oregon. The number of DS-1s per shelf is based on expert knowledge and vendor claims. The sizing factor is based on expert opinion, with the knowledge that this type of equipment is modular and capacities can be rapidly increased or decreased.

3.12.10 DS-1 Customer Premises Equipment

Definition: The per-DS-1 customer premises equipment investments for DS-1 loops delivered via copper or fiber feeder cables.

Default Value:

DS-1 Customer Premises Investment	
Customer premises equipment investment per DS-1, installed (copper and fiber feeder)	$850.00

Support: This is based on values determined by the model development team, including discussions with data LEC representatives, as well as information filed by Qwest Corporation in its publicly filed DS-1 Model for ADC Soneplex equipment in the State of Oregon.

4. FEEDER

4.1. COPPER PLACEMENT

4.1.1. 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 may be adjusted by HM 5.3 based on input values used in Section 4.2.1, Fiber Feeder Structure Fractions, Fraction of Buried Available for Shift.

Default Values:

Copper Feeder Structure Fractions – Verizon			
Density Zone	Aerial/Block Cable	Buried Cable	Underground Cable (calculated)
0-5	.37	.58	.05
5-100	.37	.58	.05
100-200	.37	.58	.05
200-650	.37	.43	.20
650-850	.37	.33	.30
850-2,550	.20	.30	.50
2,550-5,000	.10	.10	.80
5,000-10,000	.05	.05	.90
10,000+	.00	.00	1.00

Support: ***{NOTE: Excerpts from the discussion in Section 3.5. [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.

<u>*Aerial/Block Cable:*</u>

"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."[16]

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.

<u>*Buried Cable:*</u>

Default values in HM 5.3 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

[16] *Notes on the Network*, p. 12-45.

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.

4.1.2. 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."[17]

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[18], the largest used by HM 5.3. Therefore the longest distance between manholes used for copper cable is 800 feet.

4.1.3. Copper Feeder Pole Spacing, Feet

Definition: Spacing between poles supporting aerial copper feeder cable.

[17] *Notes on the Network*, p. 12-46

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

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:

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.[19] 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."[20]

4.1.4. Copper Feeder Pole Investment

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

Default Values:

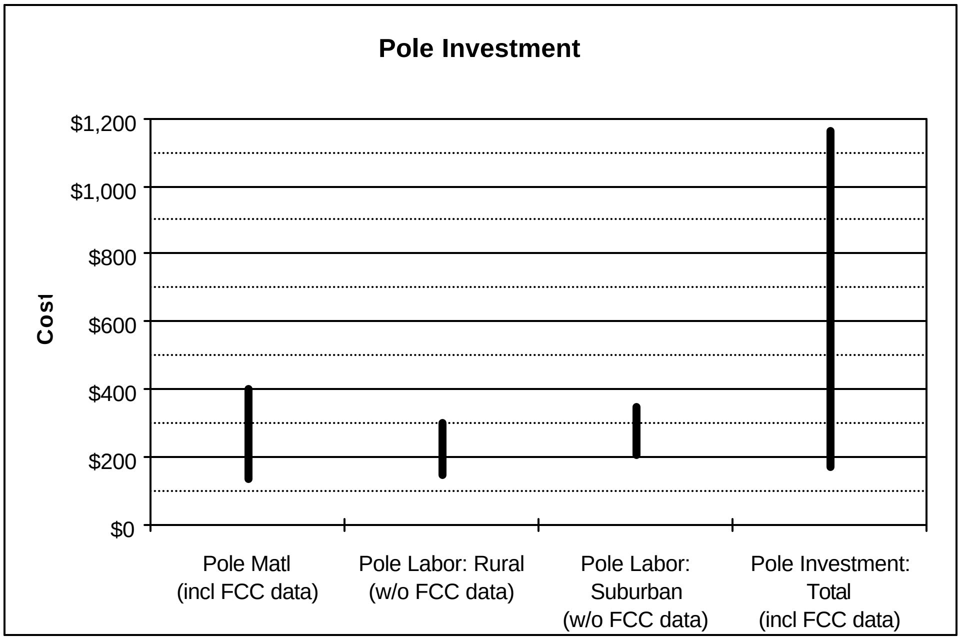
Pole Investment	
Materials	$201
Labor	$216
Total	$417

Support:

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

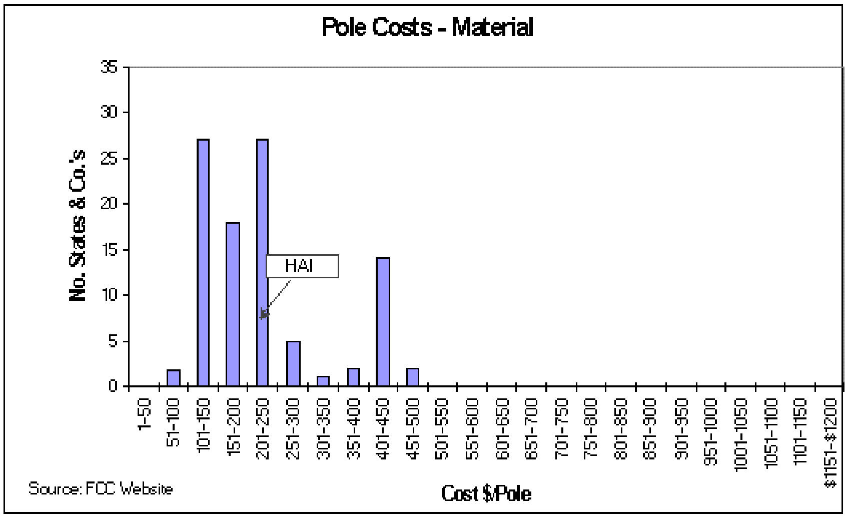
[20] Lee, Frank E., *Outside Plant, abc of the Telephone Series, Volume 4*, abc TeleTraining, Inc., Geneva, IL, 1987, p. 41.

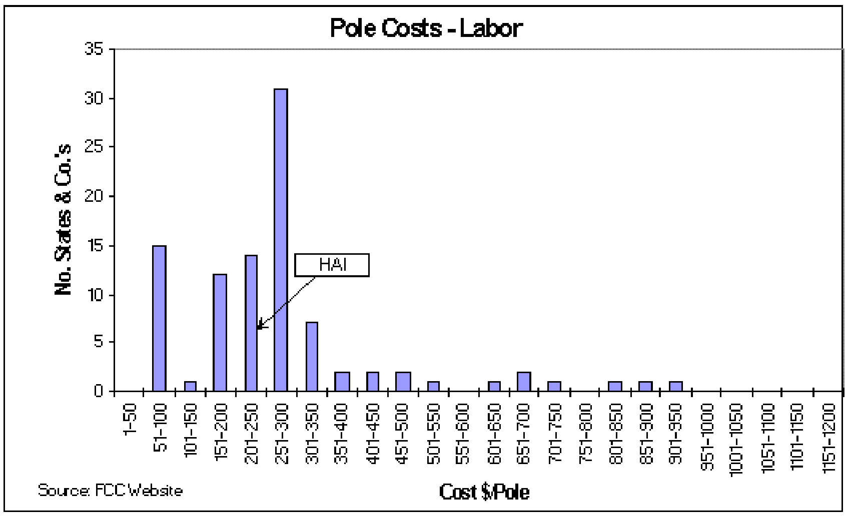
Pole investment is a function of the material and labor costs of placing a pole. Costs include periodic down-guys and anchors. Utility poles can be purchased and installed by employees of ILECs, but are frequently placed by contractors. Several sources revealed the following information on prices.

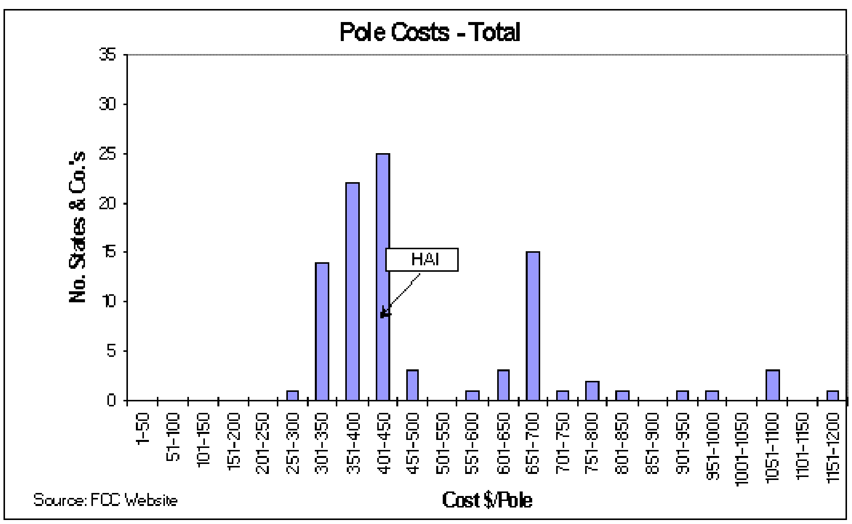


Pole data has also been recently filed by large telephone companies with the FCC.[21] A compilation of that information is shown below:

[21] 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.

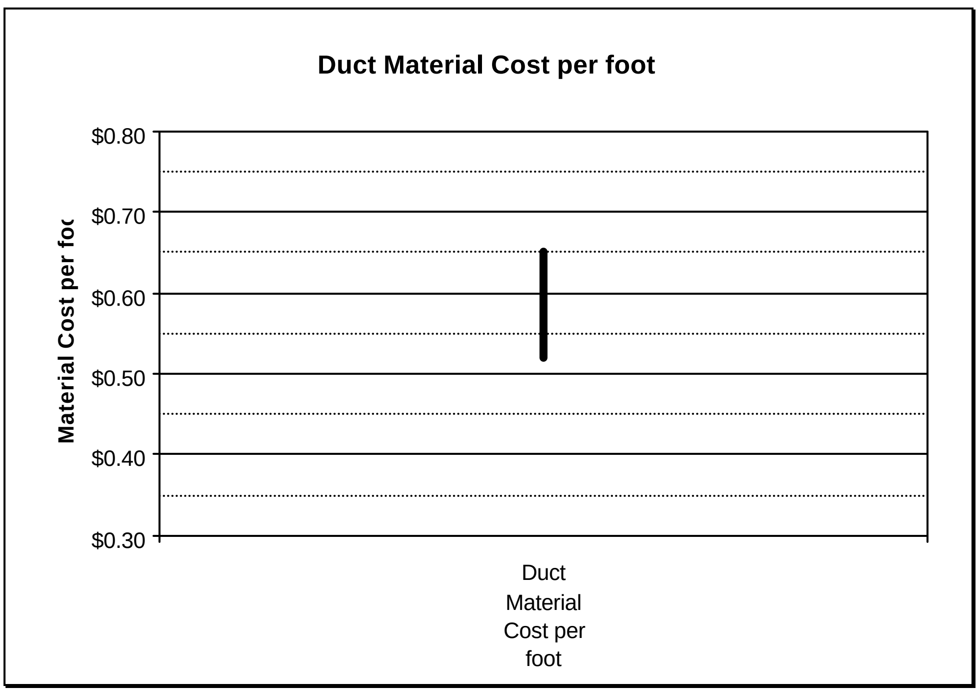
4.1.5 Conduit Material Investment per Foot

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 12,000 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.

4.1.6. 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.[22] Since HM 5.3 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 HM 5.3 developers. 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.

4.1.7 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

[22] 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.

reserve vacant ducts for maintenance purposes."[23] HM 5.3 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.

4.1.8 Amount of Feeder Structure Common with Distribution

Definition: The percentage of structure supporting feeder facilities that is also shared by distribution facilities, expressed as a fraction of the smaller of the feeder and distribution 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 Feeder Structure Common with Distribution
.55

Support: "the model uses an assumption that 55% of the feeder facilities will use the same structure as distribution facilities based on the evidence from several regulatory proceedings that 1) approximately 75% of the feeder facilities share the same structure as distribution facilities and 2) about 75% of those joint routes are assumed to share the same structure.

[23] *Notes on the Networks* , p. 12-46.

4.2. FIBER PLACEMENT

4.2.1. 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 5.3 may adjust the input values based on the buried fraction available for shift parameter using the process described in Section 3.5.2.

Default Values:

Fiber Feeder Structure Fractions - Verizon				
Density Zone	Aerial/Block Cable	Buried Cable	Underground Cable (calculated)	Buried Fraction Available for Shift[24]
0-5	.29	.27	.44	.75
5-100	.29	.27	.44	.75
100-200	.29	.27	.44	.75
200-650	.29	.27	.44	.75
650-850	.29	.27	.44	.75
850-2,550	.20	.20	.60	.75
2,550-5,000	.10	.10	.80	.75
5,000-10,000	.05	.05	.90	.75
10,000+	.00	.00	1.00	.75

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 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."[25]

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.

Buried Cable:

Default values in HM 5.3 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.

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

[25] *Notes on the Networks*, p. 12-45.

And third, the public now clearly desires more out-of-sight plant for both aesthetic and safety-related reasons.

<u>*Underground Cable:*</u>

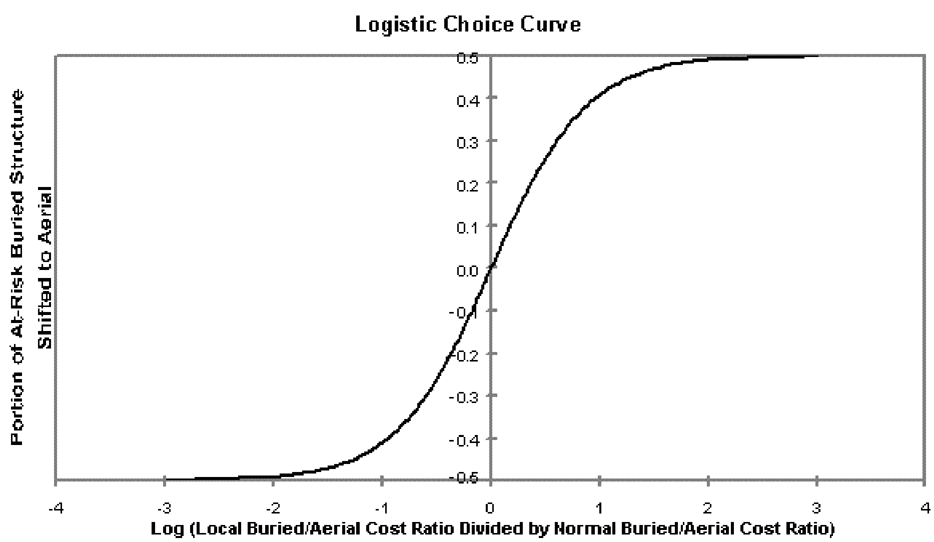
Underground cable, conduit, and manholes are primarily used for feeder and interoffice transport cables, not for distribution cable. Any conduit runs short enough to not require a splicing chamber or manhole are classified to the aerial or buried cable account, respectively.

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 5.3 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 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 judgment 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.

4.2.2. 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.[26] It is common practice for outside plant engineers to require approximately two slack boxes per mile.[27]

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

[27] 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.

