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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

AT&T

295 North Maple Avenue
Basking Ridge, NJ 07920

March 30, 1999

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, D.C. 20554

RE: Ex Parte Presentation
CC Docket No. 96-45 – Universal Service/Proxy Cost Models
CC Docket No. 97-160 – Forward-Looking Cost Mechanism

Dear Ms. Salas:

On March 26, 1999, Richard Clarke of AT&T and Chris Frentrup of MCI WorldCom met with Don Stockdale, Lisa Zaina, Jeff Prisbrey and Bill Sharkey of the Commission staff. And on March 29, 1999, Richard Clarke and Mike Lieberman of AT&T and Chris Frentrup of MCI WorldCom met with Craig Brown, Chuck Keller, Mark Kennet, Katie King, Bob Loube, Jeff Prisbrey, and Richard Cameron of the Commission staff.

The purpose of these meetings was to provide the Commission with the results of several analyses that AT&T and MCI WorldCom have performed on the FCC's Synthesis Model for universal service. These analyses were performed using the most recently available customer location data from PNR, and model platform and user input values from the Commission. As a result of these analyses, we believe that the Synthesis Model does not yet perform in the manner required by the Commission's specifications for an accurate and reliable calculator of basic universal service costs. This is due both to several failures of the model's platform algorithms properly to engineer an efficient, forward-looking local network and to certain inconsistencies in the user inputs posited for the model. These deficiencies cause the Synthesis Model's current cost results to differ significantly from the more accurate estimates of forward-looking economic costs that it would calculate if these deficiencies were corrected.

A copy of the materials that we presented at these meetings is attached. Two copies of this Notice are being submitted to the Secretary of the FCC in accordance with Section 1.1206(a)(2) of the Commission's rules.

Sincerely,

Richard N. Clarke /ha

Richard N. Clarke

Attachments

cc:	Don Stockdale	Lisa Zaina	Jeff Prisbrey
	Craig Brown	Chuck Keller	Mark Kennet
	Katie King	Bob Loube	Bill Sharkey
	Richard Cameron	Sheryl Todd	

bcc: Chris Frentrup, MCI WorldCom

Further Analyses of the Synthesis Model's Performance

1 *Overview*

Based on additional analyses of the Commission's Synthesis Model (SM), AT&T and MCI WorldCom wish to provide the Commission with further information about the reliability and the plausibility of the SM's performance.[1]

As indicated with our initial analyses, it is only within the last several weeks that AT&T and MCI WorldCom have been able to run the SM using actual customer location data and a complete set input of input values (provided by PNR and the Commission staff, respectively). Two points elicited our initial concern. The first is that cost results from the most recent version of the SM have oscillated dramatically from the results suggested by the immediately previous release of the model and its test input values. Second, the cost levels returned by this most recent release of the SM are implausible for forward-looking economic costs, and are at odds with other Commission findings about local exchange cost structures.[2]

Analyses performed by AT&T and MCI WorldCom show that the root cause of these improper cost results is errors in both the operation of certain optimization algorithms in the SM platform and in the test input values inserted into the platform. Once these errors are corrected, the SM generates local service cost figures that are much more reasonable – and which would provide an appropriate basis for the calculation of federal universal service entitlements.

2 *Algorithm Faults*

2.1 *Fiber/Copper Optimization*

The SM platform is supposed to make an optimizing choice between copper cable and fiber-fed digital loop carrier (DLC) for engineering feeder routes. In particular,

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1 AT&T and MCI WorldCom provided the Commission with their initial views of the SM's performance in an ex parte submission filed by AT&T on March 17, 1999.

2 The most implausible aspect of the SM's current results is that for certain study areas, the SM calculates gross universal service plant investments that exceed significantly overall embedded gross investment (Total Plant in Service, or TPIS) – which incorporates all of an ILEC's Part 32 investments. Such a result simply does not comport with well-accepted industry and Commission findings that ILEC total factor productivity and X-factors are distinctly positive. Indeed, the Commission's current interstate productivity factor of 6.5%, coupled with an average age of 14 years for ILEC plant, would suggest that forward-looking gross capital stocks should be about 40% of embedded TPIS. In fact, even the overly conservative 2% value suggested by the ILECs for their total factor productivity would suggest forward-looking gross capital stocks to cost about 75% of embedded TPIS – certainly not in excess of TPIS.

the SM is supposed to first determine the sum of the maximum distribution distance within a cluster, plus the feeder distance to the cluster. If this distance exceeds 18 kft., the SM should engineer the cluster's feeder on fiber DLC. If this distance falls short of 18 kft., the SM is supposed to compare the cost of engineering the cluster's feeder on copper cable versus on fiber DLC, and to select the least-cost technology. Our analyses demonstrate that the SM platform is failing to engineer using the least-cost technology. Instead, it chooses to equip many clusters' feeder on fiber DLC – even though the distance calculation does not require the use of fiber and the cost of fiber DLC exceeds that of copper feeder.[3] As a result, the SM equips far too many lines on fiber DLC – in fact, on average, the SM places upwards of 89% of all of its switched lines on fiber DLC. [SEE FIGURE 1a] But even more disturbing, this massive use of DLC appears to elevate total monthly loop cost by up to 30% in some study areas.[4]

There are several apparent reasons for the SM's miscalculation. First, the SM uses annual charge factors (ACFs) against investments to determine the expected monthly cost of a particular investment technology. A different ACF is computed for each class of plant. Each ACF is the sum of three components: one for depreciation, one for return on capital and one for operations and maintenance. The ACFs used by the SM are reported in the ANNCHG sheet of the SM's inputs workbook. As described in our earlier ex parte, the return portion of the ACF has not had its equity portion grossed up for income taxes, and it has not been adjusted and levelized to recognize that return is paid on average net investment – which depreciates from original gross plant down to zero over the economic life of the plant. Thus the first required correction is to use properly calculated ACFs for each plant class from the SM's expense module. This correction tends to reduce slightly both the portion of lines the SM equips on fiber DLC, as well as the investments and average monthly cost to provide universal service loops.

In addition to this error in the ACF input values used by the SM's optimization routine, the algorithm has further difficulties. These may be demonstrated by skewing the ACFs used by the optimization routine to make fiber DLC appear more expensive, and copper cable to appear less expensive. If the optimization algorithm is working correctly, this should cause the SM to engineer fewer lines on

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3 It also may be possible that the SM is uneconomically attempting to engineer too-long feeder and distribution cables in an attempt to minimize their number and total route distance, but not accounting for the fact that choosing to this causes great cost penalties to be paid if it results in requiring the cluster to be served off of fiber DLC rather than copper. This is discussed at further length, below.

4 Based on a back-of-the-envelope calculation, it seems extremely unlikely for there to be nonrural study areas where it is economic to place such large numbers of lines on fiber DLC. Given the SM's current input values, even the cheapest DLC would cost close to $200 per line in fixed plus variable investment. And because DLC is classified as circuit equipment, this investment would have to be recovered over a 10 year depreciation life. In contrast, $200 would buy, roughly, 20,000 feet of copper pair, which is recovered over a 20 year life. Thus, even though the maintenance factor for copper exceeds that for fiber DLC, it seems exceedingly unlikely that it should be cheaper to employ DLC to serve clusters located close to the wire center.

fiber DLC, and more on copper.[5] But when the SM is run using these skewed ACFs, not only does portion of lines equipped on fiber DLC decline, but the SM's computed loop investments and monthly loop cost also decline. This cannot occur if the optimization routine is working correctly – skewing its ACF inputs should only cause an increase in computed investments and monthly cost.[6] Indeed, by skewing down the ACFs for copper plant to 0.01, and skewing up the ACFs for fiber plant and DLC to 0.99, both reduces the percent on lines engineered on DLC down to 55% in Alabama and to 1% in D.C., it reduces computed monthly loop cost by $0.86 in Alabama and by $1.48 in D.C. [SEE FIGURE 1b]

This difficulty in determining the economically correct amount of lines to engineer on fiber DLC may be linked to another related anomaly. The SM appears to tend to engineer lines on very long) serpentine runs of feeder and distribution cable (with the latter still kept to less than 18 kft.). This is evidenced by the extremely long average loop lengths computed in the model. This is not appropriate engineering practice. While service quality remains above minimums when the analog portion of loops is restricted to less than 18 kft., costs generally do rise, and quality does degrade, as loop length rises. Furthermore, increasing feeder length to reduce total route-feet, if it causes an otherwise copper cluster to be served off of fiber, is unlikely to be economic.

