merely the calculated cost minus the support threshold of $30. The final column is the total CBG support, which is the support requirement per household multiplied by the number of households. In this example, three of the five individual CBGs would require support, amounting in the aggregate to $101,765.

Line Costs Compared Separately for Each CBG:

$$USF = \sum_{i=1}^{5} (\text{Support})CBGs_i = \$101,765$$

Table 6.1

Costs Are Too High if Based upon CBG Averages
Illustrative Analysis of Wire Center AVONCOMA, Colorado
Assumes Cost Support at $30 Per Line Level[153]

CBG	Households (H.H.)	Monthly Cost/Line	Support/Line	CBG Support
80379534002	144	$ 50.15	$ 20.15	$ 34,813
80379534004	177	$ 15.52	-	-
80379534003	595	$ 22.76	-	-
80379534005	266	$ 36.65	$ 6.65	$ 21,220
80379534006	771	$ 34.94	$ 4.94	$ 45,732
Total	1953			$ 101,765

Now take the alternative approach in which support is calculated at the wire center level. Utilizing the same five CBGs, the total cost in the final column is the monthly cost per household multiplied by the number of households, then multiplied by 12 to annualize the costs. Using this approach, the weighted average of the monthly cost per line is $30.82, an amount that barely qualifies the wire center for support at the $30 threshold, and the total support requirement across the wire center drops to $21,548. The major difference between this approach and the former is that high cost CBGs are counterbalanced by the low cost CBGs. Thus, by looking at high cost support requirements over the broader unit

153. See Appendix 6.

of a wire center, the overall support is significantly lower.[154] As this example shows, for those wire centers that straddle inexpensive and expensive CBGs, the difference between determining support strictly on a CBG-specific basis and determining it by rolling up results to the wire center level can be very large (in our example, $80,217 a year for a single wire center).

CBG-Based Line Costs Aggregated and Compared for the Wire Center:

$$USF=[\ \sum_{i=1}^{5} (\text{Weighted Cost})CBG_i \text{ divided by } \sum_{i=1}^{5} (\text{Households})CBG_i]$$

minus $30 * 12 months = $ 21,548

Table 6.2
Costs Should Be Aggregated to the Wire Center
Illustrative Analysis of Wire Center AVONCOMA, Colorado
Assumes Cost Support at $30 Per Line Level

CBG	Monthly Cost/Line	Households	Total Cost
80379534002	$ 50.15	144	$ 86,664
80379534004	$ 15.52	177	$ 32,964
80379534003	$ 22.76	595	$ 162,504
80379534005	$ 36.65	266	$ 116,988
80379534006	$ 34.94	771	$ 325,508
Total	$ 30.82	1953	$ 724,628
Less Threshold			$ 703,080
Total Support per ETI corrections			$ 21,548

154. Of course, there are also many wire centers for which aggregating costs to the wire center level would not affect the support requirement. Such is the case when a wire center serves all high-cost CBGs (e.g., a completely rural area) or all low-cost CBGs (e.g., an area of moderate density). The incidence of exchanges containing both CBGs that would require support and ones that would not is also directly affected by the specification of the affordability threshold: with a lower threshold (e.g., $20), a significant number of wire centers have CBGs falling both above and below the threshold, whereas with a higher threshold (e.g., $40), there is a significantly lower incidence of "mixed" results.

This illustrative analysis shows an 80% reduction in the USF requirement that is actually needed. In order to implement ETI's correction on a statewide (or national basis), the Joint Sponsors would need to revise the model to allow for aggregation of cost results at the wire center level.

Competitors will seek out opportunities to develop their own economies of scale and scope, and will not find it efficient to limit service to discrete CBGs

Some have suggested that the geographic unit for determining both cost and universal service support must be very small, in order to prevent competitors from "cream-skimming." According to this argument, allowing higher- and lower-cost CBGs within a wire center to cancel each other out is fine so long as the LEC is serving the whole area, but not appropriate if a competitor can selectively "pick off" customers in the lower-cost CBG and leave the incumbent with the unsupported higher costs in the remainder.