4.2.3 Hi-Cap/POTS Structure Adjustment

Definition: A fraction applied to the amount of feeder structure investment the model assigns to hi-capacity loops

Default Value: 1.0

Support: The HAI model uses an algorithm for assigning shared feeder structure investments to copper-based and fiber based services[28] based on the relative number of copper versus fiber sheaths, and of fiber strands within a fiber sheath, that carry the two kinds of services. The HAI developers believe this to be the most reasonable assignment scheme; the default value of 1.0 for this factor retains the assignments based on that algorithm. The parameter is intended to allow the effect of other assignment schemes to be tested.

[28] As defined in the HM 5.3 Model Description, copper-based services are those that are delivered to customers on copper loops, such as POTS, DS-0 non-switched data, and ISDN, whereas fiber-based loops are those delivered on fiber, such as DS-3 and other higher-bit-rate non-switched circuits.

4.3. CABLE SIZING FACTORS

4.3.1. 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	.65.80
5-100	.75.80
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 3.6.1. [Distribution Cable Sizing Factors] are reproduced here for ease of use.}***

HM 5.3 uses uniform copper cable feeder sizing factors across most density zones for the following reasons:

- The ratio of adjacent cable sizes is considerably greater for the small cables used in lower density zones than for the large ones used in higher density zones. Pair counts for small cables essentially double between cable sizes, so that such cables easily allow enough extra pairs to accommodate administrative spare needs.[29] 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.[30]

- 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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[29] 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.

[30] 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 predominant default value of 80% in HM 5.3 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."[31] 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 5.3 default values for the feeder cable sizing factors are conservatively low from an economic costing standpoint.

4.3.2. 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 5.3 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.

[31] *Notes on the Networks*, p. 12-2. See also Telcordia, Telecommunications Transmission Engineering, Third Edition, 1990, p. 91.

4.4. DLC EQUIPMENT I

4.4.1. DLC Remote Terminal Line Size Ranges

Definition: The ranges of line sizes into which DLC investments are organized. The model determines the required DLC line size in a given cluster and uses this line size range table to look up other DLC investment parameters described in the remainder of this section as well as Sections 4.5 and 4.6. The parameters are organized into these same ranges.

Default Values:

DLC Remote Terminal Line Size Ranges	
From	To (Model Indicator)
0	24
25	120
121	240
241	672
673	1,344
1,345	2,016
2,017	2,688
2,689	3,360
3,361	4,032
4,033	4,704
4,705	5,376
5,377	6,048
6,049	6,720
6,721	7,392
7,393	8,064

Support: These line ranges are based on the base and incremental capacities of four commonly-utilized commercially-available DLC systems such as those manufactured by Advanced Fibre Communications (AFC) and Alcatel. The 24-line to 24-line systems are modeled around the AFC UMC-1000 system, and the 672-line and larger systems are modeled around the Alcatel Litespan 2000 system. The 24-line unit is very small and can be pedestal or fastened to a telephone pole or short stub pole. The 120-line and 240 line systems are in small cabinets. The 672-line, 1,344-line and 2,016-line systems are contained in outdoor cabinets. The 2,688-line, 3,360-line and 4,032-line systems are contained in a 6-foot by 16-foot Controlled Environmental Vault ("CEV"). The 4,704-line, 5,376-line, 6,048-line, 6,720-line, 7,392-line and 8,064-line systems are contained in a 6-foot by 24-foot CEV

4.4.2. DLC Installed Common Equipment Investment

Definition: The installed investment in DLC common equipment, specified in each of the line size ranges identified in Section 4.4.1.

Default Values:

DLC Installed Common Equipment Investment	
Maximum Line Size	**Investment**
24	$15,100.00
120	$18,498.00
240	$27,898.00
672	$70,290.00
1,344	$88,840.00
2,016	$107,390.00
2,688	$163,150.00
3,360	$184,100.00
4,032	$198,850.00
4,704	$250,800.00
5,376	$270,650.00
6,048	$291,600.00
6,720	$318,550.00
7,392	$338,400.00
8,064	$353,150.00

Support: Support for the DLC Installed Common Equipment Investment cost is detailed and thorough. Material costs for DLC electronic equipment continues to fall at the rate of 4% to 7% per year.[32] The following information is based on the expert opinion of engineering consultants, a review of industry available public data, and observations of costs across a number of ILECs.

DLC equipment is not assembled and wired on site. This equipment is pre-wired, pre-installed, and thoroughly tested in its enclosures prior to being shipped. Installation requires simply placing the Remote Terminal housing, and hooking up power and copper feeder cable connections to the Serving Area Interface.

The following breakdown of costs is detailed, revealing the granularity of the analysis that went into determining these costs

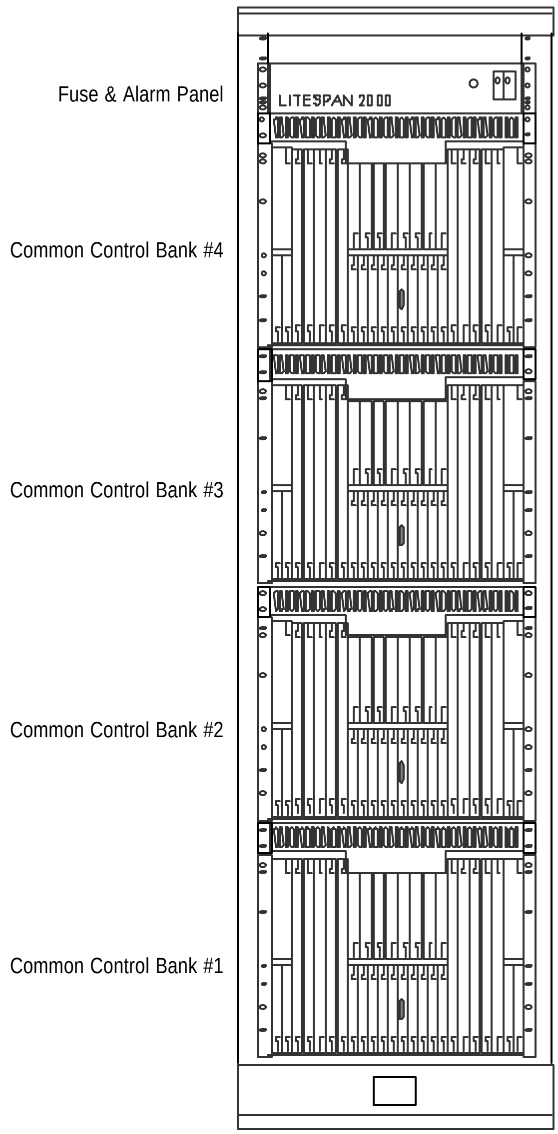
[32] RHK, Inc., *Access Network Systems: Market Forecast*, February 29, 2000, p. 1-28 , and RHK, Inc., *Optical Access: North America: Market Forecast: 2001-2005 BB-DLC* [Broadband-DLC], December 2001, pg. 23

High Density GR-303 DLC			
Central Office Terminal Common Equipment		Central Office Terminal Labor	
SONET Firmware	$7,000	Engineering	$720 (12.0 hrs.)
SONET Transceivers	$2,200	Place Frames & Racks	$180 (3.0 hrs.)
Multiplexer Commons	$5,600	Splice DSX Metallic Cable	$60 (1.0 hr.)
Time Slot Interchanger	$2,200	Place DSX Cross Connections	$30 (0.5 hrs.)
DS-1 Shelf Commons	$500	Connect Alarms, CO Timing & Power	$60 (1.0 hr.)
DSX-1 & Cabling	$800	Place Common Plug Ins (21 ea.)	$30 (0.5 hrs.)
		Turn Up & Test System	$180 (3.0 hrs.)
Subtotal	$18,300	Subtotal	$1,260
Remote Terminal Common Equipment		Remote Terminal Labor	
Cabinet	$27,500	Engineering	$1,920 (32.0 hrs.)
SONET Transceivers	$2,200	Place Cabinet	$240 (4.0 hrs.)
Multiplexer Commons	$5,600	Copper Splicing (2 hrs. + 672 pairs @ 400/hr.)	$240 (4.0 hrs.)
Time Slot Interchanger	$2,200	Place Batteries & Turn Up Power	$120 (2 hrs.)
Channel Bank Assemblies	$4,000	Place Common Plug Ins (21 ea.)	$30 (0.5 hrs.)
Channel Bank Assembly Commons	$2,500	Turn Up & Test System	$180 (3.0 hrs.)
Subtotal	$44,000	Subtotal	$2,730
Total = $66,290			

A central office bay normally serves multiple remote terminal sites. The drawing below shows a typical central office DLC equipment bay layout containing four Common Control Bank Assembly Units. Although a single Common Control Bank Assembly Unit may serve multiple Remote Terminals, we have chosen a conservative approach of having one Common Control Bank Assembly Unit per Large DLC Remote Terminal that can serve up to 2,016 POTS lines.

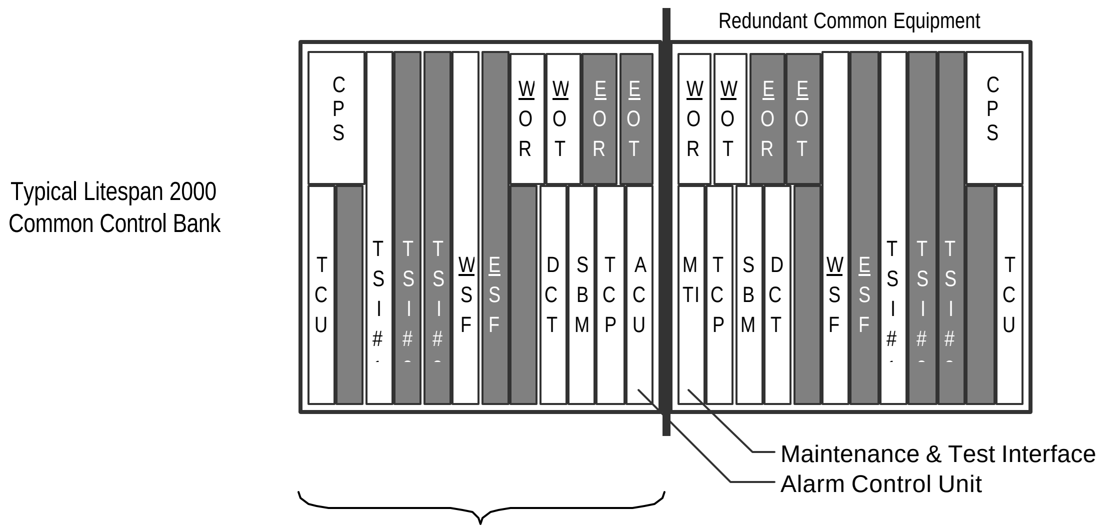
DLC Costs
Litespan 2000 Central Office Terminals

COMMON CONTROL BANKS THAT HOST REMOTE TERMINALS

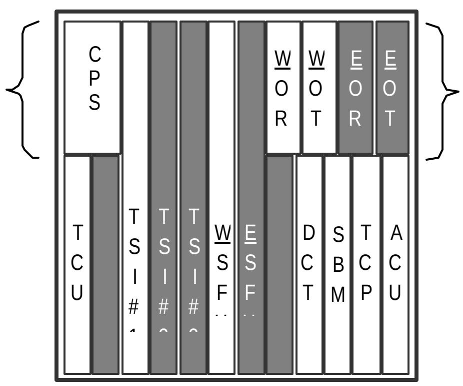


The following diagram shows appropriate equipment cards contained within a central office terminal, and how manufacturers price them as equipment packages.

Litespan 2000 Central Office Terminal
Common Control Bank with Full Redundancy
(except for ACU & MTI)



Common Support Group
CPS = Common Control Power Supply
ACU = Alarm Control Unit
MTI = Maintenance & Test Interface

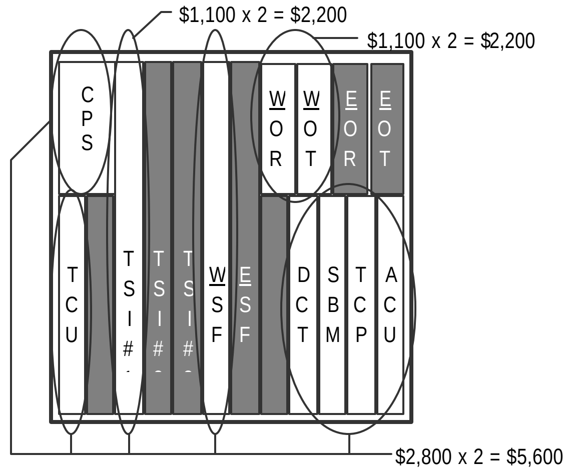


Common Optical Group
ORU = Optical Receiver Unit
OTU = Optical Transmitter Unit
W = West SONET direction
E = Optional East SONET direction
(for bi-directional rings – not modeled)

One Half of Common Control Bank

Common Equipment Group
TCU = Timing Control Unit
TSI #1 = Time Slot Interchanger (OC-1 #1: Initial 672 lines)
(W)SFU = (West direction) SONET Formatter Unit
Optional
TSI #2 = Time Slot Interchanger (OC-1 #2: Incremental Investment for 1344 lines)
TSI #3 = Time Slot Interchanger (OC1 #3): Incremental Investment for 2016 lines)
(E)SFU = (East direction) Optional SONET Formatter Unit (for bi-directional rings – not modeled)

Prices for this type of equipment are usually based on sets of cards. The diagram and information that follows is sufficient to support an initial increment of up to 672 lines.



Litespan 2000 Common Control Bank Pricing

Common Control Bank [Fiber Optics Multiplexer] Pricing				
Item	Description	Quantity	Cost	Total Cost
ORU + OTU	SONET Transceivers (Receive + Transmit)	2 pr.	$1,100	$2,200
TSI	Time Slot Interchange (1 per 672 Lines)	2 ea.	$1,100	$2,200
2 ea. SFU 2 ea. TCU 2 ea. TCP 2 ea. SBM 2 ea. DCT 2 ea. CPS 1 ea. ACU 1 ea. MTI	2 ea. SONET [Ring] Formatter Unit 2 ea. Timing Control Unit 2 ea. Terminal Control Processor 2 ea. System Backup Memory 2 ea. Datalink Controller & Tone Generator 2 ea. Common Control Power Supply 1 ea. Alarm Control Unit 1 ea. Maintenance & Test Interface	1 set	$5,600	$5,600
			Total	$10,000

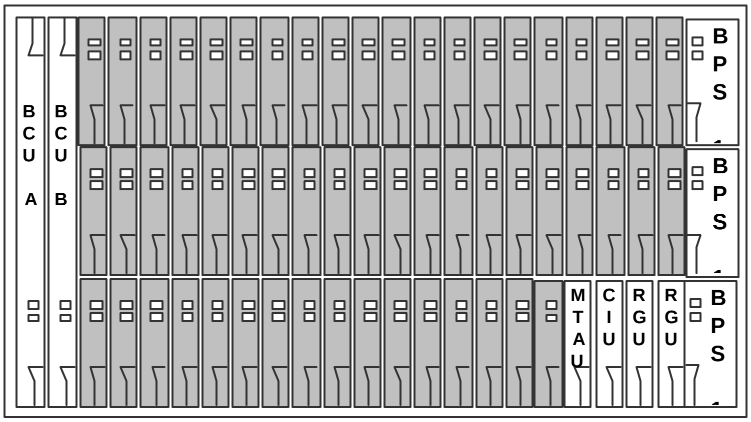
Central Office DLC Equipment				
Item	Description	Quantity	Cost	Total Cost
Matl	Common Control Bank	1 shelf	$10,000	$10,000
Matl	SONET Firmware (rack & multiplexer shelf)	1 shelf	$7,000	$7,000
Matl	Channel Bank Assembly w/ BCUs & BPSs	1 set	$500	$500
Matl	Digital Cross Connection Frame & Cabling	1 shelf	$800	$800
Matl	Fiber Splice Panel	1 shelf	$200	$200
Labor	Engineering hours	12.0 hrs	$60	$720
Labor	Place Frames & Racks	3.0 hrs.	$60	$180
Labor	Connect Alarms, CO Timing & Power	1.0 hr.	$60	$60
Labor	Splice DSX Metallic Cable	1.0 hr.	$60	$60
Labor	Place DSX Cross Connections	0.5 hr.	$60	$30
Labor	Place Common Cards	0.5 hr.	$60	$30
Labor	Place Fiber Splice Panel & Splice Fibers	5.0 hrs.	$60	$300
Labor	Turn Up & Test System	3.0 hrs.	$60	$180
			Total	$20,060

Most of the same common equipment required in the central office is required in the field Remote Terminal. In addition, channel banks are needed at the RT to convert the digital signals to analog signals that can be routed to a SAI and out into the copper distribution cable network. The diagram and information that follows is sufficient to support an initial increment of up to 672 lines.