2.2 Cluster Characteristics

The clustering algorithm used by the SM may tend to form clusters that are not the most economic for provisioning with OSP. In particular, it may be uneconomic to add certain remote locations to a cluster if adding these locations causes the sum of the feeder plus maximum distribution distance to exceed 18 kft. -- and the cluster then to be engineered on fiber DLC. This is because adding these locations causes the model to have to equip all of the cluster's closer-in locations with, at minimum, DLC channel cards plus a share of the fixed cost attributable to the larger DLC remote terminal necessary to serve these closer-in locations. This unnecessary additive easily will exceed $100 to $150 per line for the close-in locations.

Unfortunately, the clustering criteria used by the SM focus almost entirely on ensuring that maximum distribution distances are limited to less than 18 kft., with no concern about keeping the sum of the feeder distance plus the maximum distribution distance to within 18 kft.[7] Thus, it is likely that clusters formed by the

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5 Note that skewing these ACFs does not disable the distance check for whether fiber DLC must be employed. It only should decrease computed fiber DLC use in clusters whose maximum distribution plus feeder distance is less than 18 kft.

6 Note that the values of the ACFs in the SM inputs workbook affect only the operation of the SM's optimization routines. In particular, they are not linked to the input prices for investment items such as copper or fiber cable, DLC systems, etc. Thus, changing the values of the ACFs should change investment and monthly service costs only to the extent that these ACFs cause the SM's optimization routines to place different configurations of equipment.

7 By focusing only on distribution plant expense to the exclusion of feeder and concentration expense, this optimization is "myopic." A similar limitation exists in the PNR clustering algorithms used by the HAI 5.0a model.

SM and served off of fiber DLC, will contain many customer locations that could have been served more economically if they were placed in a separate cluster, all of whose points are close enough to the wire center so that copper feeder would be adequate to serve the cluster. [SEE FIGURE 2]

By failing to generate separate copper-only clusters surrounding the wire center, the SM is likely to incur a severe cost penalty. There are two reasons. The first is that the DLC it uses to serve fiber clusters is likely too expensive [see, section 3.4, below], the second is that due to the SM's sophisticated method for sharing the use of sub-feeder across clusters, the cost of the extra feeder structure to serve the additional copper cluster(s) surrounding the wire center is likely very small.

2.3 Structure Type Optimization

An additional optimization performed by the SM is to permit variation of the relative proportions of aerial and buried structure engineered in inverse fashion to their relative costs.[8] Thus, if aerial plant is less expensive than buried in a certain location, the SM should place relatively more of it than would be indicated by its default percents for that density zone.

The SM's optimization routine uses the same set of ACFs to determine the relative lifecycle costs of aerial versus buried plant as it uses to determine fiber versus copper. Thus, the faults that we found with these ACFs in the previous section will also cause the SM incorrectly to determine its relative use of buried versus aerial structure. Employing the correct ACFs causes total buried plus aerial OSP investments to drop by 0.2% and for monthly loop costs to drop by $0.04. Moreover, when input structure percents for aerial are reduced to zero, the optimization routine generates increased total structure investments. This is not logically possible if the optimization routine is operating correctly. The effect of structure choice on the SM's total modeled investments is severe. If the input structure percents for buried are reduced to zero, the optimization routine generates total investments that are reduced by 16%. Setting all plant to aerial reduces total investment by 19%. Analogous effects are seen in monthly loop costs. These impact suggest that these values should be carefully reviewed. [SEE FIGURE 3]

2.4 Density Zone Assignment

Many of the costs of placing OSP are specific to the density of the location where this plant is placed. In particular, higher lines or population densities are usually associated with more built-up areas, intersected by many streets, covered by significant amounts of concrete or asphalt, and containing many structures or other impediments to the easy laying of OSP. For this reason, the SM, the BCPM and the HAI models incorporate different unit input costs for placement of OSP by

[8] This optimization is invoked by the SM only when the user-input percents for buried, aerial and underground structure sum to less than 100% in a density zone. Because underground structure generally is employed only when required by natural or man-made obstacles, environmental concerns or extreme urbanization, its percentage use is not allowed to vary endogenously from the SM's default configuration.

density zone.[9] In general, these unit input costs are believed to rise as the zone where the OSP is placed increases in density.

There are two general methodologies for calculating the "lines density" of a cluster. One is to calculate density directly as the quotient of the number of lines in the cluster and the area of the cluster. The second way, used by both the HAI and BCPM models, to calculate density using a more expansive area denominator. In the HAI 5.0a model, the density assigned to a cluster is the lines density of the predominant CBG in which it lies. In the BCPM3, density is computed as the number of lines in the assumed-populated micrograms of an ultimate grid, divided by the area of the ultimate grid.

This second methodology provides density figures that more accurately depict the likelihood of impediments to the easy placement of OSP. There are two reasons. The first is because clusters, by their very nature, are designed to exclude to the maximum extent reasonable, "empty" area between customer locations. [SEE FIGURE 4]. Thus measured densities that use only the actual cluster area as a divisor will be skewed upward relative to any other divisor. This will cause anomalous results. Consider the situation of a rural crossroads or intersection with an Interstate highway. At this intersection, there may be several gas stations, restaurants or truck stops – but no other telephone customer locations within several miles. By considering only the area included in the cluster, extremely high lines densities may be computed – suggesting the use of very expensive OSP.[10] [SEE FIGURES 5 and 6] Thus, use of just cluster area as the density divisor will provide a misleading signal as to the true cost of placing OSP to serve customers in such clusters.

The second reason why such a methodology is misleading is the fact that OSP does not need just to be placed within a cluster's boundaries. It also needs to be placed in the "empty" area outside of the cluster's boundaries in order to provide connectivity to its wire center or to other clusters on the feeder or subfeeder route . Because such area is "empty," its density would be calculated by the SM distribution density methodology to be zero. But instead of considering OSP laid between clusters as being in a "zero" density zone, the SM calculates an average density of all clusters served by a wire center, and assigns this density to feeder OSP. Because this plant is being laid in areas of the wire center where the SM-computed distribution density is zero, its assignment of wire center average density to feeder OSP will bias upward its cost calculations of feeder relative to distribution. Thus, both feeder and distribution OSP unit costs based only on within-cluster densities will be severely overstated. This suggests strongly that the SM's density measure should be revised to measure more broadly the density of its clusters. If it is not possible to correct this fault directly, a "second-best" way to

9 For example, cost per foot of trench, distance between poles, etc.

10 The elevated expense of this OSP may derive both from the higher per-foot OSP placement costs assumed in dense locations, but also because of the SM's assumption of increased use of expensive underground plant in dense locations.

mitigate this upward cost bias would be to adjust downward the density zone-specific input values to the SM. When HAI engineers selected the default input values for the HAI model, the relation of these input values to density zones was predicated on the HAI method of computing density. Similarly, when BCPM engineers selected their model's default input values, they were predicated on the BCPM method of computing density. Since the SM currently uses a density methodology that generally is biased upwards relative to the HAI and BCPM methodologies, any SM input values that are based on HAI or BCPM input values should be adjusted down.

Again, the impact of density assignment is very significant. Converting the HAI model to calculating density like the SM causes its calculated investments to rise by 7%, and loop costs to rise by 8%. [SEE FIGURE 7] We expect a similar cost overstatement to be occurring within the SM.