As a general matter, the history of other telecommunications markets that have been opened to competition shows that concerns about "cream-skimming" and niche marketing as an entry strategy are typically misplaced and overstated. For example, initial niche competition in the long distance market matured into robust competition in the small business and residential markets. That robust competition itself has had the effect of lowering prices and making service more affordable for consumers, and is a far more efficient means of promoting affordable service than the indirect and distorting approach of requiring all providers to contribute to "social pricing." Moreover, although interexchange carriers confront lower average costs for serving customers in urban and metropolitan areas than in remote communities that are distant for the interexchange carriers' (IXC) "points of presence," IXCs offer service ubiquitously throughout the US and do not engage in geographic rate deaveraging or offer better prices to their urban customers.

There are several reasons why it is implausible that competitive providers of local exchange service will selectively pick off individual CBGs to serve, shunning selective high-cost CBGs within a wire center:

- It would be inefficient for a new entrant to design a network to serve such small segments because they would not be likely to be able to recover fixed costs if they were allocated over only units of 400 lines.

- Facilities-based competitors will seek to exploit their own economies of scale and scope (e.g., cable companies will serve, at a minimum, their franchise areas, not smaller niches).

- Distribution systems are not typically engineered to "hop around" to noncontiguous 400-customer serving areas, but rather are designed to radiate out from the center.

- The desirability of serving any particular area varies not only by the cost to serve but also by the anticipated revenue stream (i.e., not every high-cost area is undesirable to serve).

- Advertising for customers through mass media (e.g, newspapers and television) is not conducive to targeting such minuscule markets.

The question of how to define the appropriate area within which to assess the need, if any, for universal service support is an entirely different question from the question of how to define the areas that local exchange carriers should be required to serve.

6.2 The failure to eliminate costs incurred to enable the provision of second (and additional) lines would grossly distort universal service support requirements

As discussed previously, just as it is indisputable that a residential customer's first exchange access line meets the Act's criteria defining universal service, it is just as plain that a customer's second or additional lines do not fall within the definition. Additional residential access lines are not necessary for public health or safety, are not subscribed to by a significant portion of households (let alone a significant majority), and are, by and large, still used by more affluent customers for discretionary purposes (e.g., children's phone).

The inclusion of additional residential access lines within the scope of universal service would not be an issue if the aggregate capital investment (and associated revenue requirement) for the provision of residential service were unaffected by the potential demand for additional lines. Were that the case, any revenues derived from additional lines would be pure "gravy" from the perspective of the LEC. In fact, however, in order to provide capacity to satisfy demand for additional lines, LECs have designed and constructed far more extensive feeder and distribution infrastructures than would have been required for a "one line per household" service objective.

The costs of additional lines must be identified and removed from the aggregate cost of distribution plant to arrive at the economic cost of providing universal service

For context, it is helpful to start with a brief overview of the architecture of LEC outside subscriber plant. LEC subscriber outside plant is configured in a tree-and-branch type of architecture beginning at the serving central office building (the wire center). *Feeder cable* leaves the central office building in several different directions. At various points along its route, the feeder passes through a *Service Area Interface* (SAI) in which a portion of the total feeder cable capacity is cross-connected to a network of *distribution cables* that serve up to several hundred customers, usually located within 1,000 to 3,000 feet of the SAI.[155] Distribution cables run down individual streets and roads in the area subtending the SAI, where individual twisted copper pairs are connected to *drop wires* serving individual houses along the route. In the case of (relatively large) multiple-unit buildings, the SAI might be physically located within the building itself, with the *building cable* serving to distribute the service to individual apartments.

There is an inextricable relationship between the design of the outside plant and the demands for service that it is expected to satisfy. Also, because of the relatively high fixed costs of initial construction, the quantity of plant that is placed must be sufficient to satisfy demand for a reasonable period of time. Thus, in specifying an outside plant construction job, the LEC confronts an economic trade-off between incurring higher *initial* costs (to provide additional capacity for growth) vs. higher *future* costs if more frequent relief jobs are required because insufficient capacity was installed at the outset.