Litespan 2000 Remote Terminal

Channel Bank Assembly & Channel Bank Common Cards

Channel Bank Assembly with 56 Card Slots



Channel Bank Commons ***$833***
BCU = Bank Control Unit
BPS = Bank Power Supply
MTAU = Metallic Test Unit
RGU = Ringing Generator Unit
CIU = Communications Interface

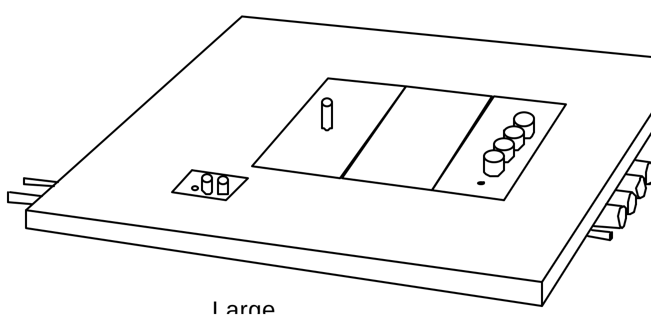
Remote Terminal DLC Equipment				
Item	Description	Quantity	Cost	Total Cost
Matl	Common Control Bank (same as C.O.)	1 shelf	$10,000	$10,000
Matl	Cabinet / Housing, equipped at factory	1 ea.	$27,500	$27,500
Matl	Channel Bank Assembly	3 shelves	$1,333	$4,000
Matl	Channel Bank Commons	3 sets	$833	$2,500
Matl	Power Pedestal	1 set	$500	$500
Matl	Fiber Splice Panel	1 shelf	$200	$200
Labor	Engineering	32 hrs.	$60	$1,920
Labor	Construct Pad & Site	1 site	$2,000	$2,000
Labor	Place Power Pedestal & Hook Up Power	1 site	$500	$500
Labor	Place Cabinet	4.0 hrs.	$60	$240
Labor	Install Batteries & Turn Up Power	2.0 hrs.	$60	$120
Labor	Place Fiber Patch Panel & Splice Fibers	5.0 hrs.	$60	$300
Labor	Copper Splicing	4.0 hrs.	$60	$240
Labor	Install Common Cards	0.5 hrs.	$60	$30
Labor	Turn Up & Test System	3.0 hrs.	$60	$180
			Total	$50,230

In the central office, incremental additions to increase a 672 line system to a capacity of 1,344 lines, or then again to 2,016 lines would require additional DSX-1 cross connect terminations, cabling, engineering labor, and installation labor in the central office to bring additional DS-1s to the switch. Most of the incremental investment required for this type of capacity expansion is in the Remote Terminal for a larger capacity cabinet, an additional Time Slot Interchanger, a Channel Bank Assembly, Channel Bank Assembly Commons, additional engineering, and additional installation labor. Each 672-line capacity increment requires costs detailed 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	$60 (1.0 hr.)
		Place DSX Cross Connections	$30 (0.5 hrs.)
		Turn Up & Test System	$120 (2.0 hrs.)
Subtotal	$800	Subtotal	$210
Remote Terminal Common Equipment		Remote Terminal Labor	
Cabinet	$7,300	Copper Splicing (2 hrs. + 672 pairs @ 400/hr.)	$120 (2.0 hrs.)
Time Slot Interchanger	$3,500	Turn Up & Test System	$120 (2.0 hrs.)
Channel Bank Assemblies	$4,000		
Channel Bank Assembly Commons	$2,500		
Subtotal	$17,300	Subtotal	$240
Total = $18,550			

Common equipment investment inputs do not include the cost of line cards since the study separately includes line cards that provide the capacity for four POTS lines per card. HM 5.3 includes a cost input of $192 per installed line card ($48/line). If a large 672-line DLC system is loaded up to its full capacity, it requires 168 4-line plug-in cards at a cost of $192 each. That is an additional investment of $52,080 added to the recommended common equipment cost of $66,000 plus a fiber optic patch panels at $1,000 plus site preparation of $3,000, or a total of $122,080 for a fully loaded 672-line RT.

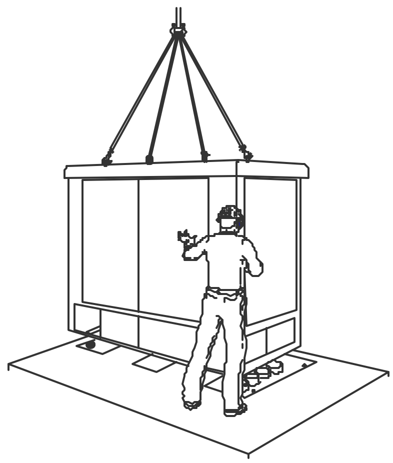
The concrete site pad for a large DLC above-ground Remote Terminal is not at all complicated. The largest 2,016-line DLC remote terminal site amounts to little more than a 15-foot by 19-foot concrete “patio” slab. This is a basic diagram of such a site.



The Remote Terminal equipment installation procedure is not at all difficult. This equipment is most efficiently assembled and tested in the factory by the manufacturer. This improves quality control, and avoids costly on-site assembly by highly paid technicians who should be utilized for tasks better suited to their skills. The information below includes excerpts from typical practices.

Litespan 2000 Remote Terminal Cabinet Installation

Installation of a large DLC Remote Terminal is greatly simplified because the cabinet and its components are preassembled and tested at the factory. In fact, DSC, now Alcatel, states in its documentation,



"The Litespan ... cabinet is a fully self-contained remote terminal (RT) containing Litespan-2000 channel banks and auxiliary equipment to support up to 672 POTS lines, or up to 50 DS1 or T1 lines and an additional 472 POTS lines. It is completely assembled and tested at the factory. Once the equipment is on site and bolted to its mounting pad, the only assembly required consists of connecting local power, connecting drop facilities, connecting optical fiber facilities, installing the back-up batteries, and plugging the circuit packs into their assigned locations in the racks."

"The cabinet is prewired at the factory for DC bulk power distribution, environmental alarm reporting, temperature control, and lightning protection. Ringing power is provided by Ring Generator Units (RGUs) installed in the Litespan channel banks [as opposed to a bulk ringing generator unit]. The cabinet is also provisioned for emergency battery backup and has connections for remote testing facilities."

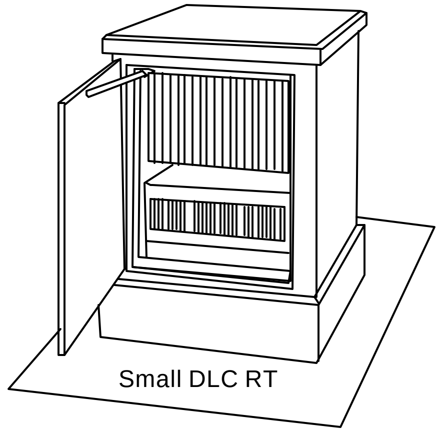
The following information is appropriate for a small 24-line and 120-line Integrated DLC ("IDLC") system without line cards. In the case of low density GR-303 IDLC systems, it is important to note that one central office Host Digital Terminal ("HDT") provides services for a number of small Remote Terminals. This is appropriate engineering design of such systems. The major difference between the 120-line DLC system and the 24-line system is that the 24-line system unit cost includes a pedestal for buried placement, or a pole mounting bracket and hookup to electric power.

Common Equipment Investment for 120-line DLC Equipment			
Central Office Terminal Common Equipment		Central Office Terminal Labor	
SONET Firmware	$3,000	Engineering	$720 (12.0 hrs.)
SONET Transceivers*	See Below*	Place Frames & Racks	$180 (3.0 hrs.)
Common COT Plug Ins	$1,200	Splice DSX Metallic Cable	$60 (1.0 hr.)
DSX-1 & Cabling	$800	Place DSX Cross Connections	$30 (0.5 hrs.)
		Connect Alarms, CO Timing & Power	$60 (1.0 hr.)
		Place Common Plug Ins (21 ea.)	$30 (0.5 hrs.)
		Turn Up & Test System	$180 (3.0 hrs.)
Subtotal	$5,000	Subtotal	$1,260
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	$1,080 (18.0 hrs.)
SONET Transceivers	$2,000	Place Cabinet	$240 (4.0 hrs.)
Multiplexer and Channel Bank Assembly Commons	$3,500	Copper Splicing (2 hrs. + 120 pairs @ 400/hr.)	$138 (2.3 hrs.)
		Place Batteries & Turn Up Power	$60 (1 hr.)
		Turn Up & Test System	$180 (3.0 hrs.)
Subtotal	$11,000	Subtotal	$1,698
Total = $16,198			

Common Equipment Investment for 24-line DLC Equipment			
Central Office Terminal Common Equipment		Central Office Terminal Labor	
SONET Firmware	$3,000	Engineering	$720 (12.0 hrs.)
SONET Transceivers*	See Below*	Place Frames & Racks	$180 (3.0 hrs.)
Common COT Plug Ins	$1,200	Splice DSX Metallic Cable	$60 (1.0 hr.)
DSX-1 & Cabling	$800	Place DSX Cross Connections	$30 (0.5 hrs.)
		Connect Alarms, CO Timing & Power	$60 (1.0 hr.)
		Place Common Plug Ins (21 ea.)	$30 (0.5 hrs.)
		Turn Up & Test System	$180 (3.0 hrs.)
Subtotal	$5,000	Subtotal	$1,260
Allocation of COT Host Digital Terminal Investment per 24-line 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 24-line 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	$300 (5.0 hrs.)
SONET Transceivers	$2,000	Place Cabinet	$120 (2.0 hrs.)
Multiplexer and Channel Bank Assembly Commons	$3,500	Copper Splicing (2 hrs. + 120 pairs @ 400/hr.)	$60 (1 hr.)
		Place Batteries & Turn Up Power	$60 (1 hr.)
		Turn Up & Test System	$60 (1 hr.)
Subtotal	$11,000	Subtotal	$600
Total = $15,100			

The site preparation for a small DLC cabinet is extremely simple. Whereas the Alcatel Litespan 2000 IDLC system as typical of a cost effective large system, a popular small system, manufactured by Advanced Fibre Communications ("AFC") was used for the small IDLC model. This small cabinet is provided, as the manufacturer states, in "Pad, pole, H-frame, or wall mounting options."[33] Such a system has a very small footprint, or can even be mounted on a short "stub pole." The study relies upon a site preparation cost of $1,300 in addition to the $16,000 in common costs, $1,000 for fiber patch panels, and whatever number of line cards is needed to meet capacity at $288 per card.

[33] See AFC's website at http://www.fibre.com



Controlled Environmental Vaults ("CEVs")

CEVs" are used to house large concentrations of Digital Loop Carrier equipment in a below-ground watertight structure. A CEV consists of a bottom half and a top half. The bottom half contains telecommunications equipment that is preinstalled and tested in a factory environment. Disadvantages include the very high cost of the structure that precludes their use for small concentrations of subscriber lines. Advantages include the ability to reap the benefits of economies of concentrating a large number of loop services for transport back to the central office on fiber feeder cable, and the relatively unobtrusive above-ground hatch that belies the large amount of equipment maintained below the surface. The two sizes of CEV normally deployed are a 6-foot by 16-foot CEV that can house approximately 4,032 POTS lines, and a 10-foot by 24-foot CEV that can house up to 8,064 POTS lines.[34]. CEVs are generally deployed where a requirement exists for more than 2,016 lines. HM 5.3 utilizes above-ground closures for DLC equipment in increments of 24, 120, 240, 672, 1,344, and 2,016 lines. HM 5.3 utilizes 6-foot by 16-foot CEVs in 672-line increments up to 4,032 lines (2,688, 3,360, and 4,032 lines); 10-foot by 24-foot CEVs are used in 672-line increments up to 8,064 lines (4,704, 5,376, 6,048, 6,720, 7,392, and 8,064 lines).
A variety of sources were consulted, including personal experience of members of the engineering team, as well as costs obtained from ILECs, in estimating appropriate default values for CEV structure and equipment costs. The following breakdown of costs has been deemed reasonable by engineering experts. It is very important to note that very little telephone company labor is involved in the installation of a CEV and its equipment. This type of facility comes prepackaged and tested from the factory. It has already been assembled and has been working under test in the factory. Once a crane lowers the bottom segment into the pit, and cables are run into the vault and hooked up, the facility can be turned up and tested for immediate service. Because CEVs are pre-engineered and pre-packaged, Engineer, Furnish & Install ("EF&I") costs include some engineering, but primarily consist of site acquisition, coordination, permits, and contract excavation, placing and restoration costs.

[34] Line sizes continue to increase as equipment becomes more compact.