3 *Input Value Faults*

3.1 OSP Placement Costs and Structure Percents

Overall cost levels for buried cable placement in the test dataset are too high – particularly in the low and middle density zones. In these zones, OSP engineers typically have the flexibility to choose the type of plant structure they wish to employ, and buried will only be chosen if its costs are reasonable. Thus, the fact that there may be locations in these zones where buried plant is expensive by no means permits one to conclude that the average placement cost of the buried plant that is actually placed in these zones will be expensive. Rather, in the expensive locations within these zones, the engineer will chose to substitute a different type of structure.

In addition, the test inputs suggest a very steep ramp-up of plant placement costs as one progresses through the density zones. These inputs suggest that it is over *twice* as expensive per foot to place buried or underground plant in zones 3 and 4 as in 1 and 2. It is difficult to understand why this should be the case. Neither the BCPM or HAI default inputs suggested that per-foot costs would rise by more than 20 to 30% as one progresses into these higher density zones.

Similarly, both the BCPM and HAI model inputs posit rough parity between buried and aerial structure costs in these lowest four zones. In constrast, the SM's test input values suggest that buried structure is over 30% more expensive (pre-sharing) than aerial structure.

At this point is useful to observe that the effect of many input values errors is not uniform, but multiplicative, *e.g.*, an input value for placement cost that is 20% above its correct amount, coupled with a selected structure type percent that is 20% above its correct amount, coupled with a structure sharing percent that is 20% below its correct amount, leads not to a cost that is 20% above its correct amount, but rather is compounded into a cost that is 73% above its correct amount. In an economic environment, selecting too high an input value for a typical type of plant placement will cause decision makers to substitute strongly away from it in favor of less expensive plant. However, the SM's default inputs frequently do not exhibit this characteristic.

As indicated in earlier ex parte presentations, the SM incorrectly assumes that manholes will be employed in the intermittent event that distribution plant is placed in outside structure. Because manholes constitute, between 30 and 60% of the total cost of placing underground structure in the lower density zones, their inclusion results in a significant cost additive.

Both the BCPM and HAI models assume the use of fiberglass pullboxes (or "handholes") in rural situations where only thin fiber cables need be pulled and spliced. Not only are these pullboxes much cheaper than traditional manholes (HAI: $500, BCPM: $1000), but because of the ease and distance over which fiber cables are pulled, they may be spaced at 2000 foot intervals. In contrast, the cheapest manhole in the SM's test dataset costs over $1400, and is assumed to be placed every 763 (or less) feet. This results in SM's minimum manhole expenses being $1.83 per foot – compared with minimum HAI expenses of $0.25 per foot and minimum BCPM expenses of $1.38 per foot.[11]

3.2 Other OSP Costs

As AT&T and MCI WorldCom have indicated in our earlier presentations, many other OSP input values (e.g., copper cable costs, SAI costs, drop costs, etc.) in the SM appear to be excessive. We again urge the Commission to review the justifications for HAI-proposed input values in the HAI Inputs Portfolio. In addition, we attach here as FIGURE 8, lists of the vendor bid values that were used by the HAI engineering team to develop its suggested input values.

3.3 Structure Sharing Percents

The values set for these inputs are the single most significant in the SM. This is because they *multiply* the effect of every other input value related to OSP structure.

As was demonstrated in our ex parte presentation of February 9, 1999, the structure sharing percents in the test dataset are too low relative to what may be inferred as forward-looking levels for aerial and conduit sharing from the Commission's February 6, 1998 *Report and Order* in CC Dkt. No. 97-151. And in our ex parte presentation of March 17, 1999, we demonstrated that the expected amount of underground sharing logically must exceed the expected amount of buried sharing – a characteristic still not represented in the SM's test dataset.

11 The BCPM erroneously does not recognize the greater intervals at which fiber manholes can be placed relative to copper manholes. The BCPM cost figure calculated here assumes its continued use of 725 foot copper spacings.

But there are additional reasons why the currently posited values for structure sharing must be rejected as too low. These are because they do not comport with other engineering input values posited for the SM and they do not recognize that the ILEC will use the same structures to provide other of its services not considered by these universal service cost proxy models.

The OSP structures assumed in the HAI, BCPM and SM models are all extremely high quality: poles are 40 feet high, trenches are two to three feet deep and one foot wide, spare conduit is placed in trenches, manhole capacity is installed to accommodate this spare conduit, all excavations are completely restored to their original state, etc. A significant reason for placing structure of this quality is that it is intended to be shared by uses other than narrowband universal service. Poles would not have to be 40 feet tall if their only use was for basic telephony and power. Extra width and conduit would not have to be put in trenches if they were intended only for universal service. Thus, if the Commission believes that OSP structures will not be shared extensively, it should factor down appropriately the asssumed input cost of poles, trenching, manholes, etc. to reflect the more limited use that these structures are expected to serve. Furthermore, it is imperative that the Commission's structure sharing input values also reflect the degree to which these OSP structures will be shared with the ILECs' other than narrowband basic service uses. It would be an improper cross-subsidy if the SM were to assume that universal service should bear the complete cost of structures that benefit ILEC services not costed by the SM.

3.4 Digital Loop Carrier

DLC costs remain too high. As our previous ex parte presentations have shown, this appears to be the result of costing out DLC that was engineered on a custom design basis, rather than based on a standard design. These presentation also have demonstrated that the additives for installation and site preparation implicit or explicit in these test input values simply do not withstand a test of reasonableness.

Because of a significant change in the SM's platform engineering assumptions that has appeared in this month's release, copper T-1 DLC has been eliminated from the SM and replaced by fiber DLC.[12] Because the SM previously did not generally use fiber DLC to serve small clusters, the "small" fiber DLC that was specified in the SM was a system that had 96-line capability. The cost of such a system should not be used as the basis for determining the cost of small (24-line) fiber DLC systems designed to replace the copper T-1 DLC. In contrast to the input values for 24-line fiber DLC now existing in the SM's test dataset, modern small DLCs are priced much more economically. The attached chart provides the list prices from Advanced Fibre Communications for such small fiber DLC systems. Allowing, conservatively, for a 20% discount off of list price, yields estimated costs for small fiber DLCs that are up to 50% less than in the SM's suggested input values. [SEE FIGURE 9]

[12] We are unaware of the engineering or service quality need for this change in the SM platform.

In addition, web sites for manufacturers of small DLC systems indicate that they may be fed off of fiber, or copper digital transmission systems.[13]

3.5 Switching and Interoffice Costs

AT&T and MCI WorldCom are pleased that the current set of test input values for switching have adopted our earlier suggestion that the regression equation's functional form should restrict variable per-line host and remote cost coefficients to be identical. We are concerned, though, about a new specification for the effects of time trend that is used in the current input equation. Rather than continuing to specify time trends in terms of logarithms, the new equation uses reciprocal time. This departs from standard default econometric practice for specifying the effects of time, and appears to have a profound effect on the calculated coefficients.[14]

Figure 10a displays the regression statistics for the equation that was proposed by AT&T and MCI WorldCom in our January 9, 1999 ex parte presentation. Both the depreciation and RUS data are employed, and each coefficient is statistically significant at the 5% level. Figure 10b displays the regression statistics for the equation implicit in the current data set. Only the depreciation data no more than three years removed from installation date are employed, and using reciprocal time, five out of the six coefficients are not statistically significant. In particular, there is no identified difference in host versus remote costs In contrast, if the same data selection is used to estimate our proposed form using logarithmic time, the specification is much better identified. [SEE FIGURE 10c]

The input cost for interoffice fiber cable appears still to be set to an old HAI 5.0a value, and not to the value for 24 strand fiber in the SM's loop module.

3.6 Local Number Portability Costs

The test input data assume a monthly cost of $0.77 for LNP cost. This is approximately double the average *filed* tariff for LNP.

Company	Per Line Surcharge	Source
BA	$ 0.24	BA Tariff FCC No. 1 3/23/99
US West	$ 0.54	US West Tariff FCC 5 3/9/99
GTE	$ 0.38	GTE Tariff FCC 1 3/4/99
SWBT	$ 0.48	SWBT Tariff FCC 73, 2/1/99
Ameritech	$ 0.42	Ameritech Tariff FCC 2, 2/1/99

In addition, if the cost development and tariff process for LNP costs approximates that experienced for 800 number portability costs, once actual cost experience

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13 See, http://www.fibre.com or http://www.teltrend.com for examples.