The three principal *drivers* of the investment cost of subscriber outside plant are (1) the initial base capacity, (2) the anticipated growth in capacity demand over the life of the plant, and (3) the variability (volatility) of demand for capacity over time. If demand were fixed (i.e., not growing) and stable (not variable) over the anticipated life of the installation, there would be no need to construct additional spare capacity at the outset; all that would be required is capacity minimally necessary to satisfy the known demand, with allowances for maintenance/administrative spare and for "breakage" (i.e., the need to order the next highest capacity cable, which is available in discrete capacity units). But subscriber outside plant supports a number of *different* services and demands, including the initial residential access line, additional residential access lines, business exchange access lines and trunks, private lines, and other special services. To the extent that these services may exhibit significantly different growth and variability characteristics, they impose capacity demands on the outside plant *that are not in direct proportion to actual utilization.*

155. The current version of the BCM does not include the costs of the SAI. Apparently the next version will include these costs. California PUC, Universal Service Proceeding, *A Discussion of Assumptions used in the Hatfield Model, op. cit.*, footnote 27, at 10.

It is also important to note that, with respect to outside plant, the facilities requirements that are imposed by the first residential access line in each dwelling unit are extremely stable — indeed, probably the most stable and predictable of any of the categories of service that are provided by a LEC. If demand for residential access were limited to one line per household, there would be no need for the LEC to provide distribution capacity for either growth or to accommodate variability and churn.

An illustration may be helpful. Assume a street that has 80 households, each with a single residential access line. The distribution cable necessary to meet the requirements of this street would have 80 working lines, plus approximately 10% spare capacity (for maintenance requirements). Using standard cable sizes, the distribution plant would be provided over a 100-pair cable, with a ratio of working lines to total lines of 80%. Now, assume that the LEC knows that, on average, 20% of residential customers order a second line, but does not know which customers will request an additional line (or possibly more than one additional line). Thus, the LEC decides to install (on average) two pairs per household, increasing the number of pairs on the street to 160. With maintenance and administrative spare (again, 10%), the number of lines required totals 176, and the cable size deployed will need to be 200-pair cable. But, since the average demand for second lines is only 20%, only 16 more access lines in addition to the original 80 (first) access lines are actually utilized. In this example, including the capability to serve additional residential access lines results in a doubling of cable capacity and causes the utilization to drop from 80% to an extremely low 48%.

The foregoing discussion clearly illustrates that the aggregate cost of the distribution plant would be lower if it were designed solely to support a one-line-per-household demand. Building distribution plant piecemeal is not efficient, however. Thus, there is no argument that the distribution infrastructure should be built to accommodate more than the core one-line level of demand, recognizing the demand for additional services and because the incremental cost of building these additional units of capacity is significantly less *at the time of initial construction.* Nonetheless, to arrive at the economic cost of meeting the universal service objective, the costs for additional lines must be stripped away from the aggregate cost of constructing distribution plant. The *maximum* cost level that can legitimately be ascribed to universal service would be the stand-alone cost of constructing plant just sufficient to satisfy the non-growing, non-variable first line demand.

Universal service customers must obtain a reasonable share of the benefits arising from scale and scope economies

However, the costs that should actually be recovered through a universal service mechanism are *considerably less than* this upper limit. If the entire stand-alone cost is assigned to universal service, then all of the benefits associated with the economies of scale

and scope that result from the ubiquitous deployment of plant would flow to services *other than the first residential access line*. Such a result would stand universal service policy on its head, and violates both the Act's definitional guidelines and its prohibition against cross-subsidization.

Again, the previous example is helpful to illustrate our point. Suppose that the stand-alone cost of the 100-pair installation (the one-line-per-household case) is $14,000, and that the cost of installing a 200-pair cable (the size that will accommodate first lines as well as additional lines) is $20,000. Under the stand-alone cost method, the entire $14,000 would be assigned to the 80 first line pairs, representing an investment cost of $175 per working primary access line. The cost for the additional 100 pairs placed to accommodate demand for additional residential lines would require (if placed at the same time as the first 100 pairs) is an additional $6,000. If seen in this light, the additional cost of the second 100 pairs is only 30% as much as the base cost of the first 100 pairs. In this example, this significant cost reduction in the construction of the additional lines is directly attributable to the deployment of the first 100 pairs: in other words, it represents a benefit from an economy of scale that arises directly from the LEC's fulfillment of its universal service obligation.