6-ft. X 16-ft. Controlled Environmental Vault – CEV – Costs				
Component	**# Lines**	**2688**	**3360**	**4032**
Protector Frames (per 100 lines)	$900	$24,300	$30,600	$36,900
Protectors (per line)	$2.00	$5,400	$6,800	$8,200
Component	**# CBAs**	**12**	**15**	**18**
Channel Bank Assembly Pkg (per 224 DS-0s)	$1,333	$16,000	$20,000	$24,000
Component	**#DS3s**	**4**	**5**	**6**
Support Frames (per 672 DS-0s)	$300	$1,200	$1,500	$1,800
Time Slot Interchangers (per 672 DS-0s)	$1,750	$7,000	$8,750	$10,500
Component	**# OC3s**	**2**	**2**	**2**
CCA Getting Started Pkg (per OC3)	$6,000	$12,000	$12,000	$12,000
Component	**# Bays**	**4**	**5**	**5**
Bay Equipment Pkg (per 4 position Bay)	$6,200	$24,800	$31,000	$31,000
Component	**# Batt Strings**	**6**	**7**	**8**
Batteries (per 48 volt string)	$1,000	$6,000	$7,000	$8,000
CEV Structure				
Enclosure-Matl	$40,000	$40,000	$40,000	$40,000
Fiber Termination Shelf	$1,000	$1,000	$1,000	$1,000
Ladder Rack Kit	$500	$500	$500	$500
Span Termination Equipment	$300	$300	$300	$300
RT Power Bay	$9,300	$9,300	$9,300	$9,300
DC Power Distribution Panel	$350	$350	$350	$350
TOTAL	**# Lines**	**2688**	**3360**	**4032**
	Material	**$148,150**	**$169,100**	**$183,850**
	EF&I	**$15,000**	**$15,000**	**$15,000**
	Total	**$163,150**	**$184,100**	**$198,850**

10-ft. X 24-ft. Controlled Environmental Vault – CEV – Costs							
Component	**# Lines**	**4704**	**5376**	**6048**	**6720**	**7392**	**8064**
Protector Frames (per 100 lines)	$900	$43,200	$48,600	$54,900	$61,200	$66,600	$72,900
Protectors (per line)	$2.00	$9,600	$10,800	$12,200	$13,600	$14,800	$16,200
Component	**# CBAs**	**21**	**24**	**27**	**30**	**33**	**36**
CBA Pkg (per 224 DS-0s)	$1,333	$28,000	$32,000	$36,000	$40,000	$44,000	$48,000
Component	**#DS3s**	**7**	**8**	**9**	**10**	**11**	**12**
Support Frames (per 672 DS-0s)	$300	$2,100	$2,400	$2,700	$3,000	$3,300	$3,600
Time Slot Interchangers (per 672 DS-0s)	$1,750	$12,250	$14,000	$15,750	$17,500	$19,250	$21,000
Component	**# OC3s**	**3**	**3**	**3**	**4**	**4**	**4**
CCA Getting Started Pkg (per OC3)	$6,000	$18,000	$18,000	$18,000	$24,000	$24,000	$24,000
Component	**# Bays**	**6**	**7**	**8**	**9**	**10**	**10**
Bay Equipment Pkg (per 4 position Bay)	$6,200	$37,200	$43,400	$49,600	$55,800	$62,000	$62,000
Component	**# Batt Strings**	**9**	**10**	**11**	**12**	**13**	**14**
Batteries (per 48 volt string)	$1,000	$9,000	$10,000	$11,000	$12,000	$13,000	$14,000
CEV Structure							
Enclosure-Matl		$60,000	$60,000	$60,000	$60,000	$60,000	$60,000
Fiber Termination Shelf	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000
Ladder Rack Kit	$500	$500	$500	$500	$500	$500	$500
Span Termination Equipment	$300	$300	$300	$300	$300	$300	$300
RT Power Bay	$9,300	$9,300	$9,300	$9,300	$9,300	$9,300	$9,300
DC Power Distribution Panel	$350	$350	$350	$350	$350	$350	$350
TOTAL	**# Lines**	**4704**	**5376**	**6048**	**6720**	**7392**	**8064**
	Material	**$230,800**	**$250,650**	**$271,600**	**$298,550**	**$318,400**	**$333,150**
	EF&I	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**	**$20,000**
	Total	**$250,800**	**$270,650**	**$291,600**	**$318,550**	**$338,400**	**$353,150**

4.4.3. DLC Fiber Strands Required

Definition: The number of strands of fiber required to serve the DLC Remote Terminal, specified in each of the line size ranges identified in Section 4.4.1.,

Default Values:

DLC Fiber Strands Required	
Maximum Line Size	**Fiber Strands Required**
24	2
120	4
240	4
672	4
1,344	4
2,016	4
2,688	8
3,360	8
4,032	8
4,704	12
5,376	12
6,048	12
6,720	16
7,392	16
8,064	16

Support: The number of fiber strands required is based on manufacturers' documentation. The AFC 24-line DLC system permits operating that unit with a single bidirectional fiber, or optionally allows protection by using wave division multiplexing on two fibers. Other DLC systems traditionally use one transmit fiber, one redundant transmit fiber, one receive fiber, and one redundant receive fiber for each OC-3 multiplexer (each increment of 2,016 lines is conservatively engineered to require 4 fibers each, even though concentration, higher speed multiplexers, and wave division multiplexing could be used to reduce fiber strand requirements).

4.4.4. DLC POTS Channel Unit Density and Investment

Definition: The number of POTS lines that can be served by a single DLC POTS line card, and the investment associated with that line card, specified in each of the line size ranges defined in Section 4.4.1

Default Values:

DLC POTS Channel Unit Density and Investment		
Maximum Line Size	**POTS Lines per Card**	**Investment**
24	6	$288.00
120	6	$288.00
240	6	$288.00
672	4	$192.00
1,344	4	$192.00
2,016	4	$192.00
2,688	4	$192.00
3,360	4	$192.00
4,032	4	$192.00
4,704	4	$192.00
5,376	4	$192.00
6,048	4	$192.00
6,720	4	$192.00
7,392	4	$192.00
8,064	4	$192.00

Support: The lines served for the low density DLC card and the high density DLC line card are based on vendor documentation. The cost of individual POTS Channel Unit Cards is based on a market research report by RHK, Inc., a well respected telecommunications market research company often quoted in publications such as the Wall Street Journal. In their most recent report, *Optical Access: North America, Market Forecast: 2001 – 2005 BB-DLC* [Broadband-DLC], December 2001. In that report, RHK identifies a continuing downward trend of 4% per year price reductions in DLC POTS line cards. It's projection for year 2003 is $48 per line served. This value was reviewed by engineering consultants, and found to be reasonable (although somewhat high for an ILEC with mass purchasing power). The value of $48 per line was used to determine the costs in the above table ($48 x 6 = $288 and $48 x 4 = $192).

4.4.5. DLC POTS Range Extension Threshold and Incremental Investment

Definition: The distribution distance threshold above which more expensive line cards are required to provide a sufficient signal at customers' premises, and the investment required to provide such range extension, specified in each of the line size ranges identified in Section 4.4.1.

Default Values:

DLC POTS Range Extension Threshold & Line Card Investment		
Maximum Line Size	Extended Range Distance (ft.)	Investment
24	16,000	$432.00
120	16,000	$432.00
240	16,000	$432.00
672	16,000	$288.00
1,344	16,000	$288.00
2,016	16,000	$288.00
2,688	16,000	$288.00
3,360	16,000	$288.00
4,032	16,000	$288.00
4,704	16,000	$288.00
5,376	16,000	$288.00
6,048	16,000	$288.00
6,720	16,000	$288.00
7,392	16,000	$288.00
8,064	16,000	$288.00

Support: The distance limit for Regular POTS ("RPOTS) line cards is based on vendor documentation. Cost per card is based on the assumption that such a card cost is 150% the cost of a Regular POTS card, which is deemed to be reasonable by consultations with engineering consultants and observation of ILEC line card costs in a number of states.

4.5 DLC INPUTS II

4.5.1. DLC Coin Channel Unit Density and Investment

Definition: The number of coin loops that can be served by a single DLC coin line card, and the investment associated with that line card, specified in each of the line size ranges defined in Section 4.4.1

Default Values:

DLC Coin Channel Unit Density and Investment		
Maximum Line Size	**Lines per Card**	**Investment**
24	6	$360.00
120	6	$360.00
240	6	$360.00
672	4	$240.00
1,344	4	$240.00
2,016	4	$240.00
2,688	4	$240.00
3,360	4	$240.00
4,032	4	$240.00
4,704	4	$240.00
5,376	4	$240.00
6,048	4	$240.00
6,720	4	$240.00
7,392	4	$240.00
8,064	4	$240.00

Support: The number of lines served per DLC Coin Channel Unit card is based on vendor documentation. Cost per card is based on the assumption that such a card cost is 125% the cost of a Regular POTS card, which is deemed to be reasonable by consultations with engineering consultants and observation of ILEC line card costs in a number of states.

4.5.2. DLC DS-1 Channel Unit Density and Investment

Definition: The number of DS-1lines that can be served by a single DLC DS-1 line card, and the investment associated with that line card, specified in each of the line size ranges defined in Section 4.4.1

Default Value:

DLC DS-1 Channel Unit Density & Investment		
Maximum Line Size	**Lines per Card**	**Investment**
24	1	$760.00
120	1	$760.00
240	1	$760.00
672	1	$760.00
1,344	1	$760.00
2,016	1	$760.00
2,688	1	$760.00
3,360	1	$760.00
4,032	1	$760.00
4,704	1	$760.00
5,376	1	$760.00
6,048	1	$760.00
6,720	1	$760.00
7,392	1	$760.00
8,064	1	$760.00

Support: The number of lines served per DLC DS-1 Channel Unit card is based on vendor documentation. Cost per card is based on the expert opinion of engineering consultants and observation of ILEC line card costs in a number of states. The value in the table represents the cost for two DS-1 Channel Unit cards – one at the Central Office Terminal ("COT") and one at the Remote Terminal ("RT").

4.5.3. DLC Line Card Investment Increase for ADSL functions [35]

Definition: The incremental investment per ADSL line that must be added to a DLC POTS line card to support ADSL functions, specified in each of the line size ranges identified in Section 4.1.1.

[35] Costs associated with ADSL are currently performed in an xDSL adjunct model, not in HM 5.3, so these fields are not used.

Default Values:

DLC Line Card Investment Increase for ADSL	
Maximum Line Size	**Increased Investment**
24	$48.00
120	$48.00
240	$48.00
672	$48.00
1,344	$48.00
2,016	$48.00
2,688	$48.00
3,360	$48.00
4,032	$48.00
4,704	$48.00
5,376	$48.00
6,048	$48.00
6,720	$48.00
7,392	$48.00
8,064	$48.00

Support: The increased cost per card over the cost of a POTS line card is based on the expert opinion of engineering consultants, and consultations with xDSL providers such as Covad and Rhythms and observation of ILEC line card costs in a number of states. The value in the table represents the increased cost for one ADSL Channel Unit card at the Remote Terminal ("RT").

4.5.4. DLC ISDN Line Card Density and Investment

Definition: The number of ISDNlines that can be served by a single DLC ISDN line card, and the investment associated with that line card, specified in each of the line size ranges defined in Section 4.4.1
Default Values:

DLC ISDN Line Card Density & Investment		
Maximum Line Size	**Lines per Card**	**Investment**
24	6	$360.00
120	6	$360.00
240	6	$360.00
672	4	$240.00
1,344	4	$240.00
2,016	4	$240.00
2,688	4	$240.00
3,360	4	$240.00
4,032	4	$240.00
4,704	4	$240.00
5,376	4	$240.00
6,048	4	$240.00
6,720	4	$240.00
7,392	4	$240.00
8,064	4	$240.00

Support: The number of lines served per DLC ISDN Channel Unit card is based on vendor documentation. Cost per card is based on the assumption that such a card cost is 125% the cost of a Regular POTS card, which is deemed to be reasonable by consultations with engineering consultants and observation of ILEC line card costs in a number of states.

4.6 DLC MISCELLANEOUS INPUTS

4.6.1. Copper Feeder Maximum Distance

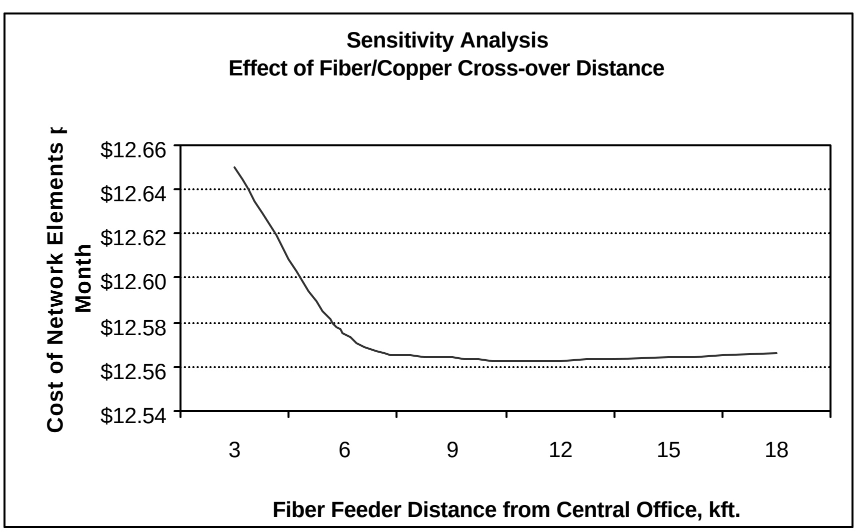
Definition: The feeder length above which fiber feeder cable is used in lieu of copper cable. The value must be less than Maximum Analog Copper Distance.

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 5.3 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 5.3 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.



4.6.2 Maximum Outlier Terminals in Cascade

Definition: The maximum number of DLC remote terminals that can be connected serially in a chain of outlier clusters.

Default Value: 5

Support: Based on manufacturer's specification for the 24-line DLC assumed by the model to serve outlier clusters.

4.6.3. DLC Channel Unit 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 Value: 0.9

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 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.

4.7. UDLC INPUTS

4.7.1. UDLC Fraction of Total DLC Lines

Definition: The incremental cost of adding central office Channel Bank Assemblies ("CBAs") if some percentage of loops are determined to require the provision of services over a Universal Digital Loop Carrier ("UDLC") system, rather than using a more efficient and higher quality Integrated Digital Loop Carrier ("IDLC") system.

Default Value:

UDLC Fraction of Total DLC Lines
0.00

Support:
It is more economical to serve longer loops on fiber fed DLC than on copper. There are two methods of designing DLC systems: Integrated Digital Loop Carrier ("IDLC") and Universal Digital Loop Carrier ("IDLC"). IDLC is more efficient and provides higher quality service because an analog copper loop is converted to a digital format at the DLC Remote Terminal, and the signal remains high quality digital throughout its path. UDLC is less efficient and of lower quality because it requires central office equipment

at the DLC Central Office Terminal to convert the digital signals back to analog copper-based signals. Once so converted, the signal transits a tie cable to the Main Distribution Frame ("MDF") where it is terminated. A CLEC desiring access to such a loop must then arrange for a new cross connection at the MDF, a tie cable from the MDF to its collocation arrangement, and the CLEC must install DLC equipment to re-multiplex the analog signal to a digital format before transporting it over the CLEC network.
The default value is zero percent UDLC. However, if a user wishes to allocate a percentage of loops to UDLC technology, then this fraction allows HM 5.3 to compute the appropriate costs. UDLC should never be assumed for costs associated with UNE-P arrangements.

4.7.2. Additional UDLC CO Channel Bank Assembly Investment

Definition: The incremental cost of adding central office Channel Bank Assemblies ("CBAs") if some percentage of loops are determined to require the provision of services over a Universal Digital Loop Carrier ("UDLC") system, rather than using a more efficient and higher quality Integrated Digital Loop Carrier ("IDLC") system.