14 The use of logarithmically transformed time is the econometric standard, because logarithms convert uniform time intervals into intervals that reflect constant percentage growths over time. We are not aware of any accepted interpretation of reciprocal time progressions.

(rather than projected experience) is acquired by the LECs, initially tariffed rates will shrink to less than a quarter of their initial value.

4 Summary

In selecting the input values to be used in its Synthesis Model, the Commission must take care to ensure that the values chosen bear a logical technical and economic relationship to each other. Thus, input values should be chosen to represent the values that would be reflected *as a group* in an efficient firm, not simply selected from an amalgam of ILEC practices without adequate regard for their internal consistency.

Correcting these faulty input values and SM platform difficulties is a necessary step before the SM can be used as an accurate and reliable calculator of forward-looking universal service costs.

FIGURE 1a

State	Company	Total Lines	DLC Lines	Pct DLC Lines
Alabama	South Central Bell-Al	1,969,732	1,856,698	94%
Arizona	Mountain Bell-Arizona	2,897,847	2,747,643	95%
Arkansas	Southwestern Bell-Arkansas	1,043,480	961,443	92%
California	Pacific Bell	13,648,804	12,166,596	89%
Colorado	Mountain Bell-Colorado	3,143,463	2,773,600	88%
Connecticut	Southern New England Tel	2,121,240	1,934,003	91%
Delaware	Diamond State Tel Co	545,546	502,347	92%
District of Columbia	C And P Telephone Company Of Wa Dc	1,067,696	526,463	49%
Florida	Southern Bell-Fl	6,481,233	6,017,164	93%
Georgia	Southern Bell-Ga	4,241,403	4,037,336	95%
Idaho	Mountain Bell-Idaho	571,280	522,901	92%
Illinois	Illinois Bell Tel Co	7,621,457	6,395,400	84%
Indiana	Indiana Bell Tel Co	2,163,193	1,931,762	89%
Kansas	Southwestern Bell-Kansas	1,460,251	1,305,671	89%
Kentucky	South Central Bell-Ky	1,266,972	1,147,947	91%
Kentucky	Cincinnati Bell-Ky	187,150	176,619	94%
Louisiana	South Central Bell-La	2,301,795	2,084,903	91%
Maine	New England Tel-Maine	629,711	545,360	87%
Maryland	C And P Tel Co Of Md	3,566,640	3,211,187	90%
Massachusetts	New England Tel-Ma	4,515,483	3,629,106	80%
Michigan	Michigan Bell Tel Co	5,812,534	5,330,555	92%
Minnesota	Northwestern Bell-Minnesota	2,677,893	2,296,156	86%
Mississippi	South Central Bell-Mississippi	1,333,422	1,230,228	92%
Missouri	Southwestern Bell-Missouri	2,988,938	2,696,178	90%
Montana	Mountain Bell-Montana	412,232	340,627	83%
Nebraska	Northwestern Bell-Nebraska	702,235	598,218	85%
Nevada	Nevada Bell	353,001	293,472	83%
New Hampshire	New England Tel-Nh	768,517	689,341	90%
New Jersey	New Jersey Bell	6,111,810	5,311,404	87%
New Mexico	Mountain Bell-New Mexico	902,945	840,803	93%
New York	New York Tel	11,822,799	9,461,074	80%
North Carolina	Southern Bell-Nc	2,525,349	2,333,797	92%
North Dakota	Northwestern Bell-North Dakota	341,090	289,410	85%
Ohio	Cincinnati Bell-Ohio	793,765	710,526	90%
Ohio	Ohio Bell Tel Co	4,585,096	4,113,909	90%
Oklahoma	Southwestern Bell-Oklahoma	1,751,864	1,621,937	93%
Oregon	Pacific Northwest Bell-Oregon	1,667,376	1,474,946	88%
Pennsylvania	Bell Of Pennsylvania	6,261,962	5,374,208	86%
Rhode Island	New England Tel-Ri	667,323	618,961	93%
South Carolina	Southern Bell-Sc	1,471,763	1,391,575	95%
South Dakota	Northwestern Bell-South Dakota	328,250	281,700	86%
Tennessee	South Central Bell-Tn	2,748,462	2,583,917	94%
Texas	Southwestern Bell-Texas	10,270,715	9,550,418	93%
Utah	Mountain Bell-Utah	1,339,101	1,212,218	91%
Vermont	New England Tel-Vt	349,646	285,749	82%
Washington	Pacific Northwest Bell-Washington	2,767,788	2,465,918	89%
West Virginia	C And P Tel Co Of W Va	810,805	713,685	88%
Wisconsin	Wisconsin Bell	2,379,515	2,130,501	90%
Wyoming	Mountain Bell-Wyoming	254,134	225,570	89%
		136,644,706	**120,941,150**	**89%**