If the entire stand-alone cost of the first 100 pairs ($14,000) is assigned to universal service, then 100% of the gains from the economy of scale will flow to *additional lines* and none will inure to the benefit of universal service customers. The benefit at issue in this example is $8,000 — i.e., the difference between the $14,000 stand-alone cost of the second 100 pairs and the $6,000 additional cost that the LEC actually incurs. *There is no defensible policy reason why 100% of that $8,000 benefit should flow to discretionary services or to LEC shareholders, with none of it flowing back to defray any portion of the cost of furnishing the universal service primary residential access line.*

To address this issue, an economically reasonable method must be developed to apportion such benefits to the two distinct uses of the shared distribution cable. There are several alternative methods for achieving such an apportionment:

- *Apportion the benefit on the basis of capacity committed to each service category:* using the previous example, since 100 pairs are deployed to serve "first line" demand, and an additional 100 pairs are placed in order for the LEC to satisfy "additional line" demand, the $8,000 of economy of scale would be spread according to the ratio of 100:100, or $4,000 to each category. The $14,000 stand-alone cost (applicable to either of the two groups of 100 lines) would be reduced by $4,000, so that both the first and the additional lines would each be assigned a cost of $10,000. Expressed on a per working line basis, the cost per first line would be $125 (i.e., $10,000 / 80), whereas the cost per working additional line (20% of 80 households, or 16 lines) would be $625.

- *Apportion the benefit on the basis of working loops associated with each service category:* In our example, there are a total of 96 working lines (80 first lines plus 16 additional lines). Spreading the $8,000 of economy of scale across these 96 working lines results in a per-line benefit of $83.33. Thus, $6,667 of benefits would be assigned to the first line service (80 x $83.33) and $1,333 of benefit would flow to the additional line service (16 x $83.33). This would result in a per-line cost for first lines of $91.67 [($14,000 / 80) – $83.33] and for additional lines of $791.67 [($14,000 / 16) – $83.33].

By contrast, the costing process employed by the LECs to allocate the shared costs of outside plant between first and additional lines puts a disproportionate cost burden on first (universal service) lines. The LEC methodology makes no distinction among services that share outside plant with respect to their relative growth and variability. Rather, it incorrectly calculates a per-working-pair unitized cost through a process that implicitly assigns all *unused capacity* in direct proportion to in-service capacity. This is accomplished by simply dividing the total cost of the outside plant by the number of working pairs. In our previous example, the LEC process calculates a per-working-pair cost of $208.33, by dividing the total $20,000 cost by the 96 working pairs. This methodology produces a total assignment of cost to the first line, universal service category of $16,667 which, in our example, is substantially in excess of the $14,000 stand-alone cost of providing for first line demand. The method also assigns only $3,333 of cost to the additional line demand. Thus, not only does the *entire benefit* of the scale economy flow to the additional line capacity, the first line service is actually made *worse off* than it would have been if the plant had been designed to accommodate first line demand only, i.e., at a cost of only $14,000.

There is no economic rationale for merely spreading spare capacity in proportion to in-service capacity, since the need for spare is not driven by the static quantity of in-service demand extant at any given point in time. In our example, the 80 working first line pairs account for 5/6th of the total working pairs in the cable, yet have no requirement for *any* spare capacity other than for maintenance and administrative purposes. The decision to construct an additional 100 pairs was driven entirely by the potential demand for *additional lines*, and should be assigned to that category of service. Instead, the LEC "proportionate allocation of spare capacity" method assigns 5/6ths of the total spare to *first lines* when in fact *none* of the additional 100 pairs are required for or utilized by first line service demand.

The additional costs of providing capacity for second lines are not insignificant

LECs seek to portray the additional costs of deploying additional capacity at the time of initial construction as being minimal, implying that the policy of providing capacity for

additional lines and other (non-universal) service demands imposes little extra investment costs on the LEC. In fact, evidence adduced in the California Universal Service Proceeding suggests that the additional costs for this extra capacity may be quite substantial. In particular, it appears that the sizing and placement of Service Area Interfaces (SAIs) is driven by the total potential capacity demand rather than the number of initially-deployed working loops. Thus, if the "ideal" size of an SAI (for a given neighborhood) is 400 lines, the SAI will be assigned to only 200 dwelling units, on the basis of a potential demand of two lines per unit. The proliferation of SAIs will impose additional capacity costs on the feeder cables that connect the SAIs with the central office. Additional fiber strands and associated electronics (pair gain equipment) will be required for SAIs served by fiber, and additional copper feeder capacity to serve the more fragmented SAI architecture may also be needed. The proliferation of SAIs may also result in inefficient choices being made as between the use of copper vs. fiber optic feeder cable. The "crossover point" between these two technologies is a function of distance and capacity. Deloading of SAIs may make fiber feeder more costly on a per-working-pair basis, leading to more use of copper than might otherwise occur.