Default Value:

UDLC Inputs	
RT Line Size	Additional CO Channel Bank Assembly Investment
24	$0.00
120	$0.00
240	$0.00
672	$4,000.00
1,344	$8,000.00
2,016	$12,000.00
2,688	$16,000.00
3,360	$20,000.00
4,032	$24,000.00
4,704	$28,000.00
5,376	$32,000.00
6,048	$36,000.00
6,720	$40,000.00
7,392	$44,000.00
8,064	$48,000.00

Support:
It is preferable to serve fiber-fed DLC loops via an IDLC design rather than a UDLC design for the reasons stated in Section 4.7.1. However, should a user wish to include some UDLC costs, then several additional costs would be incurred. Besides a doubling of the channel unit cards, since the COT would now require a channel unit card at each end, there must be sufficient Channel Bank Assembly card slots available to hold those cards, additional cabling and MDF terminations for every derived pair would be required, and the allocation of investment for a DSX-1 card must be backed out.

The 24-line, 120-line, and 240-line LETs (COTs) by AFC provide a sufficient number of spare channel unit slots to accommodate additional channel units required for a UDLC configuration, so no additional CBA cost is required for those line sizes.

For DLC sizes of 672 and larger, modeled on Alcatel Litespan 2000 equipment, additional CBA costs at $1,333.33 per 224 lines ($4,000.00 per 672 lines) is required.

4.7.3. UDLC Reduction for DS-1 COT Interface Card Investment

Definition: The allocation of investment for a DSX-1 card used to bring groups of IDLC lines out of a central office terminal must be backed out for UDLC.

Default Value:

UDLC Inputs	
RT Line Size	Reduction for DS-1 COT Interface Card, per Line
24	-$18.00
120	-$18.00
240	-$18.00
672	-$12.00
1,344	-$12.00
2,016	-$12.00
2,688	-$12.00
3,360	-$12.00
4,032	-$12.00
4,704	-$12.00
5,376	-$12.00
6,048	-$12.00
6,720	-$12.00
7,392	-$12.00
8,064	-$12.00

Support:
An investment is required for DSX-1 cards needed to interface at the DS-1 level with IDLC systems. UDLC does not require this, so an appropriate investment must be backed out. The costs represent a $288.00 DSX-1 COT card, using a concentration ratio of 4:1 operating under GR-303 (which allows a 24-channel DSX-1 card to handle 96 time slots). $288.00 ÷ 96 = $3.00 per line, so that the three smallest DLCs terminating 6 lines per card = $18.00 and the larger DLCs terminating 4 lines per card = $12.00.

4.7.4. Additions for Central Office Cabling and MDF Investment per UDLC Line

Definition: The additional cost of for central office cabling from the UDLC Channel Bank Assemblies to the MDF, and the cost of MDF terminations, per UDLC line.

Default Value:

CO Cabling and MDF Investment per UDLC Line
$12.00

Support:
The incremental investment per line for central office cabling and MDF terminations is based on the expert opinions of the model developers and their consultants.

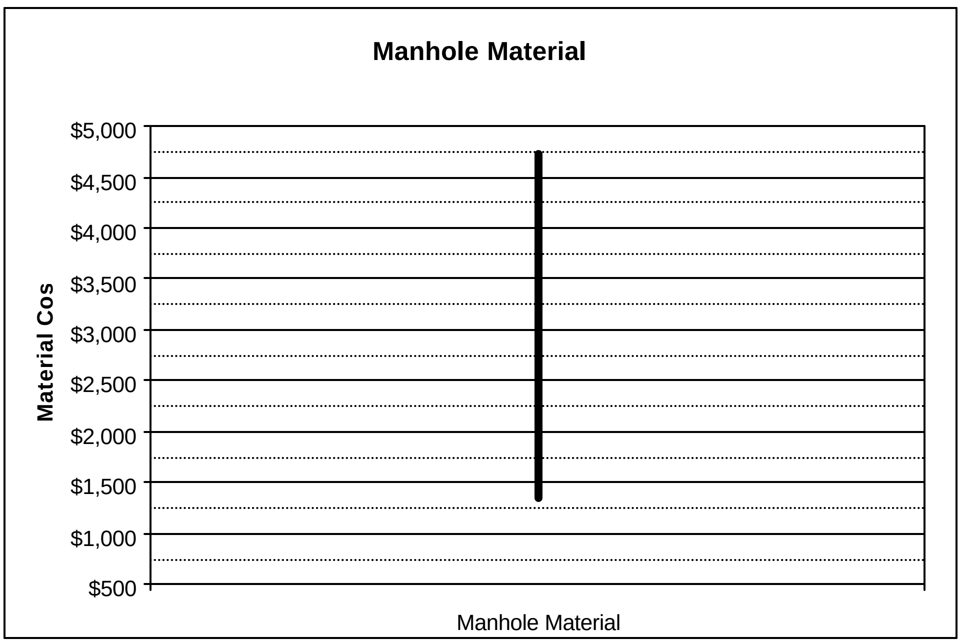
4.8. MANHOLE INVESTMENT – COPPER FEEDER

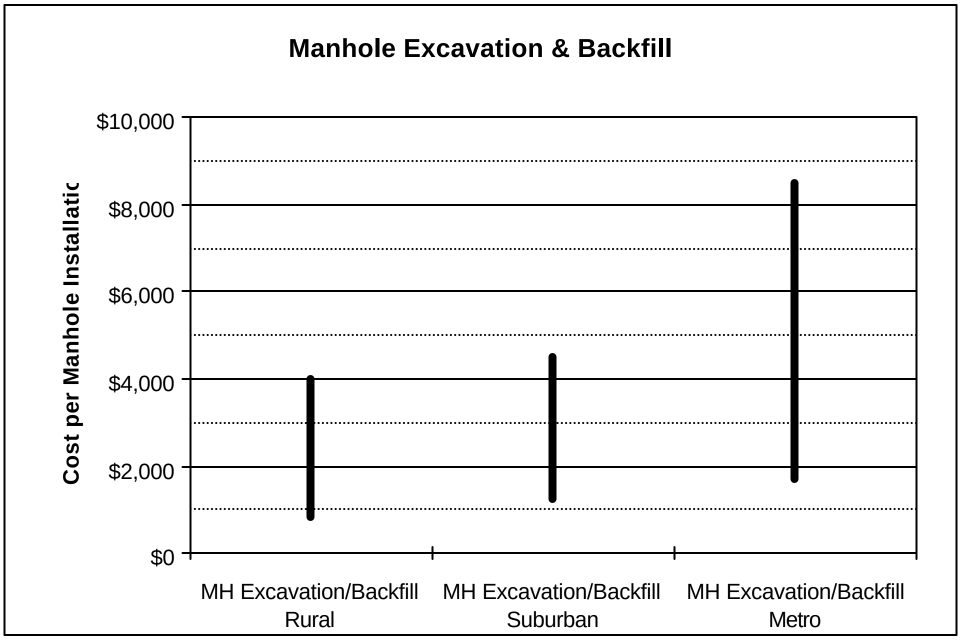
Definition: The installed cost of a prefabricated concrete manhole, including backfill and restoration. All the non-italicized costs in the following table are separately adjustable.

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.





4.8.1. 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.

4.8.2. 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.

4.9. 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 5.3 uses a default value of $500.

5. SWITCHING AND INTEROFFICE TRANSMISSION PARAMETERS

5.1. LOCAL ATM SWITCHING

5.1.1. ATM Switch Investment

Definition: The fixed component of the investment in an ATM switch.

Default Values:

ATM Switch Investment
$25,000

Support: Based on HAI expertise and knowledge of typical ATM switch products being used in conjunction with ADSL today.

5.1.2 ATM Switch Capacity, Gbps

Definition: The maximum capacity of an ATM switch of the size represented by the investment shown in Section 5.1.1.

Default Values:

ATM Switch Capacity, Gbps
2.0

Support: Based on HAI expertise and knowledge of typical ATM switch products being used in conjunction with ADSL today.

5.1.3 ATM Switch Fill Factor

Definition: Maximum ATM switch port utilization.

Default Values:

ATM Switch Fill Factor
0.90

Support: Modeling assumption by HAI Model developers.

5.1.4 ATM Switch Interface Investment

Definition: Additional ATM switch investment per switch interface.

Default Values:

ATM Switch Interface Investment
$14,000

Support: Based on HAI expertise and knowledge of typical ATM switch products being used in conjunction with ADSL today.

5.1.5 ATM Switch Interface Port Rate, Mbps

Definition: The bit rate at which the ATM switch ports operate.

Default Values:

ATM Switch Interface Port Rate, Mbps
44.736 Mbps

Support: The ATM switch ports operate at a bit rate of 44.736 Mbps.

5.1.6 ATM Port Density Per Interface

Definition: The maximum number of ATM switch ports per ATM switch interface.

Default Values:

ATM Port Density Per Interface
4.0

Support: Based on conversations with DLEC technical personnel responsible for ATM network deployment in support of retail ADSL service.

5.1.7 Average ADSL Users per DS-3

Definition: The number of ADSL users that can be supported on a single DS-3 link to the ATM switch

Default Values:

Average ADSL Users per DS-3
1,000

Support: Assumes transmission rate of 384 kbps per subscriber at an oversubscription ratio of 10 (10:1 oversubscription supported by GTE as providing “full throughput to subscribers 95% of the time” in Network World, 3/1/00. See http://www.nwfusion.com/news/1999/0301dsl.html)

5.2. END OFFICE SWITCHING

5.2.1. 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	20,000
1,000-10,000	90,000
10,000-40,000	350,000
40,000+	1,000,000

Support: Based on Nortel product information for their XA Core processor technology and their ENET non-blocking switch fabric for their DMS switch, .

5.2.2. 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.

Default Values:

Lines	Busy Hour CCS
1-1,000	48,000
1,000-10,000	216,000
10,000-40,000	840,000
40,000+	2,400,000

Support: Same as Section 5.1.1.

5.2.3. 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
120,000

Support: This is a conservative assumption based on industry common knowledge and the Lucent Technologies web site.[36] The site states that the 5ESS-2000 can provide service for as many as 250,000 lines.

5.2.4. 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
0.94

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

5.2.5. 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.

Default Value:

Switch Maximum Processor Occupancy
0.90

Support: Telcordia, *LSSGR: Traffic Capacity and Environment*, GR-517-CORE, Issue 1, December 1998, figure 5-1, p 5-4.

5.2.6. 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
$0.00

Support: This input parameter not used in HM 5.3. MDF Investment is included in the calculations for fixed and per-line switch investment.

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

5.2.7. 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
$30.00 per line

Support: The MDF is not required for DLC lines and therefore, at a minimum, an adjustment needs to be made to account for the $12 MDF investment. In addition, the Sayer Declaration[37] states (page 5, para. 11) that a DLC switch port termination is between $8.00 and $28.00 less than an analog line interface, and this does not include the MDF impacts described above. Thus the $30.00 offset is derived as the $12.00 + $18.00 (the midpoint of the $8.00 and $28.00).

5.2.8. Switch Installation Multiplier

Definition: The telephone company investment in switch engineering and installation activities, power, and main distribution frame associated with switching, expressed as a multiplier of the switch investment.

Default Value:

Switch Installation Multiplier
1.00

Support: This input parameter is set to unity in HM 5.3 because the switch installation investment is included in the calculations of fixed and per-line switch investment.

5.2.9. End Office Amalgamated Switching Fixed Investment

Definition: The value of the constant ("A") appearing in the function A + B * L that calculates the total investment in a switch, where L is the line capacity of the switch, and A and B are user-adjustable input values. This function averages the investment function per-line investments over a portfolio of host, remote, and standalone end office switches. Alternatively, if the value of this parameter is set to –999, the Model calculates the switched investment for an amalgamated switch from the inputs for the fixed investments for host and remote switches, weighting them according to the relative percentages of wire centers served by host and remote switches, respectively.

Default Values:

End Office Amalgamated Switching Fixed Investment	
BOC & Large ICO	Small ICO
-999	-999

Support: When HM5.3 is run with the host/remote option turned off, the Model automatically calculates the amalgamated end office switch fixed investment. Queries were added to the Model's database (hm.mdb) to determine the fraction of wire centers in the cluster data table that contain remote switches. After obtaining

[37] Declaration of Nancy Sayer on behalf of Bell Atlantic filed with the FCC "In the Matter of NYNEX Corporation Transferor, and Bell Atlantic Corporation, Transferee, Application for Consent to Transfer Control" Tracking No. 960205, 960221; October 22, 1996.

the list of wire centers represented in the cluster data, the queries consult the LERG host/remote table, also in the database, to compute the remote fraction. A modified master.xls file then writes the remote fraction into the switching and interoffice module.

The default values for the small ICO and large ILEC fixed switching investments (labeled “EO Amalgamated Switching Fixed Investment, small ICO” and “EO Amalgamated Switching Fixed Investment, BOC and large ICO” in the interface form) have been set in the database to –999. The modified switching and interoffice module checks the input value for the fixed investment. If it is negative, the module then uses the remote fraction as a weighting factor to compute the amalgamated fixed investment from the standalone and remote fixed investments for BOCs/large ICOs and small ICOs which are entered via the “Host/Remote Investment” form in the user interface. The default values for these investments are the values determined by the FCC in its Inputs Order for the Synthesis Model.

The user can override the automatic calculation by entering the desired values in the Switching Inputs/End Office Switching input form in the user interface. When the switching and interoffice module “sees” a positive value as written by the interface, it uses that investment value instead of computing the weighted average using the automatically-calculated remote fraction.

The Model also writes the computed remote fraction into cells J212 and K212 in the “User Adjustable Inputs” worksheet contained in the density zone and wire center expense modules.

5.2.10. End Office Amalgamated Switching Per Line Investment

Definition: The value of the constant (“B”) appearing in the function A + B * L that calculates the total investment in a switch, where L is the line capacity of the switch, and A and B are user-adjustable input values. This function averages the investment function per-line investments over a portfolio of host, remote, and standalone end office switches.

Default Value:

EO Switching Investment Slope Term
$87.00

Support: Based on prices adopted by the FCC in the *USF Inputs Order*. Details of the derivation of this formula and its values are provided in the HAI Model Description.

5.2.11. 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 WorldCom subject matter experts.

5.2.12. 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 WorldCom subject matter experts.

5.3. WIRE CENTER

5.3.1. 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.

5.3.2. 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 Telcordia's Local Exchange Routing Guide (LERG) data.

5.3.3. 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	$0
1000	$0
5000	$0
25,000	$0
50,000	$0

Support: This input parameter not used in HM 5.3. Power Investment is included in the calculations for fixed and per-line switch investment.

5.3.4. 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	750
5,000	1,500
25,000	3,000
50,000	4,500

Support: Based on the testimony of John C. Klick in California UNE Relook Proceeding.

5.3.5. 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.

5.3.6. 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.

5.4. TRAFFIC PARAMETERS

5.4.1. 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: 2001 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.

5.4.2. 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: Telcordia, *LSSGR: Traffic Capacity and Environment*, GR-517-CORE, Issue 1, December 1998. This number is a composite of the results shown in table 6-2.

5.4.3. IntraLATA Calls Completed

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

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

Support: 2002 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.

5.4.4. InterLATA Intrastate Calls Completed

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

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

Support: 2002 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.

5.4.5. InterLATA Interstate Calls Completed

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

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

Support: 2002 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.

5.4.6. Local DEMs, Thousands

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

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

Support: 2002 ARMIS report 43-04 and NECA DEM reporting to the FCC.