FIGURE 1b

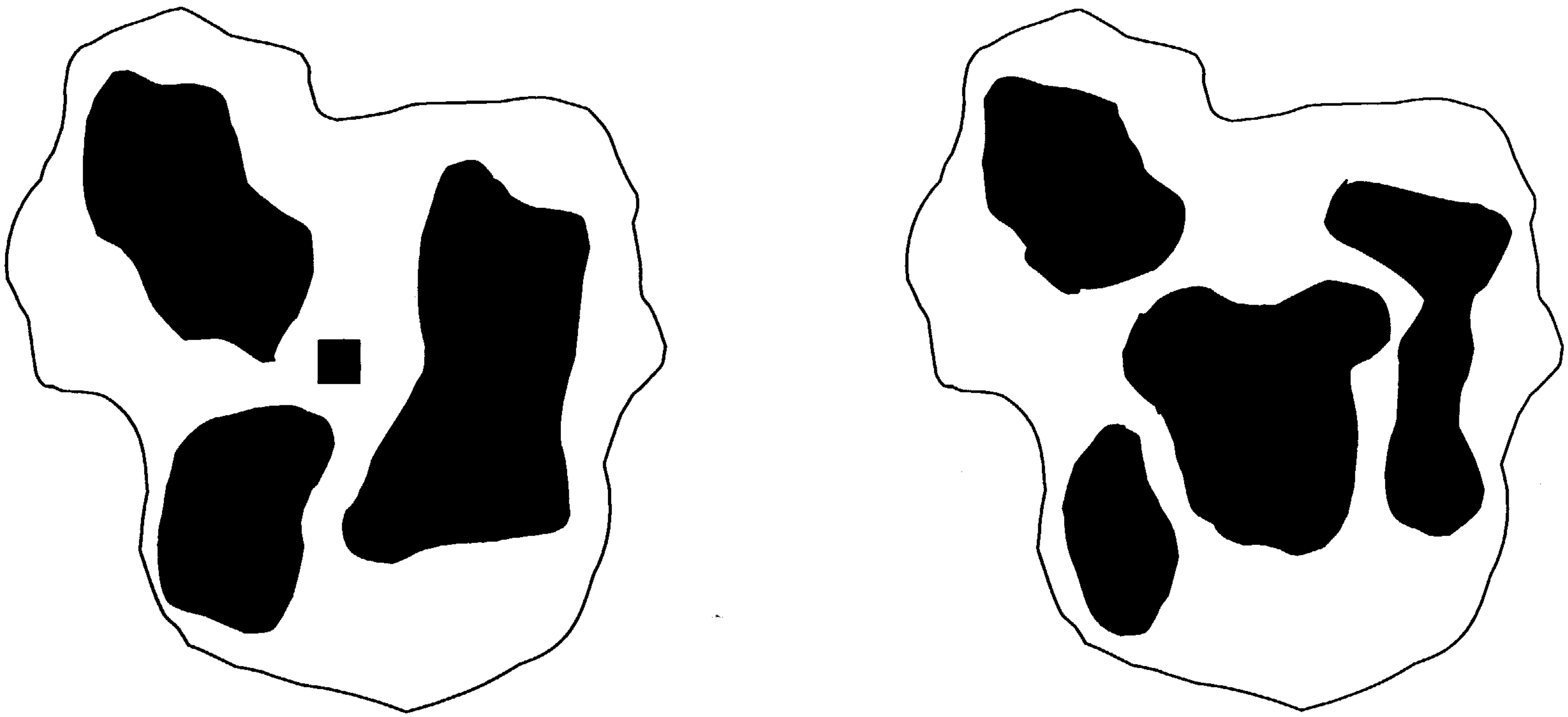
COST SUMMARY

Alabama South Central Bell-Al	HCPM32 Baseline	HCPM32 Correct ACFs	HCPM32 Fiber ACF .99	HCPM32 Fiber ACF .99 Cu ACF .01
Network Element	Investment	Investment	Investment	Investment
NID	$ 58,178,760	$ 58,178,760	$ 58,178,760	$ 58,178,760
Distribution (DLC)	1,777,423,701	1,770,854,415	1,598,723,925	1,478,444,814
Distribution (non-DLC)	36,533,479	43,102,765	215,233,255	335,512,366
Distribution (all)	1,813,957,180	1,813,957,180	1,813,957,180	1,813,957,180
Concentrator (DLC)	523,242,401	517,553,552	415,202,266	353,182,570
Concentrator (non-DLC)	144,335	109,351	502,883	750,227
Concentrator (all)	523,386,735	517,662,903	415,705,150	353,932,798
Feeder (DLC)	161,723,851	160,764,724	168,637,992	177,979,901
Feeder (non-DLC)	15,790,829	17,247,498	47,377,101	68,577,773
Feeder (all)	177,514,680	178,012,222	216,015,093	246,557,674
End Office Switching	225,522,567	225,522,567	225,522,567	225,522,567
Signaling	19,473,621	19,473,621	19,473,621	19,473,621
Dedicated Transport	65,272,470	65,274,219	65,283,950	65,290,451
Dedicated Transport Transmission	22,784,782	22,784,782	22,784,782	22,784,782
Direct Transport	46,789,712	46,790,211	46,795,135	46,799,010
Direct Transport Transmission	11,222,759	11,222,759	11,222,759	11,222,759
Common Transport	10,163,009	10,163,050	10,164,047	10,164,689
Common Transport Transmission	2,150,552	2,150,552	2,150,552	2,150,552
Tandem Switching	8,821,431	8,821,431	8,821,431	8,821,431
Operator Systems	12,034,456	12,034,456	12,034,456	12,034,456
Public Telephone	-	-	-	-
Loop investment	2,514,858,595	2,509,632,305	2,445,677,423	2,414,447,652
Total	$ 2,997,272,714	$ 2,992,048,712	$ 2,928,109,482	$ 2,896,890,730
Total Loop cost	$ 654,967,451	$ 653,808,354	$ 640,234,685	$ 634,108,667
UNE Loop	$ 27.71	$ 27.66	$ 27.09	$ 26.83
USF loop	$ 28.34	$ 28.30	$ 27.77	$ 27.52
Total Lines	1,969,732	1,969,732	1,969,732	1,969,732
Lines on DLC	1,856,698	1,836,254	1,379,561	1,092,349
Percent lines on DLC	94%	93%	70%	55%

District of Columbia
C And P Telephone Company Of Wa Dc

Network Element	HCPM32 Baseline	HCPM32 Correct ACFs	HCPM32 Fiber ACF .99	HCPM32 Fiber ACF .99 Cu ACF .01
	Investment	Investment	Investment	Investment
NID	$ 13,009,167	$ 13,009,167	$ 13,009,167	$ 13,009,167
Distribution (DLC)	64,638,731	59,327,137	14,870,710	3,525,144
Distribution (non-DLC)	42,953,998	48,265,592	92,722,020	104,067,586
Distribution (all)	107,592,729	107,592,729	107,592,729	107,592,729
Concentrator (DLC)	107,863,660	97,892,329	19,423,634	3,083,106
Concentrator (non-DLC)	573,925	402,490	678,107	735,617
Concentrator (all)	108,437,585	98,294,818	20,101,741	3,818,724
Feeder (DLC)	14,439,242	14,801,600	11,464,714	3,363,380
Feeder (non-DLC)	8,225,801	9,225,918	30,582,997	46,162,731
Feeder (all)	22,665,043	24,027,518	42,047,711	49,526,111
End Office Switching	105,635,755	105,635,755	105,635,755	105,635,755
Signaling	5,713,975	5,713,975	5,713,975	5,713,975
Dedicated Transport	1,158,214	1,158,150	1,157,447	1,156,801
Dedicated Transport Transmission	12,813,619	12,813,619	12,813,619	12,813,619
Direct Transport	253,311	253,306	253,149	253,049
Direct Transport Transmission	2,106,140	2,106,140	2,106,140	2,106,140
Common Transport	55,562	55,560	55,556	55,472
Common Transport Transmission	456,437	456,437	456,437	456,437
Tandem Switching	2,027,038	2,027,038	2,027,038	2,027,038
Operator Systems	4,259,199	4,259,199	4,259,199	4,259,199
Public Telephone	-	-	-	-
Loop investment	238,695,357	229,915,066	169,742,182	160,937,564
Total	$ 386,183,774	$ 377,403,411	$ 317,229,663	$ 308,424,215
Total Loop cost	$ 82,949,800	$ 80,667,152	$ 65,654,822	$ 64,082,182
UNE Loop	$ 6.47	$ 6.30	$ 5.12	$ 5.00
USF loop	$ 6.55	$ 6.37	$ 5.20	$ 5.07
Total Lines	1,067,696	1,067,696	1,067,696	1,067,696
Lines on DLC	526,463	479,440	96,237	14,545
Percent lines on DLC	49%	45%	9%	1%

Many clusters formed by the SM include customer locations that could more economically be served if formed in a way that would permit them to be served by copper.



Centroid of each cluster is so far from wire center that each is served by fiber/DLC.

An alternative clustering would permit five locations in this example to be served by copper.

Figure 2

FIGURE 3

Alabama South Central Bell-Al	Synthesis Model ACF Corrected Baseline Investment	Synthesis Model No Input Aerial Investment	Impact of Input Change	Synthesis Model No Input Buried Investment	Impact of Input Change	Synthesis Model 100% Buried Investment	Impact of Input Change	Synthesis Model 100% Aerial Investment	Impact of Input Change
Network Element	(A)	(B)	(B/A)-1	(B)	(B/A)-1	(B)	(B/A)-1	(B)	(B/A)-1
NID	$ 58,178,760	$ 58,178,760	0%	$ 58,178,760	0%	$ 58,178,760	0%	$ 58,178,760	0%
Distribution (DLC)	1,770,854,415	1,844,634,704	4%	1,313,894,933	-26%	2,096,682,191	18%	1,215,763,153	-31%
Distribution (non-DLC)	43,102,765	49,986,409	16%	35,395,295	-18%	62,071,194	44%	21,228,510	-51%
Distribution (all)	1,813,957,180	1,894,621,113	4%	1,349,290,229	-26%	2,158,753,385	19%	1,236,991,663	-32%
Concentrator (DLC)	517,553,552	516,426,370	0%	512,286,363	-1%	512,747,613	-1%	522,927,651	1%
Concentrator (non-DLC)	109,351	183,646	68%	128,833	18%	127,348	16%	89,284	-18%
Concentrator (all)	517,662,903	516,610,016	0%	512,415,197	-1%	512,874,961	-1%	523,016,936	1%
Feeder (DLC)	160,764,724	172,051,891	7%	172,139,552	7%	171,211,220	6%	159,638,789	-1%
Feeder (non-DLC)	17,247,498	24,570,818	42%	12,956,226	-25%	40,825,213	137%	3,880,751	-77%
Feeder (all)	178,012,222	196,622,709	10%	185,095,779	4%	212,036,433	19%	163,519,540	-8%
End Office Switching	225,522,567	225,522,567	0%	225,522,567	0%	225,522,567	0%	225,522,567	0%
Signaling	19,473,621	19,473,621	0%	19,473,621	0%	19,473,621	0%	19,473,621	0%
Dedicated Transport	65,274,219	63,412,706	-3%	64,744,627	-1%	67,551,247	3%	68,025,972	4%
Dedicated Transport Transmission	22,784,782	22,784,782	0%	22,784,782	0%	22,784,782	0%	22,784,782	0%
Direct Transport	46,790,211	45,417,872	-3%	46,438,646	-1%	48,255,199	3%	48,624,471	4%
Direct Transport Transmission	11,222,759	11,222,759	0%	11,222,759	0%	11,222,759	0%	11,222,759	0%
Common Transport	10,163,050	9,872,725	-3%	10,103,224	-1%	10,466,439	3%	10,552,338	4%
Common Transport Transmission	2,150,552	2,150,552	0%	2,150,552	0%	2,150,552	0%	2,150,552	0%
Tandem Switching	8,821,431	8,821,431	0%	8,821,431	0%	8,821,431	0%	8,821,431	0%
Operator Systems	12,034,456	12,034,456	0%	12,034,456	0%	12,034,456	0%	12,034,456	0%
Public Telephone	-	-	0%	-	0%	-	0%	-	0%
Total Investment	$ 2,992,048,712	$ 3,086,746,068	3%	$ 2,528,276,629	-16%	$ 3,370,126,592	13%	$ 2,410,919,848	-19%
Total Lines	1,969,732	1,969,732	0%	1,969,732	0%	1,969,732	0%	1,969,732	0%
Lines On DLC	1,836,254	1,825,789	-1%	1,812,375	-1%	1,814,866	-1%	1,861,242	1%
% Lines on DLC	93%	93%	-1%	92%	-1%	92%	-1%	94%	1%
USF Monthly Cost	$ 31.69	$ 32.06	1%	$ 27.61	-13%	$ 34.71	10%	$ 27.14	-14%
UNE Loop Cost	$ 27.66	$ 28.04	1%	$ 23.62	-15%	$ 30.64	11%	$ 23.15	-16%