Any model used to determine universal service costs must correct for the overstatement of universal service costs incurred to accommodate demand for additional residential lines and other services

In summary, it seems clear that the aggregate cost of providing outside plant has been materially increased by virtue of the LECs' decisions to accommodate the demand for additional residential access lines and other services that go well beyond any universal service obligation. There are several potential methods of addressing and correcting this overstatement of universal service costs:

(1) Calculate service-specific objective working fill (utilization) factors based upon each service's rate of growth and variability of demand.

(2) Calculate the stand-alone cost of an infrastructure sized to support only first residential access line demand.

(3) Calculate the stand-alone cost of an infrastructure sized to support all services *other than the initial residential access line.*

(4) Calculate the differential between (2) and (3), and calculate a per-loop unit economy of scale benefit by dividing that differential amount by total working loops.

(5) Calculate a unit cost per working pair separately for first line (universal service) and for all other services as follows:

For first line loops: (2)/working first line pairs – (4)

For other loops: (3)/working non-first line pairs – (4)

6.3 The fill factors for the feeder and distribution should be increased

What the model does

The fill factors, which are a significant cost driver in the BCM, are significantly lower than they should be for a network designed to serve one line per household. The low fill factor results in exaggerated cost results because the model "deploys" excess capacity in order to satisfy the user-specified "objective" fill. Objective fill is the fill for which one engineers. Actual fill could actually be less than the objective fill as the following example illustrates. For example, assume the modelling of service to 26 households in the least dense zone. The BCM's objective fill of 25% for distribution means that for every 25 lines in service, there is an assumed need for spare capacity of 75 lines. Using this rule, for the 26 lines to serve the 26 households, the model identifies a need for 104 lines. However, this requirement is then added to a second rule that recognizes that the cable is sized in 100 pair increments (anything over a 100 pair requirement must go to a 200 pair cable). Thus, in the example, the rule would put 26 lines on a 200 pair cable, resulting in an actual fill factor of 26/200 or 13%. This result is not a flaw in the model but is simply an inevitable characteristic of engineering for spare capacity.

However, there is an apparent flaw in the BCM: The extremely low fill factors for distribution suggest that the BCM is modelling the expectation of large amounts of growth in second lines. The inappropriate inclusion of excessive spare capacity not related to the provision of primary basic telephone lines is a major issue that must be addressed. Because of the significance of this issue, it is addressed in detail earlier in the previous section of this chapter.

What the model should do

We have engineered the BCM's network using objective fill factors of 95% for the feeder plant and the distribution plant *assuming 100% primary access line penetration*. This objective fill allows for a minimum of (and often much more than) 5% spare capacity. Recognizing that the BCM engineers a network to serve *all* households, yet, the national

subscribership is 93.8%,[156] the results of a national run should be divided by this percentage for a final number, or, alternatively, results of state-specific runs should be divided by the penetration rates of the individual states. This calculation reflects the fact that the BCM "deploys" lines to all households yet at any given time approximately 6.2% are not connected.

Using the ETI corrected fill factor of 95%, not only will spare capacity rarely fall below 10%, much of the time it will be greatly in excess of 10% as is illustrated in the simplified analysis reflected in Table 6.3 below.

Table 6.3

Cable Sizing Means that Actual Fill Will Be Significantly Less than Objective Fill
Illustrative Analysis
(95% Objective Fill)

No. of HH	Cable Size	Actual Fill
47	50	94%
48	100	48%
50	100	50%
60	100	60%
70	100	70%
80	100	80%
95	100	95%
96	200	48%

ETI reran the BCM using the corrected fill factor of 95% for the distribution and feeder plant in all density zones (see Table 6.4).