5.4.7. Intrastate DEMs, Thousands

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

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

Support: 2002 ARMIS report 43-04 and NECA DEM reporting to FCC.

5.4.8. Interstate DEMs, Thousands

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

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

Support: 2002 ARMIS report 43-04 and NECA DEM reporting to FCC.

5.4.9. 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 WorldCom subject matter experts.

5.4.10. 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 WorldCom subject matter experts.

5.4.11. 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 WorldCom subject matter experts.

5.4.12. 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.[38]

5.4.13. 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
264

Support: Based on 22 business days per month. The AT&T Capacity Cost Study uses an annual to daily usage reduction factor of 264 days.[39]

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[38] 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.

[39] 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.

5.4.14. 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.

5.4.15. 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: Telcordia, *LSSGR: Traffic Capacity and Environment*, GR-517-CORE, Issue 1, December, 1998. These numbers are composites of data contained in Tables 6-3 – 6-5.

5.5. INTEROFFICE INVESTMENT

5.5.1. 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 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 ADM, Installed	Investment per 7 DS-1s
48 DS-3s	12 DS-3s	84 DS-1s	7 DS-1s
$130,372	$78,978	$33,764	$1,042

Support: Average across four states' data submitted to the FCC USF Cost Model Inputs Process by BellSouth.[40] The OC-3 multiplexers value is only used for host/remote rings and small offices that do not appear on a ring (*see* Section 5.7.4), because modern switches directly interface to transmission facilities with an OC-3 or DS-3 interface, obviating DS-1 to OC-3 multiplexing.

5.5.2. 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.

5.5.3. 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.

[40] *Ex parte l*etter from W. W. Jordan, Vice President, Federal Regulatory, BellSouth, to Magalie Roman Salas, Secretary, FCC, re CC Docket No. 96-45 and 97-160, August 7, 1998.

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.

5.5.4 Optical Distribution Panel

Definition: The cost of the physical fiber patch panel that allows connection of up to 24 fibers to the transmission equipment.

Default Value:

Optical Distribution Panel
$4,021

Support: BellSouth, *ibid*.. This is the cost for connecting 24 fibers, although most typically the 24 fibers in a cable are not all connected to transmission equipment in a given wire center.

5.5.5. 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
$60 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.

5.5.6. 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.

5.5.7. 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.

5.5.8. 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[41] (with post- and pre-amp).

5.5.9. 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.

[41] 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
$3,415

Support: BellSouth, *ibid*.

5.5.10. 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.

5.5.11. 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
$8,742

Support: BellSouth, *ibid*.

5.5.12. 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.

5.5.13. 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	
Underground	$0.7276
Buried	$0.72
Aerial	$0.72

Support: Based on fiber cable material and labor costs discussed in Sections 2.3 4 andthrough 2.4 6

5.5.14. Number of Strands per ADM

Definition: The number of interoffice fiber strands required around a physical ring to support each logical ring. In the four-fiber bi-directional line switched ring configuration assumed by the model, four strands are required around the ring (the number of terminations on each ADM in each wire center is double this number, or eight)

Default Value:

Number of Strands per ADM
4

Support: This is the standard number of strands required for the assumed ring configuration . It provides for redundant transmission in both directions around the interoffice fiber ring. An ADM on such a ring has eight terminations, four each for transmitting and receiving signals.

5.5.15. 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 - Verizon		
Aerial	Buried	Underground
29%	27%	44%

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.

5.5.16. 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.

5.5.17. Interoffice Conduit, Cost and Number of Tubes

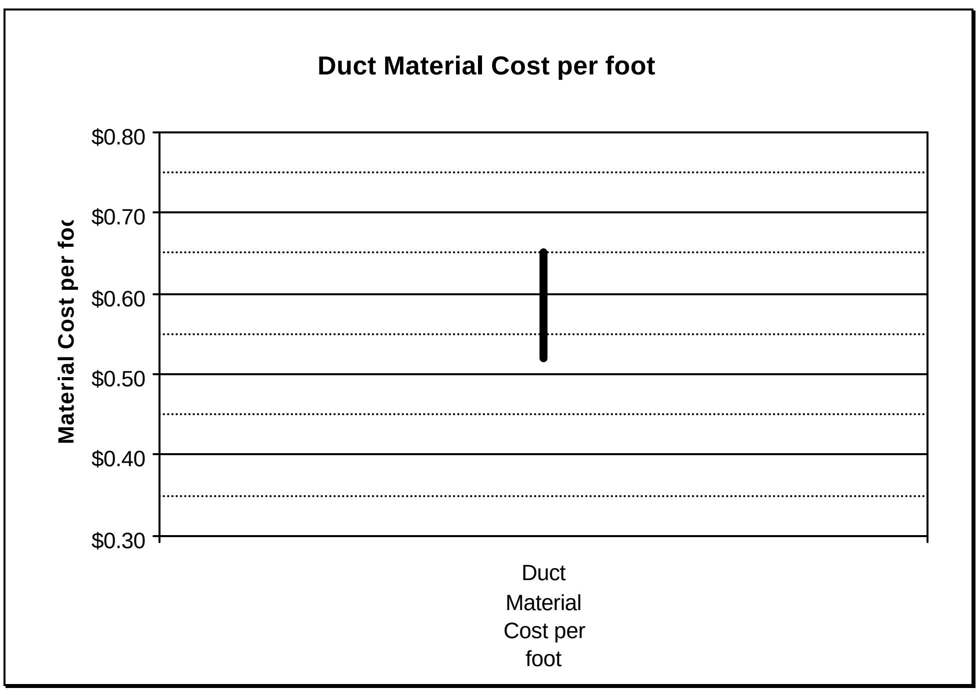
Definition: The cost per foot for interoffice fiber cable conduit, and the number of spare tubes (conduit) placed per route.

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.}***

<u>*Conduit Cost per foot:*</u>
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."[42] Version 5.3 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.

5.5.18. Pullbox Spacing

Definition: Spacing between pullboxes in the interoffice portion of the network.

Default Value:

Pullbox Spacing
2,000 feet

Support: ***{NOTE: The discussion in Section 4.2.2. [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.[43] It is common practice for outside plant engineers to require approximately 2 slack boxes per mile.

5.5.19. 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 4.8. [Feeder Pullbox Investmenr] is reproduced here for ease of use.}***

[42] *Notes on the Network*, p. 12-46.

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

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 5.3 uses a default value of $500.

5.5.20. 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.

5.5.21. Interoffice Pole Material and Labor

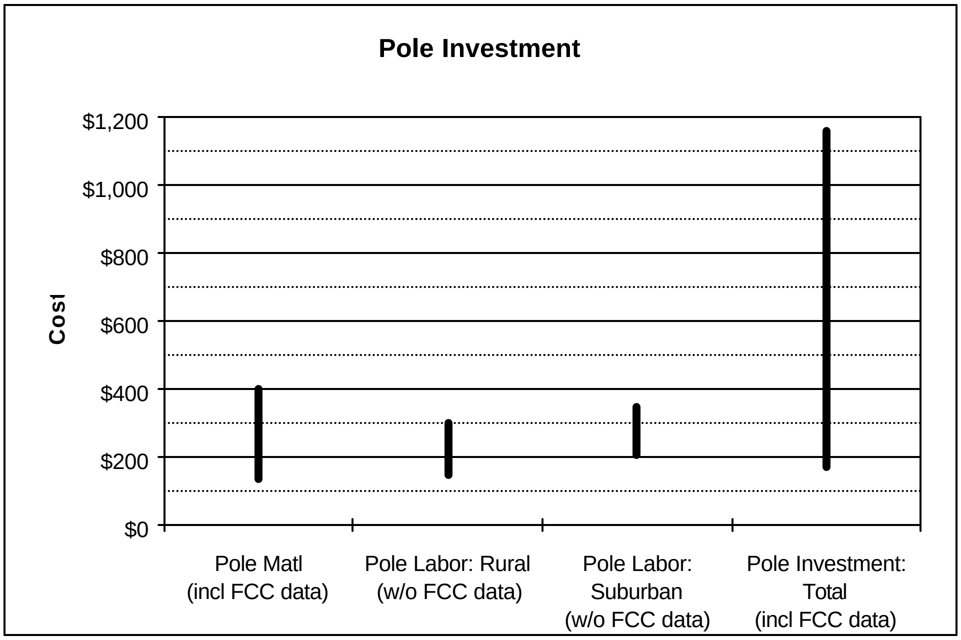
Definition: The installed cost of a 40' Class 4 treated southern pine pole.

Default Values:

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

***Support:* {*NOTE: The discussion in Section 3.4.1. [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.



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.

5.5.22. 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 5.3 to be shared with feeder cables.

5.5.23. 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.

5.6. TRANSMISSION PARAMETERS

5.6.1. 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.

5.6.2. 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.

5.6.3. 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 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.

5.6.4. 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 tandem-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.

5.6.5. 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 tandem-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.

5.7 TRANSMISSION PARAMETERS

5.7.1. 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.[44]

5.7.2. Trunk Port Investment, per End

Definition: Per-trunk equivalent investment in switch trunk port at each end of a trunk.

Default Value:

Trunk Port Investment, per end
$100

Support: AT&T Capacity Cost Study.[45] HAI judgment is that $100 is for the switch port itself.

5.7.3. 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
-

Support: Formerly needed to calculate entrance facility investment properly, but entrance facility cost is now based on loop cost, and this parameter is no longer used.

5.7.4. 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:

[44] Blake, et al., "A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p.4.

[45] Blake, et al., "A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth,", p. 7.

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.

5.7.5. 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.

5.7.6. 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.

5.7.7. 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.[46]

[46] Fujitsu, Network Design Features, FJTU-320-560-100, Issue 3, Revision 1, December 1995, p.11.

5.7.8. 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 judgment 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.

5.7.9. 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 judgment.

5.7.10 Fraction of High-Cap Loops Requiring Interoffice Transport

Definition: The fraction of high-capacity loops that appear as interoffice circuits, as opposed to such loops that are connected to other high-capacity loops in the same wire center or terminate in collocation space in the same wire center.

Default Value:

Fraction of High-Cap Loops Requiring Interoffice Transport
0.50

Support: Based on HAI conversations with ILEC representatives.

5.8. TANDEM SWITCHING

5.8.1. 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.

5.8.2. 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.[47]

5.8.3. 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.[48]

5.8.4. 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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[47] 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.

[48] 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 WorldCom subject matter experts.

5.8.5. 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: Telcordia, *LSSGR: Traffic Capacity and Environment*, GR-517-CORE, Issue 1, December 1998, figure 5-1, p 5-4. Figure 5-1, p 5-4.

5.8.6. 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.

5.8.7. Entrance Facility Distance, Miles

Definition: Average length of trunks connecting an IXC POP to the wire center that serves it.

Default Value:

Entrance Facility Distance from Serving Wire Center & IXC POP
-

Support: Formerly needed to calculate entrance facility investment properly, but entrance facility cost is now based on loop cost, and this parameter is no longer used.
.

5.9. SIGNALING

5.9.1. 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 .[49]

5.9.2. 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 5.3.

5.9.3. 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 .[50]

5.9.4. 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.

[49] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 26.

[50] 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
$224,000

Support: BellSouth, *ibid*.

5.9.5. 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
$725

Support: BellSouth, *ibid*.

5.9.6. 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.[51]

5.9.7. 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 .[52]

[51] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 25.

[52] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 24.

5.9.8. 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.

5.9.9. 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.[53]

5.9.10. 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: Telcordia 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.[54] Therefore a default value of 25 average bytes per message is appropriate for use in the HAI Model.

[53] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 25.

[54] Northern Telecom, DMS-STP Planner 1995, Product/Service Information, 57005.16, Issue 1, April, 1995, p.13.

5.9.11. 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 .[55]

5.9.12. TCAP Message Length, Bytes

Definition: The average length of a TCAP message.

Default Value:

TCAP Message Length
100 bytes

Support: Telcordia 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.[56]

5.9.13. 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.[57] 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.

[55] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 25.

[56] DMS-STP Planner 1995, p.13.

[57] Brand, et al., "An Updated Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p. 25.

5.9.14. 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
$2,444

Support: BellSouth, *ibid*.

5.10. OS AND PUBLIC TELEPHONE

5.10.1. 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.

5.10.2. 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.

5.10.3. 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.

5.10.4. 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
$815

Support: Based on coin phone and indoor/outdoor mountings from various internet sources, discounted by 20%. For instance, www.payphoneoutlet.com has a "Bell Style" phone for $797. Mountings include an outdoor pedestal for $248, and an indoor wall booth for $189; these average $219. Adding the phone and average mounting, and discounting 20%, gives $812.40. A similar exercise with prices at www.payphonedirect.com gives a result of $822.40.

5.11. ICO PARAMETERS

5.11.1. 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
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.11.2. 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
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.11.3. 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
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.11.4. 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
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.11.5. 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
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.11.6. 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
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.11.7. 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
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.11.8. 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
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.11.9. 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 5.11.11 for related terminal equipment investment.

Default Value:

Equivalent Facility Investment per DS0, Constant Term
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.11.10. 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
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.11.11. 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
-

Support: This parameter is not used in HM 5.3 for Verizon Washington.

5.12. HOST-REMOTE ASSIGNMENT

5.12.1. 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.

5.12.2. 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
Disabled

Support: As AT&T has argued before the FCC,[58]

> Even assuming a model in which the incumbent LECs' existing wire centers remain in the same locations, their historic determinations regarding remote versus host/standalone switches would be made very differently and more efficiently under today's conditions, and cannot be relied on in a forward-looking model. In particular, embedded LERG assignments of switches as host/standalones or remotes are inconsistent with the Commission's forward-looking interoffice transport architecture that directs host/remote systems be placed on separate SONET rings.
>
> Placing hosts and remotes on their own SONET rings is not a common practice. Indeed, it is unlikely the incumbent LECs' switch placement guidelines reflect the use of SONET rings for host/remote systems because many remotes, as specified by the LERG, are too small to be economically placed on a ring. In any event, the use of the LERG in combination with this assumption produces a vast

[58] AT&T's Petition for Reconsideration in FCC CC Dockets 96-45 and 97-160, January 3, 2000, p. 15.

> overstatement of the necessary interoffice cost because expensive electronics and costly redundant transport are being amortized over too few subscribers. Given the SONET requirement, a necessary consideration for determining forward-looking host remote relationships is its impact on SONET ring structure cost.

Since setting this parameter to the “enabled” value has the effect of both accepting existing incumbents’ host-remote relationships and puts a given host and its remotes on a separate SONET interoffice ring, HM 5.3 instead uses the “disabled” value that causes the model to assume an amalgamated switch cost function.

5.13. HOST - REMOTE INVESTMENT

5.13.1. 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 5.13.2, 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 5.13.2).

5.13.2. 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	$486,700	$486,700	$161,800	$87	$87	$87
640	$486,700	$486,700	$161,800	$87	$87	$87
5,000	$486,700	$486,700	$161,800	$87	$87	$87
10,000	$486,700	$486,700	$161,800	$87	$87	$87
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	$486,700	$486,700	$161,800	$87	$87	$87
640	$486,700	$486,700	$161,800	$87	$87	$87
5,000	$486,700	$486,700	$161,800	$87	$87	$87
10,000	$486,700	$486,700	$161,800	$87	$87	$87

Support: See FCC *USF Inputs Order*, paras. 290-296.