Clusters are dense by their very nature -- in rural areas, much more dense than the surrounding countryside.

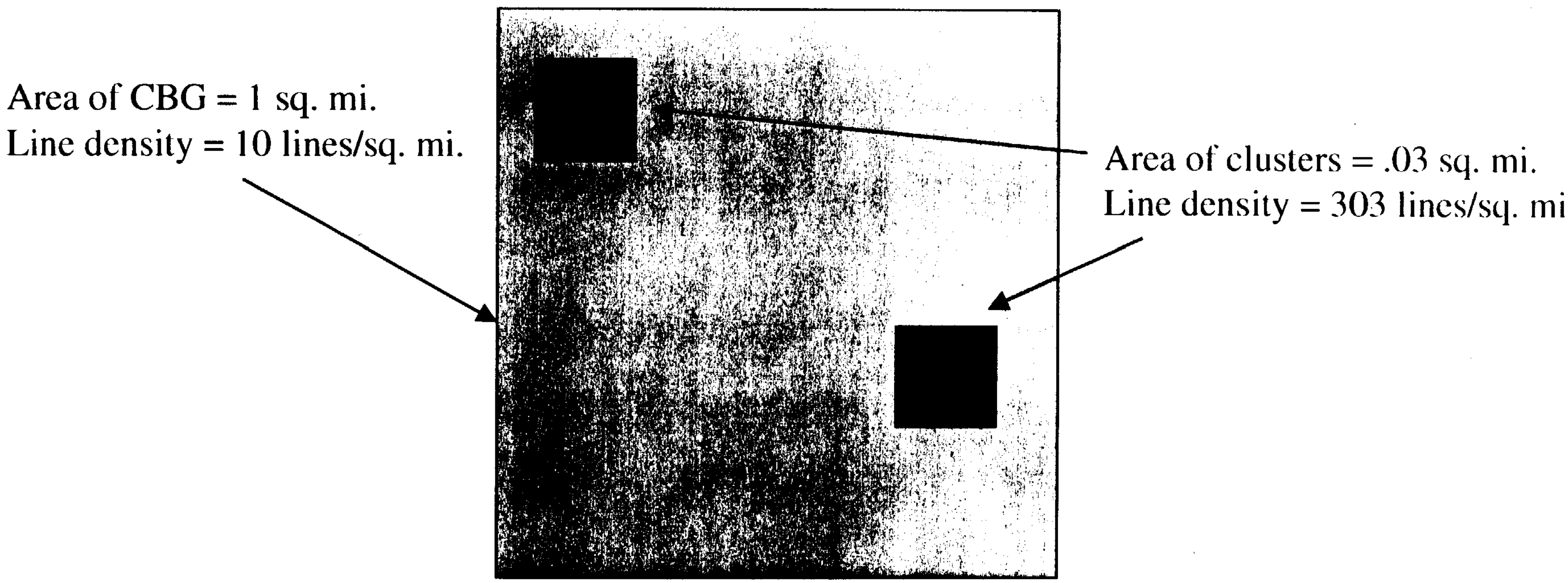
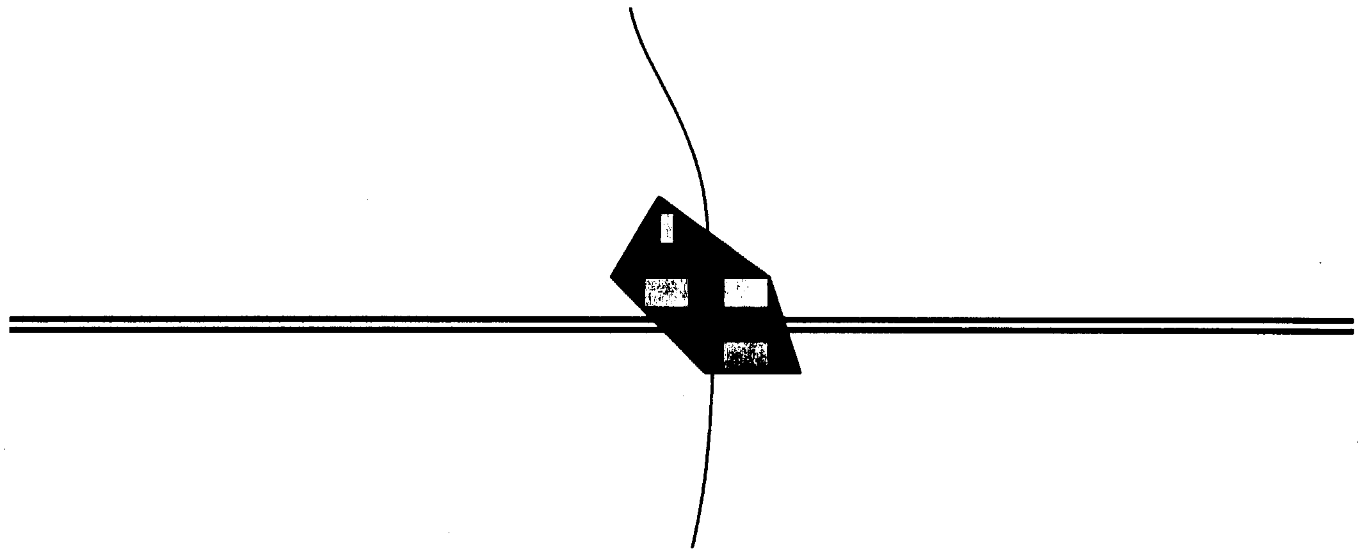


Figure 4

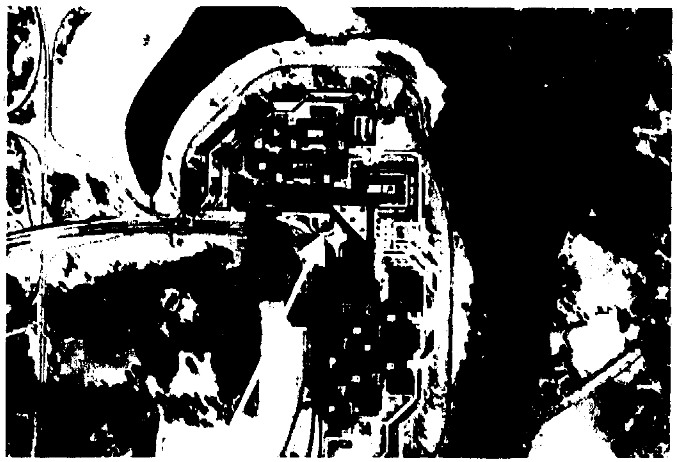
Consider a highway intersection in a rural area (nearest town 5 or 10 miles away). In an area of about five acres, there may be a gas station, a truck stop, a house, and a McDonald's, for a total of 25 telephone lines.