156. FCC Monitoring Report, May 1995, Table 1.1, at 18 (Subscribership Data for November, 1994).

Table 6.4

BCM Fill Factors for Cable Should Be Increased

	BCM		ETI Correction	
Density (HH/Sq. Mile)	Feeder	Distribution	Feeder	Distribution
0-5	65%	25%	95%	95%
5-200	75%	35%	95%	95%
200-650	80%	45%	95%	95%
650-850	80%	55%	95%	95%
850-2550	80%	65%	95%	95%
>2550	80%	75%	95%	95%

For this computer run we corrected the fill factor and, with the exception of adjusting the related structure costs, we did not incorporate any other ETI corrections. Increasing the fill factor implicitly raises the issue of the structure costs because of the BCM's algorithms for costing outside plant. The BCM includes structure cost multipliers to reflect the cost of deploying copper and fiber, with the multipliers varying depending upon several factors (e.g., whether the terrain is urban or rural and whether the cable is aerial or buried). The way the BCM is designed results in an entirely linear relationship between the size of the cable itself and the structure costs associated with installing the cable.[157] However, it is unlikely that the relationship is entirely linear because, for example, in rural areas, even if the cable size is reduced (thus reducing the cable costs), the structure costs are unlikely to decrease by a corresponding magnitude — there are certain structure costs associated with deploying cable that simply do not diminish even if the size of the cable is scaled back.[158]

157. Joint Submission, September 12, 1995, at 30-31.

158. According to one of the Joint Sponsors, were a user to increase the fill factor, it would not be necessary to make any other changes to the BCM, because the structure costs would and *should* change in a corresponding manner. Conversation with James Dunbar (Sprint), March, 1996. We believe that this effect is implausible, however, and thus have conducted runs of the BCM with and without modifications to the structure cost multipliers.

Because this characteristic is most pronounced in rural areas, we modified the distribution cable multipliers to correct for this effect.[159]

Correcting the fill factor, and increasing the structure cost multipliers for the distribution cable plant resulted in a revised average cost for the state of Washington of $14.83, approximately $2.00 less than the BCM uncorrected results.[160] However, an examination of the results page of this run, which is included in Appendix 8B, shows that we have in effect over-compensated for the structure multiplier because the ETI results — despite the higher fill factor — yield *higher* costs for the lowest density zone than does the uncorrected BCM. Therefore, we also ran the BCM with a corrected fill factor of 95% without adjusting the distribution cable multiplier, i.e., using the BCM's default multipliers. This run yielded an average cost for the State of Washington of $13.69,[161] a result which does not adequately reflect the structure costs in rural areas, i.e., which under-compensates for the effect. Finally, we increased the structure multipliers (relative to the BCM), but to a level less than the original over-stated adjustments. The effect of using these multipliers and the correct fill factor of 95% was an average cost of $14.37.[162] These adjustments to the multipliers are reflected in our analysis in Chapter 8, below. Furthermore, absent any more compelling information, we recommend that they be used in future runs of the BCM.

6.4 The BCM makes an uneconomic choice between deploying copper and fiber in the feeder plant

One of the critical "decisions" that the BCM must make is when to deploy fiber rather than copper in the feeder plant. The deployment of fiber also requires the use of digital loop carrier equipment,[163] which is a significant component of the total average cost per

159. As discussed below, we also examined the sensitivity of the BCM to varying this structure multiplier adjustment.

160. This result reflects solely the correction to the fill factor. See Appendix 8B. Specifically, we multiplied the distribution cable multiplier by 20 if the household density for a CBG was less than 200 and the total number of households was less than 200. We multiplied the distribution cable multiplier by 3 if the household density was less than 200 and the total number of households was between 200 and 400. These adjustments were made in the Data & Calcs sheet of the Data Module.

161. Appendix 8B.

162. We multiplied the distribution cable multiplier by 10 for CBGs with a density of less than 200 households per square mile and fewer than 200 households. We multiplied the distribution cable by 3 for CBGs with a density of less than 200 households per square mile and between 200 and 400 households.

163. Digital loop carrier equipment is multiplexing equipment that combines multiple electronic signals onto a single bit stream for transmission over fiber.

line. Thus, there are two related aspects of this portion of the BCM that merit particular scrutiny: (1) The algorithm in the BCM which simply "decides" to deploy fiber in all instances where the total distance of the feeder and distribution plant exceeds 12,000 feet *regardless* of the capacity of cable being deployed and (2) the costs that are assumed for the digital loop carrier equipment.