6. EXPENSE

6.1. 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 (Verizon)	
Debt fraction	0.4440
Cost of debt	0.0790
Cost of equity	0.1125
Weighted average Cost of capital	0.0976

Support: Commission-ordered cost of capital for Verizon.

6.2. 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	9.3	20.0
Garage work equipment	18.0	5.0
other work equipment	15.0	10.0
buildings	43.0	0.0
furniture	20.0	10.0
office support equipment	15.0	10.0
company comm. equipment	8.0	2.0
general purpose computers	8.0	5.0
digital electronic switching	16.5	3.0
operator systems	12.0	-2.0
digital circuit equipment	12.0	4.0
public telephone term. Equipment	8.0	10.0
poles	28.0	-75.0
aerial cable, metallic	21.0	-27.0
aerial cable, non metallic	30.0	-5.0
underground cable, metallic	26.0	-15.0
underground cable, non metallic	30.0	-5.0
buried cable, metallic	23.0	-5.0
buried cable, non metallic	30.0	-5.0
intrabuilding cable, metallic	20.0	-30.0
intrabuilding cable, non metallic	20.0	-30.0
conduit systems	50.0	-5.0

Support: Commission-prescribed values for Verizon.

6.3. 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	100 %
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.

6.4. 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.

6.5. OTHER EXPENSE INPUTS

6.5.1. Income Tax Rate

Definition: The combined federal and state income tax rate on earnings paid by a telephone company.

Default Value:

Income Tax Rate
35.00%

Support: Federal (35%) and State (0.0%) combined income tax rate.

6.5.2. 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:

Corporate 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.

6.5.3. 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, expressed as a percentage of revenues.

Default Value:

Other Taxes Factor
4.65%

Support: average for all Tier I LECs, expressed as a percentage of total revenue. This is the Washington value for Verizon, expressed as a percentage of total revenue. Revenue and tax data are taken from the 2001 ARMIS report 43-03.

6.5.4. 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: Not utilized in UNE cost studies, and therefore not recently updated. Originally based on data found in a 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.[59]

6.5.5. 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.

6.5.6. Forward-Looking Network Operations Factor

Definition: A factor that multiplies the ratio of Network Operations expenses in ARMIS[60] to the total of direct expenses plus Network Operations expenses reported in ARMIS in order to reflect any expected efficiency changes in network operations relative to total expenses. The modified ratio that results is applied to the direct expenses plus network operations that the Model associates with a particular UNE in order to determine the network operations expense that should be associated with that UNE.[61]

Default Value:

Forward Looking Network Operations Factor
100%

Support: Setting the forward-looking factor to 100% means that no adjustment is made to the ARMIS ratio identified in the definition of this factor, and thus assumes no further efficiency gains in network operations expenses relative to direct expenses. This is a conservative assumption inasmuch as today's network operations costs do not reflect many of the substantial savings opportunities posed by new technologies, such as the full implementation of the Telecommunications Management Network (TMN) family of management standards, the implementation of web-based management applications, and the like (see Appendix C). This also ignores the possibility that the embedded network operations expense contains expenses that are not applicable to a TELRIC cost estimate such as one-time accounting charges.

[59] New England Telephone Company, *"1993 New Hampshire Incremental Cost Study"*, p. 122, 126.

[60] Network Operations expenses are those reported in ARMIS accounts 6512 (Provisioning Expenses), 6531 (Power Expenses), 6532 (Network Administration), 6533 (Testing), 6534 (Plant Operations Administration), and 6535 (Engineering).

[61] Expressing the network operations cost associated with a given UNE as a function that itself includes the same UNE network operations cost yields an equation that must be solved for the network operations cost using straightforward algebraic manipulation.

6.5.7. 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 5.3.

Default Value:

Alternative Central Office Switching Expense Factor
-

Support: This input parameter is no longer used in the HAI Model. The equivalent calculation is performed in ARMIS expense sheet based on optional expense to investment ratios that, if set, override the values calculated from ARMIS data.

6.5.8. 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
-

Support: This input parameter is no longer used in the HAI Model. The equivalent calculation is performed in ARMIS expense sheet based on optional expense to investment ratios that, if set, override the values calculated from ARMIS data.

6.5.9. End Office Usage-Sensitive Cost Fraction

Definition: The fraction of the total investment in digital local switches that is assumed to be usage-sensitive.

Default Value:

End Office Non Line-Port Cost Fraction
0%

Support: All recent versions of the HAI Model ensure the switches deployed by the Model include inputs that capture the capacity constraints on the switches These constraints are based on switch vendors' statements about these three areas of capacity – See Sections 5.1.1 through 5.1.3. The Model thus checks whether local demand (expressed in terms of busy-hour call attempts, traffic, and line count) exceeds realistically-defined input switch processor capacity, traffic capacity, or line capacity. With the Model's inputs for switch real-time and traffic capacity set to their default values, the end-office switches in the Model do not exhaust either processor or switch matrix capacity, and even substantial artificial increases in input per-line busy-hour call attempts or per-line offered traffic do not force such exhaust. The switches instead reach their line capacity limits well before either usage-related limit is reached. This being the case, the number of lines, not usage, is the principal driver of switch costs. Setting the usage – or non line-port cost – to zero is consistent with this primary cost driver.

6.5.10. 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 (Verizon)
$0.36

Support: Based on *USF Inputs Order*, Appendix D, nationwide line weighted average.

6.5.11. 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
$1.03

Support: This calculation is based on data drawn from LEC ARMIS accounts 7170, 7190 and 7270 reported by all Tier I LECs. 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, and divided by the number of access lines reported by those LECs in order to express the result on a per-line basis. This figure includes all carrier customer-related expenses such as billing, billing inquiry, service order processing, payment and collections, 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. End-user retail services are not included in UNE cost development.

6.5.12. 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.

6.5.13. 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
1

Support:, This factor is not used in HM 5.3.

6.5.14. 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
1

Support: This factor is not used in HM 5.3

6.5.15. 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 3.2.5. [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*.

6.5.16. 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.[62]

[62] Blake, et al., "A Study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth", p.4.

7. EXCAVATION AND RESTORATION

7.1. 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 7.2.

7.2. 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 5.3 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.

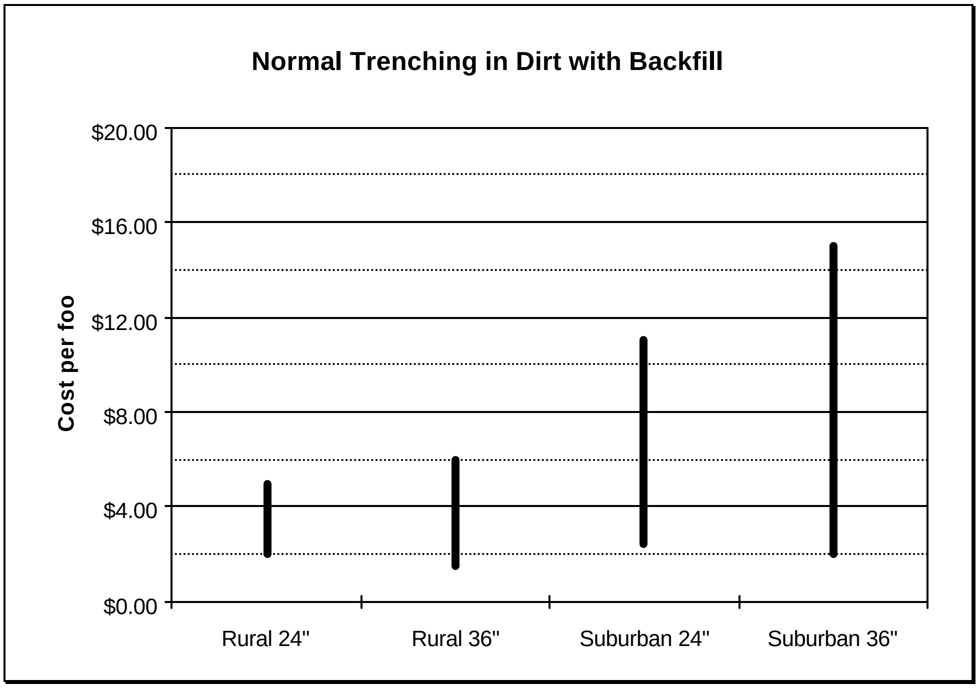
The percentages for Underground Excavation Costs total to 100%, for Restoration (Asphalt + Concrete + Sod + Simple Backfill) total to 100%, and for Conduit Placement & Stabilization total to 100%, since each is a discrete function.

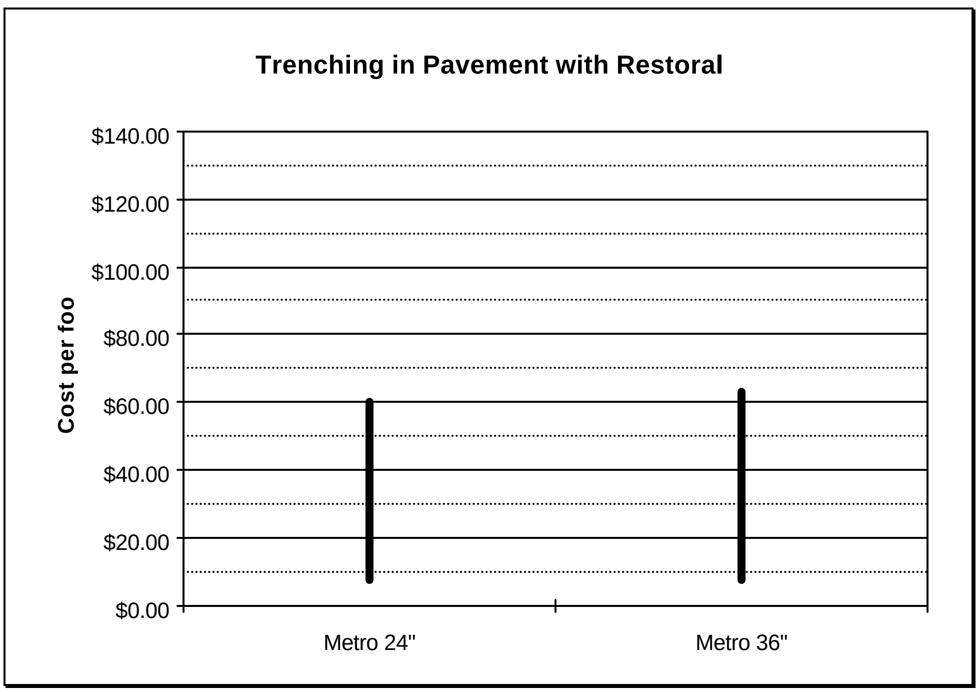
Underground Excavation, Restoration, and Conduit Placement Cost per Foot	
Density Zone	**Cost Per Foot**
0-5	$10.29
5-100	$10.29
100-200	$10.29
200-650	$11.35
650-850	$11.88
850-2,550	$16.40
2,550-5,000	$21.60
5,000-10,000	$50.10
10,000+	$75.00

Costs for various trenching methods were estimated by a team of experienced outside plant experts. Additional information was obtained from printed resources[63]. 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.

[63] Martin D. Kiley and Marques Allyn, eds., *1997 National Construction Estimator 45th Edition*, pp. 12-15.


Normal Trenching in Dirt with Backfill
Cost per foo
$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
Cost per foo
$140.00
$120.00
$100.00
$80.00
$60.00
$40.00
$20.00
$0.00
Metro 24"
Metro 36"

7.3. 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	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	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 7.4.

7.4. 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	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	Per Foot	Frac-tion	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: 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%.

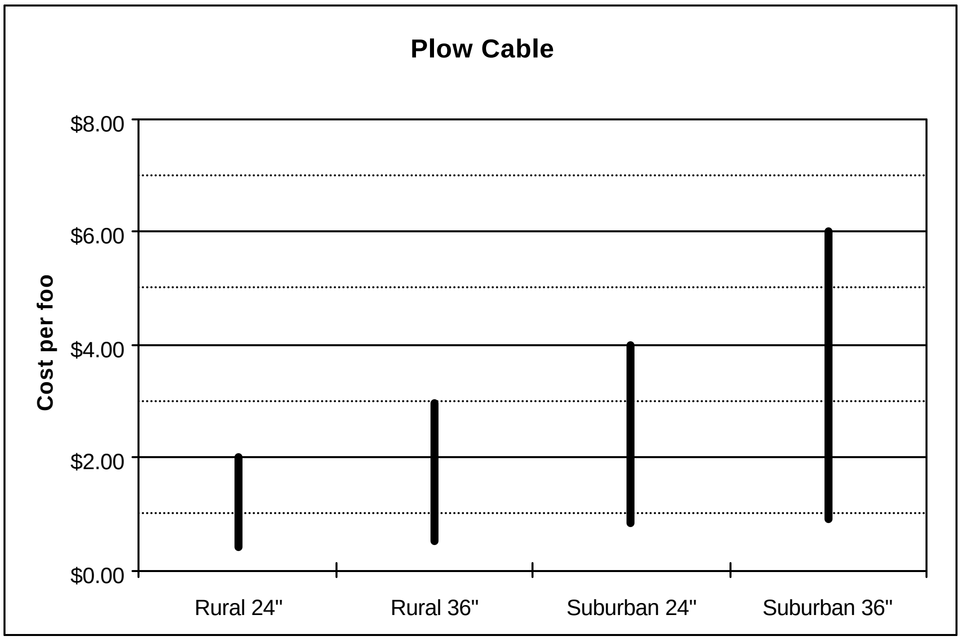
Support:
The costs reflect a mixture of different types of placement activities.

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.