The line density of the cluster would be about 3200 lines/sq. mi., suggesting a far more urban environment with very difficult plant placement conditiond. But in the real world, underground plant would hardly be required.

Figure 5

Both AT&T and MCIWCOM headquarters are very dense Clusters (> 10K lines/sq. mi.). But construction conditions in suburban New Jersey and at 18th and H in downtown D.C. are very different.



205 N. Maple Ave.,
Basking Ridge, NJ

1801 Pennsylvania Ave., NW
Washington, DC

Figure 6

FIGURE 7

Alabama South Central Bell-Al	HAI 50a Default Investment	HAI 50a Cluster Density Investment	Impact of Definition Change
Network Element	(A)	(B)	(B/A)-1
NID	$ 45,224,405	$ 45,265,688	0%
Distribution (DLC)	744,940,807	853,281,463	15%
Distribution (non-DLC)	124,087,133	159,303,615	28%
Distribution (all)	869,027,939	1,012,585,078	17%
Concentrator (DLC)	281,049,036	281,053,797	0%
Concentrator (non-DLC)	2,971,068	2,969,978	0%
Concentrator (all)	284,020,104	284,023,775	0%
Feeder (DLC)	294,710,779	295,816,726	0%
Feeder (non-DLC)	45,409,359	46,521,526	2%
Feeder (all)	340,120,138	342,338,252	1%
End Office Switching	233,684,159	233,684,159	0%
Signaling	19,009,436	19,009,436	0%
Dedicated Transport	48,383,624	48,385,681	0%
Dedicated Transport Transmission	26,261,262	26,261,262	0%
Direct Transport	33,212,714	33,211,961	0%
Direct Transport Transmission	13,303,476	13,303,476	0%
Common Transport	7,225,173	7,225,283	0%
Common Transport Transmission	2,582,978	2,582,978	0%
Tandem Switching	8,817,064	8,817,064	0%
Operator Systems	10,882,837	10,882,837	0%
Public Telephone	12,698,839	12,698,839	0%
Total Investment	$ 1,954,454,148	$ 2,100,275,770	7%

Total Lines	1,968,210	1,968,210	0%
Lines On DLC	1,379,936	1,379,936	0%
% Lines on DLC	70%	70%	0%

USF Monthly Cost	$ 23.98	$ 25.60	7%
UNE Loop Cost	$ 18.72	$ 20.27	8%

FIGURE 8

Validation of Default Costs

327 Samples

Residential NID w/o Protector — *HAI=$10*

Price	Vendor
$6.85	v
$9.38	y
→ $9.80	w
$11.90	x

4 samples

w/1 protector	
$9.92	v
$12.43	y
$14.96	x
w/3 protectors	
$24.20	w

Note: Price used is Quote for SNI-2100 w/protector(s) minus "Add a Line" kit(s).

Residential NID Protector Block/Line — *HAI=$4*

Price	Vendor
$3.05	y
$3.06	x
→ $3.07	v
$4.80	w

4 samples

Business NID (6 Pair) w/o Protector — *HAI=$25*

Price	Vendor
→ $23.44	v
$28.65	w

2 samples

w/o protectors	
$23.44	v
w/6 protectors	
$57.45	w

Note: Price used is Quote for SNI-4600

Business NID Protector Block/Line — *HAI=$4*

Price	Vendor
$3.05	y
$3.06	x
→ $3.07	v
$4.80	w

4 samples

Bury Service Wire (Drop)/ft. Rural — *HAI=$0.60*

Price	Vendor
$0.55	n
→ $0.60	c
$0.60	d
$0.60	e
$0.60	m
$0.70	l
$0.74	f
$0.75	k
$0.75	p
$0.75	q
$0.90	i
$0.90	j
$0.95	b
$1.00	o
$1.30	a
$1.75	g

16 samples

Bury Service Wire (Drop)/ft. Suburban — *HAI=$0.75*

Price	Vendor
$0.63	n
$0.70	l
$0.72	f
→ $0.75	c
$0.75	d
$0.75	e
$0.75	k
$0.90	j
$1.00	m
$1.15	p
$1.15	q
$1.25	b
$1.50	o
$1.50	i
$1.90	g
$2.10	a

16 samples

Note: letters represent vendor code

Validation of Default Costs
327 Samples

Block Terminal Material Cost (Aerial Strand Mounted) ***HAI=$60***	
→ $58.55	*y*
$72.15	*z*

2 samples

Block Terminal Material Cost Buried Pedestal ***HAI=$90***	
$39.61	*ww*
$54.20	*ww*
$87.00	*x*
→ $90.00	*y*
$93.00	*x*

5 samples

Drop Wire Material Cost/ft. Aerial 2-Pair ***HAI=$0.095***	
→ $0.0947	*y*
$0.1130	*v*

2 samples

Drop Wire Material Cost/ft. Buried 3-Pair Filled ***HAI=$0.14***	
→ $0.140	*tt*
$0.197	*ww*

2 samples

Pole Investment Material 40' Class 4 ***HAI=$201***	
$150.00	*tt*
$189.68	*yy*
→ $201.27	*yy*
$201.17	*xx*
$217.49	*yy*
$219.81	*yy*
$248.04	*yy*
$240.00	*h*
$262.68	*yy*
$392.00	*x*

10 samples

Also see FCC* data containing 94 entries of values from $134 to $402.

Pole Investment Labor Rural 40' Class 4 ***HAI=$216***	
$150.00	*o*
$155.00	*n*
→ $216.00	*h*
$294.00	*f*
$300.00	*p*
$300.00	*q*

6 samples

Also see FCC* data containing 94 entries of values from $170 to $902.

Pole Investment Labor Suburban 40' Class 4 ***HAI=$216***	
$205.00	*n*
→ $216.00	*h*
$350.00	*o*
$392.00	*f*
$350.00	*p*
$350.00	*q*

6 samples

Also see FCC* data containing 94 entries of values from $170 to $1,161.

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*http://www.fcc.gov/Bureaus/Common_Carrier/Comments/da971433_data_request/datareq.html

Note: letters represent vendor code

Validation of Default Costs

327 Samples

Duct Material Cost/ft. ***HAI=$0.60***	Vendor
$0.515	*t*
$0.585	*u*
$0.648	*s*
3 samples	

Rock Saw/ Trenching Ratio ***HAI=3.5***	Vendor
1.3	*g*
1.8	*n*
1.9	*l*
2.1	*o*
2.5	*q*
2.8	*p*
3.6	*i*
4.6	*k*

Manhole Material ***HAI=$2,340***	Vendor
$1,350	*x*
$1,700	*o*
$2,340	*uu*
$3,100	*n*
$3,389	*v v*
$3,500	*k*
$4,720	*p*
$4,720	*q*
8 samples	

Manhole Excavation & Backfill Rural ***HAI=$2,800***	Vendor
$850	o
$1,500	n
$1,600	p
$1,600	q
$1,614	f
$1,750	g
$2,800	l
$3,500	i
$4,000	k
9 samples	

Manhole Excavation & Backfill Suburban ***HAI=$3,200-$3,500***	Vendor
$1,250	*o*
$1,830	*f*
$2,050	*g*
$2,100	*n*
$2,400	*p*
$2,400	*q*
$2,800	*l*
$4,200	*i*
$4,500	*k*
9 samples	

Manhole Excavation & Backfill Metro ***HAI=$3,500-$5,000***	Vendor
$1,700	*o*
$2,650	*g*
$3,140	*f*
$3,200	*l*
$3,500	*n*
$4,000	*p*
$4,000	*q*
$5,000	*k*
$8,500	*i*
9 samples	

Normal Trenching 24"	*l*
$2.40	*p*
$3.00	*n*
$3.18	*q*
$3.25	*k*
$3.50	*g*
$4.38	*i*
$5.00	*o*
$7.00	

Frost Wheel or Rock Saw Rural & Suburban 24"	*l*
$4.50	*g*
$5.75	*n*
$5.75	*q*
$8.00	*p*
$8.50	*o*
$15.00	*k*
$16.00	*i*
$18.00	
16 samples	

uu: 1 Quote @ $1865 less frame & cover +$125 delivery. Frame+Cover from "Nat'l Constr Estimator" @ $350.00 Total=$2,340

v v: 1 Bid @ $3150 plus $239 delivery Total=$3,389

Note: letters represent vendor code

Validation of Default Costs
327 Samples

Normal Trenching in Dirt with Backfill Rural/ft. 24" depth ***HAI=$2.81-$2.97***	
$2.00	*o*
$2.00	*p*
$2.15	*n*
$2.25	*q*
$2.40	*l*
$2.50	*p**
$2.60	*n**
$2.75	*q**
→	
$3.00	*o**
$3.30	*g*
$3.50	*k*
$3.90	*g**
$5.00	*i*
13 samples	

Normal Trenching in Dirt with Backfill Rural/ft. 36" depth ***HAI=$2.81-$2.97****	
$1.50	*b*
$1.87	*f*
$2.10	*a*
$2.50	*l*
$2.75	*n*
$2.75	*j*
→	
$3.00	*o*
$3.00	*p*
$3.15	*n**
$3.20	*c*
$3.25	*q*
$3.30	*d*
$3.30	*e*
$3.40	*g*
$3.50	*o**
$3.50	*p**
$3.75	*q**
$4.00	*g**
$4.50	*k*
$4.93	*h*
$6.00	*i*
21 samples	

Normal Trenching in Dirt with Backfill Suburban/ft. 24" depth ***HAI=$2.81-$3.88****	
$2.40	*l*
→	
$3.00	*p*
$3.25	*n*
$3.25	*q*
$3.45	*g*
$3.50	*k*
$3.50	*p**
$3.75	*n**
$3.75	*q**
→	
$4.85	*g**
$5.00	*i*
$9.00	*o*
$11.00	*o**
13 samples	

Normal Trenching in Dirt with Backfill Suburban/ft. 36" depth ***HAI=$2.81-$3.88****	
$2.00	*b*
$2.46	*f*
$2.50	*l*
→	
$3.10	*j*
$3.50	*a*
$3.60	*n*
$3.60	*g*
→	
$3.90	*h*
$4.00	*p*
$4.10	*n**
$4.25	*c*
$4.25	*q*
$4.50	*d*
$4.50	*e*
$4.50	*k*
$4.50	*p**
$4.75	*q**
$4.90	*g**
$6.00	*i*
$11.00	*o*
$15.00	*o**
21 samples	

Trenching in Pavement with Restoral Metro/ft. 24" depth ***HAI=$13.58 & $48.85***	
$7.50	*k*
$8.85	*g*
$9.60	*g**
$12.00	*p*
$13.00	*q*
$13.10	*j*
$13.50	*n*
→	
$14.00	*p**
$15.00	*o*
$15.00	*q**
$16.20	*n**
$19.00	*o**
$42.00	*l*
→	
$60.00	*i*
14 samples	

Trenching in Pavement with Restoral Metro/ft. 36" depth ***HAI=$13.58 & $48.85***	
$7.40	*f*
$8.50	*k*
$8.60	*c*
$8.80	*d*
$8.80	*e*
$9.10	*g*
$9.80	*g**
$9.87	*h*
$10.00	*b*
$10.50	*a*
→	
$14.00	*p*
$14.25	*n*
$15.00	*q*
$16.00	*p**
$17.00	*o*
$17.00	*q**
$17.50	*n**
$22.00	*o**
$42.00	*l*
→	
$63.00	*i*
20 samples	

12" wide trench price as well as 6" trench price was submitted

****Equivalent Default Values Excluding Plowing, Boring, and Pushing Pipe***

Note: letters represent vendor code

Validation of Default Costs
327 Samples

Plow Cable Rural/ft. 24" depth ***HAI=$0.80***		Plow Cable Rural/ft. 36" depth ***HAI=$0.80***		Plow Cable Suburban/ft. 24" depth ***HAI=$1.20***		Plow Cable Suburban/ft. 36" depth ***HAI=$1.20***	
Normal		**Normal**		**Normal**		**Normal**	
$0.40	*p*	$0.50	*p*	$0.85	*k*	$0.90	*j*
$0.50	*q*	$0.60	*q*	$1.15	*g*	$0.95	*k*
$0.75	*l*	→ $0.80	*l*	$1.15	*n*	$1.05	*b*
→ $0.80	*k*	$0.90	*a*	→ $1.20	*l*	→ $1.20	*g*
$0.85	*n*	$0.90	*j*	$1.50	*p*	$1.25	*c*
$1.10	*g*	$0.90	*k*	$1.60	*q*	$1.30	*a*
$1.50	*i*	$0.92	*f*	$2.00	*o*	$1.30	*l*
$1.50	*o*	$0.95	*b*	$3.50	*i*	$1.35	*d*
		$0.95	*n*			$1.35	*e*
		$1.15	*g*			$1.57	*f*
		$1.25	*c*			$1.65	*n*
		$1.35	*d*			$1.90	*p*
		$1.35	*e*			$2.00	*q*
		$1.75	*i*			$2.95	*o*
		$2.00	*o*			$4.00	*i*
More Difficult		**More Difficult**		**More Difficult**		**More Difficult**	
$0.75	*l*	$0.80	*l*	$0.85	*k*	$0.95	*k*
$0.80	*k*	$0.90	*k*	$1.20	*g*	$1.25	*b*
$0.80	*p*	$1.00	*p*	$1.20	*l*	$1.30	*l*
$0.90	*q*	$1.10	*q*	$1.95	*n*	$1.40	*g*
$1.15	*n*	$1.15	*b*	$2.75	*p*	$1.40	*j*
$1.20	*g*	$1.20	*f*	$2.85	*q*	$1.87	*f*
$1.50	*i*	$1.25	*g*	$3.50	*i*	$2.35	*n*
$2.00	*o*	$1.40	*j*	$4.00	*o*	$2.50	*c*
		$1.40	*n*			$2.70	*d*
		$1.75	*i*			$2.70	*e*
		$2.00	*a*			$2.90	*a*
		$2.25	*c*			$3.75	*p*
		$2.50	*d*			$3.85	*q*
		$2.50	*e*			$4.00	*i*
		$2.95	*o*			$6.00	*o*
Ratio		**Ratio**		**Ratio**		**Ratio**	
1.00	*i*	1.00	*i*	1.00	*i*	1.00	*i*
1.00	*k*	1.00	*k*	1.00	*k*	1.00	*k*
1.00	*l*	1.00	*l*	1.00	*l*	1.00	*l*
1.09	*g*	1.09	*g*	1.04	*g*	1.17	*g*
1.33	*o*	1.21	*b*	1.70	*n*	1.19	*b*
1.35	*n*	1.30	*f*	1.78	*q*	1.19	*f*
1.80	*q*	1.47	*n*	1.83	*p*	1.42	*n*
2.00	*p*	1.48	*o*	2.00	*o*	1.56	*j*
		1.56	*j*			1.93	*q*
		1.80	*c*			1.97	*p*
		1.83	*q*			2.00	*c*
		1.85	*d*			2.00	*d*
		1.85	*e*			2.00	*e*
		2.00	*p*			2.03	*o*
		2.22	*a*			2.23	*a*
16 samples		30 samples		16 samples		30 samples	

Note: letters represent vendor code