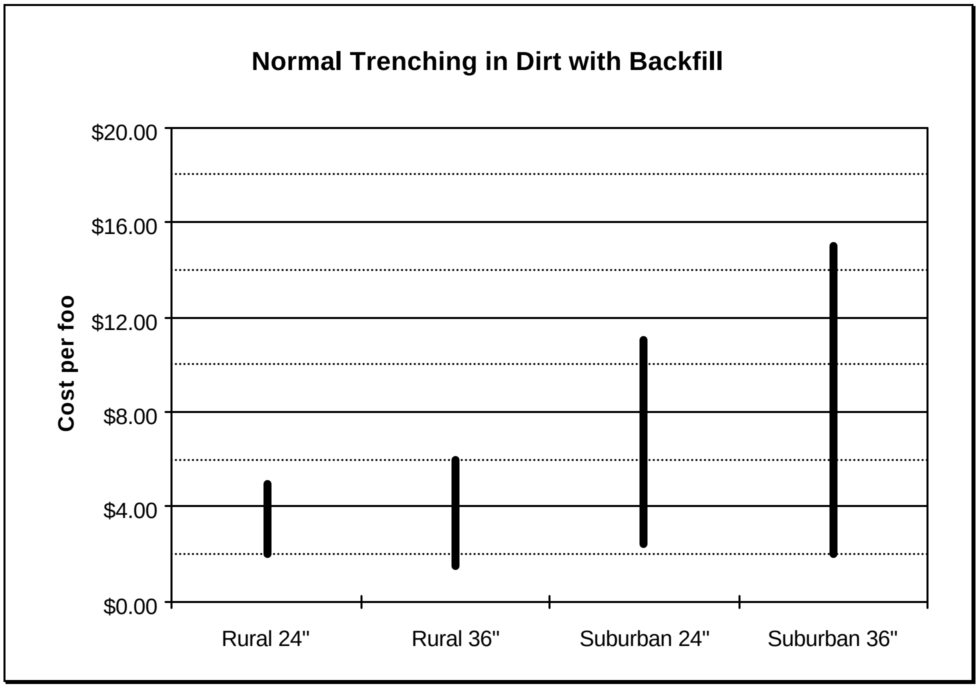
A compound weighted cost for conduit excavation, placement and restoral can be calculated by multiplying the individual columns shown above and in the immediately preceding section, "Buried Excavation Costs per Foot". Performing such calculations using the default values shown would provide the following 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

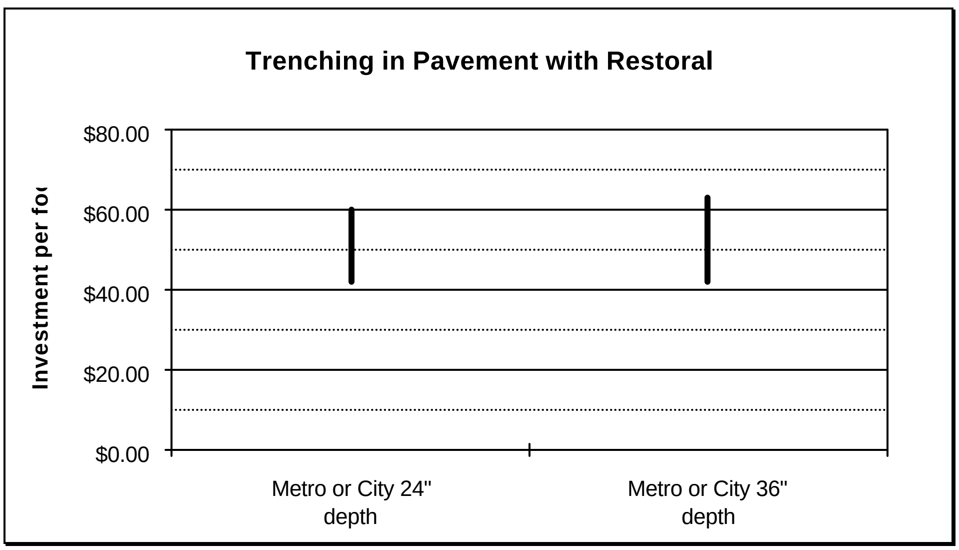
Costs for various excavation methods were estimated by a team of experienced outside plant experts. Additional information was obtained from printed resources[64]. Still other information was provided by several contractors who routinely perform excavation, conduit, and manhole placement work for telephone 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".



[64] Martin D. Kiley and Marques Allyn, eds., *1997 National Construction Estimator 45th Edition*, pp. 12-15.



Normal Trenching in Dirt with Backfill
Cost per foo
$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 fo
$80.00
$60.00
$40.00
$20.00
$0.00
Metro or City 24" depth
Metro or City 36" depth

7.5. 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
1.00	1.10	CBA-FSL	Angular Cobbly & Fine Sandy Loam

Fraction Cluster Affected	Effect	Texture	Description of Texture
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
1.00	1.20	CRC	Coarse Cherty
1.00	1.20	CRV	Very Cherty

Fraction Cluster Affected	Effect	Texture	Description of Texture
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
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

Fraction Cluster Affected	Effect	Texture	Description of Texture
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
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

Fraction Cluster Affected	Effect	Texture	Description of Texture
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
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

Fraction Cluster Affected	Effect	Texture	Description of Texture
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 5.3 has taken the conservative approach of assuming that the difficult terrain factors would affect 100% of the cluster.

8. 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	0.92

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 labor adjustment factor applies to copper cable labor, fiber cable labor, 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.[65] The following statewide labor adjustment factor indexes can be used as default values:

State	Factor[66]
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

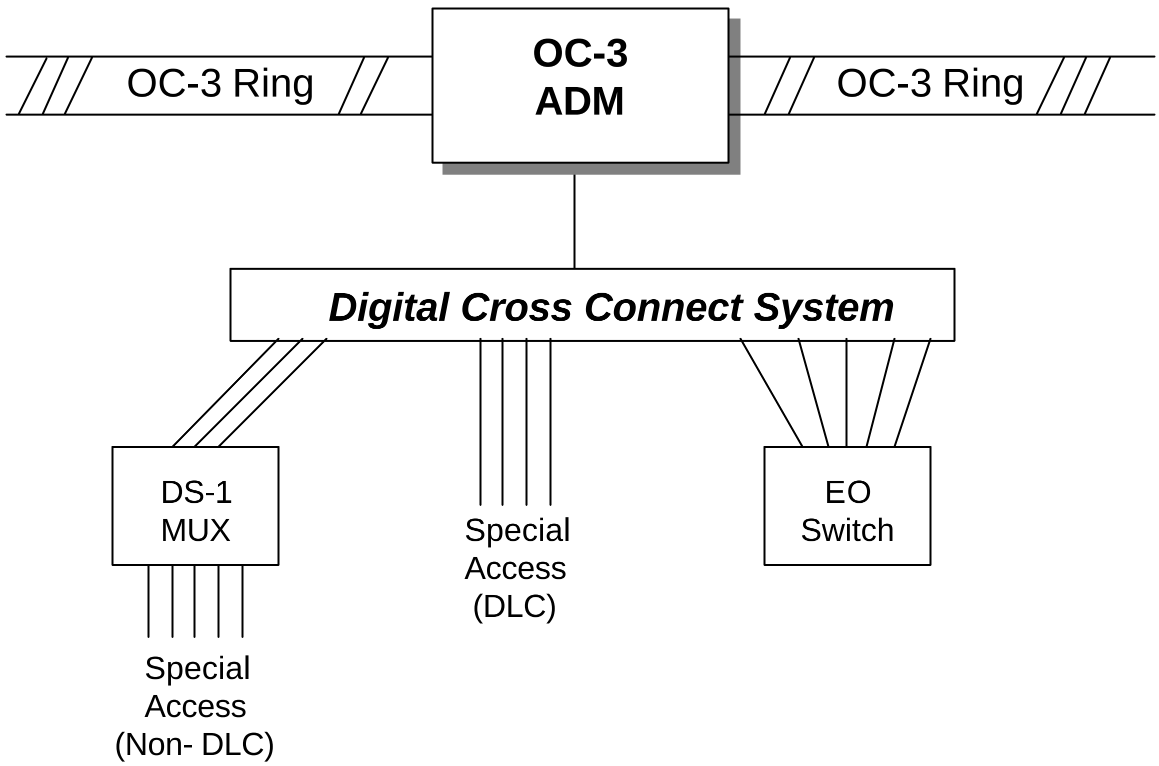
65 See, for example, R.S. Means Company, Inc., *Square Foot Costs, 18th Annual Edition*, 1996, p.429-433.

66 Martin D. Kiley and Marques Allyn, eds., *1997 National Construction Estimator 45th Edition*, pp. 12-15. [Normalized for New York State as 1.00]

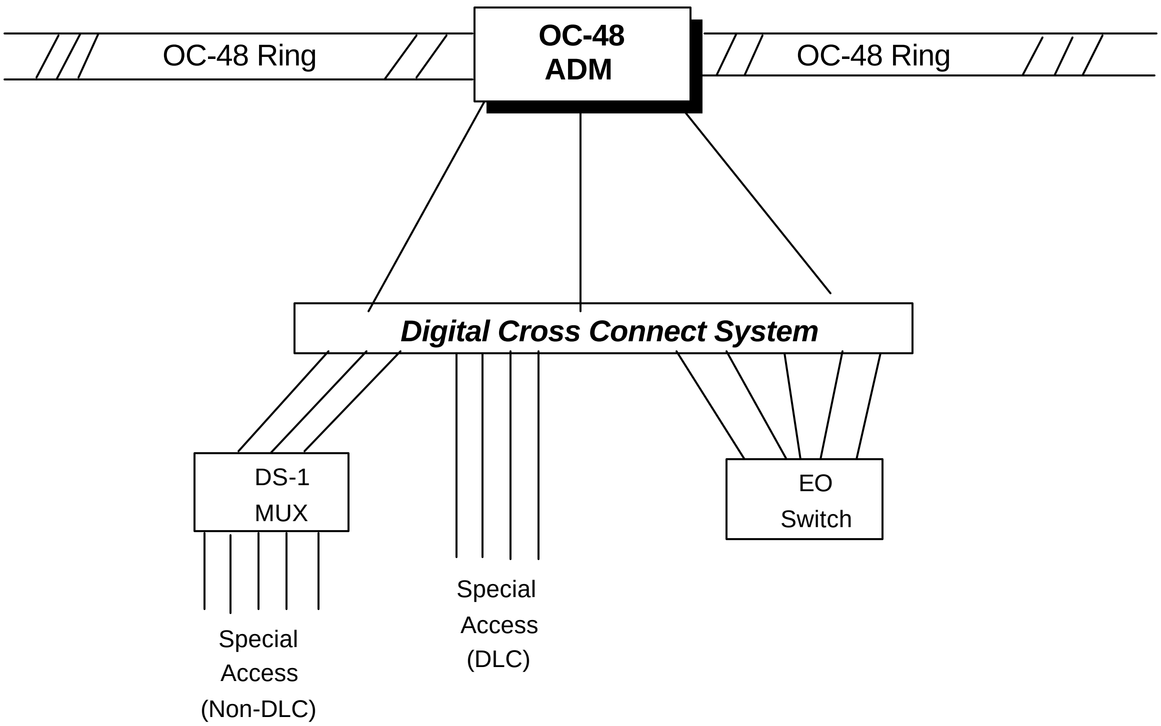
State	Factor[66]
Montana	0.85
West Virginia	0.84
Ohio	0.83
Wisconsin	0.83
Arizona	0.81
Colorado	0.77
New Mexico	0.76
Vermont	0.75
Iowa	0.74
North Dakota	0.74
Idaho	0.73
Maine	0.73
Kentucky	0.73
Louisiana	0.72
Kansas	0.71
Utah	0.71
Tennessee	0.70
Oklahoma	0.69
Florida	0.68
Virginia	0.67
Nebraska	0.65
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

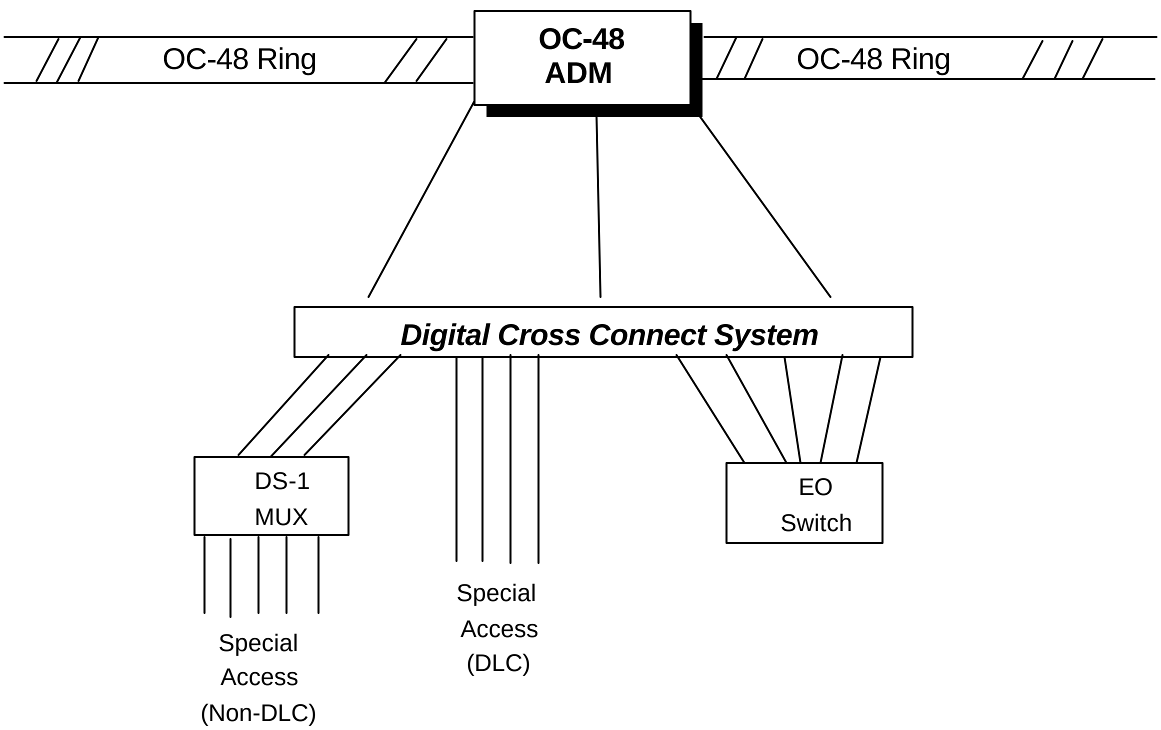
APPENDIX A

Interoffice Transmission Terminal Configuration (OC-3 Fiber Ring)



Interoffice Transmission Terminal Configuration (OC-3 Four-fiber Bi-directional Line Switched 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.[67]

[67] 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 5.3

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 5.3 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.[68]

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,[69] while, in the same proceeding, Niagara Mohawk Power Company reported that 58 percent of its pole inventory was jointly owned[70]. Financial statements of the Southern California Joint Pole Committee indicate that telephone

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[68] 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.

[69] 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.

[70] 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

companies hold approximately 50 percent of pole units[71]. 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 5.3 assumes that ILECs install the most commonly placed pole used for joint use, a 40 foot, Class 4 pole.[72] 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 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

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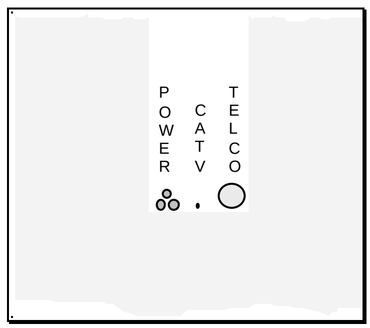
Public Service Commission, January 27, 1997. These experts also predicted that sharing of poles among six attachers would not be uncommon.

[71] " 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.

[72] 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.

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 5.3 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.[73] This trend is likely to continue as new competitors enter the local market.

[73] Empire City Subway is the subsidiary of NYNEX that operates its underground conduits in New York City.

APPENDIX C

Network Operations Reduction

In examining the various activities that are part of the Network Operations category of expenses, 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.

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. Also, 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:

- <u>Recognize industry trends and the opportunities for further reductions.</u> 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 Qwest, Sprint, and other incumbents at various times during its history, consistently calculates a level of per-line network operations expense that is well below historic levels and below the level calculated by HM 5.3-MA. This projection of forward-looking network operations expenses, prepared for and advocated by several incumbent LECs, indicates that the HM 5.3-MA 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 HM 5.3-MA 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.

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