As explained in Chapter 3, the BCM deploys copper main feeder to CBGs that have a total distribution distance (feeder and distribution) less than 12,000 feet and deploys fiber main feeder to CBGs that have a total distribution distance in excess of 12,000 feet, and selects one of two types of digital loop carrier equipment for these CBGs on the basis of household density.[164]

Implicit in this particular algorithm are important assumptions by the Joint Sponsors regarding the proper engineering of a local exchange network and the cost components that drive network development. First, the copper/fiber tradeoff for each CBG is made in isolation of other CBGs in the same quadrant. For example, the BCM assigns copper feeder to a CBG that has a total distribution distance that is less than 12,000 feet even when CBGs further out along the same main feeder route are served by fiber. In other words, the BCM would, in this case, deploy copper feeder alongside fiber feeder in the same conduit as opposed to using fiber feeder for all CBGs in the quadrant. The latter method would appear to be the more cost effective alternative as the cost of adding additional strands of fiber to serve the closest CBG would most likely be less expensive than the cost of deploying copper plant along the entire main feeder segment required by the first CBG.

One would expect that the copper/fiber crossover point that is "hardwired" into the BCM would reflect the economic crossover point between the deployment of copper and fiber feeder plant, that is, at a total distribution distance of 12,000 feet one would be indifferent as to the selection of copper or fiber main feeder plant from a cost standpoint. This assumption is complicated by the BCM's use of total distribution distance (feeder and distribution) as the point of reference for selecting a main feeder plant type as opposed to basing that decision on the length of the main feeder alone. For example, the BCM would allocate fiber main feeder plant to a CBG with a 2,000 foot main feeder segment and a total distribution distance within the CBG of 11,000 feet.[165] In contrast, a CBG that had a 10,000 foot main feeder segment and only a 1,000 foot distribution plant requirement would be served by copper main feeder plant because the total distribution distance is less than 12,000 feet. Furthermore, even if these two CBGs had the same number of households and

164. AT&T's "SLC" (Subscriber Line Carrier) is assigned to CBGs in the five largest household density classes and Advanced Fiber Communications' "AFC" is assigned to CBGs in the lowest household density class.

165. 2,000 foot main feeder distance + 11,000 foot distribution distance = 13,000 foot total distribution. The BCM assigns fiber main feeder to CBGs with total distribution distance over 12,000 feet.

the same household density, the first would be assigned a 2,000 foot fiber main feeder segment while the latter would be assigned a 10,000 foot copper main feeder segment.

We tested the implicit assumption that a 12,000 foot total distribution distance represents an economic crossover point for copper and fiber main feeder and determined through two different types of analyses that the BCM's 12,000 foot crossover point as presently constructed does not deploy the most cost effective network configuration. First, we ran the entire BCM using Washington State data and various crossover points for copper and fiber feeder plant.[166] Without altering any of the BCM's other user inputs we decreased the copper/fiber crossover point from 12,000 feet to 9,000 feet. Not surprisingly, this change resulted in an increase in the statewide average monthly cost from the default level of $16.94 to $17.84. We then increased the copper/fiber crossover point to 15,000 feet, again leaving all other user inputs and algorithms unchanged, and found that the statewide average monthly cost for Washington State decreased by $0.72 per month to $16.22. As illustrated in Table 6.5 below, the average monthly cost continued to decline as we increased the copper/fiber crossover point successively from 15,000 feet to 18,000 feet, to 21,000 feet, and finally to 24,000 feet. This analysis proves that on a statewide basis, the BCM's 12,000 foot copper/fiber crossover point, when used with the Joint Sponsors' default per line costs for SLC and AFC electronics of $500 and $550 (with the BCM's assumed discounts) does not lead to the most efficient network possible. Thus, the algorithm and the cost input data are contradictory: Our analysis shows that, if the cost data that the BCM assumes are realistic then the BCM's copper/fiber trade-off decision is uneconomic. Alternatively, if, for the sake of argument, the BCM's algorithm for the copper/fiber trade-off decision is "correct" then clearly the cost data are wrong.

166. The Main Logic Sheet of the Loop Module where the copper/fiber crossover algorithm is found, is password protected. We were able to overcome this restriction.

Table 6.5

Average Monthly Cost
by Household Density Class
Using Various Copper/Fiber Crossover Points*
Generated by the BCM

	Total Distribution Distance (Feeder and Distribution) Measured in Feet						
Density Class	**9,000**	**12,000****	**15,000**	**18,000**	**21,000**	**24,000**	**Percentage**
<= 5	$99.07	$99.08	$99.08	$98.99	$99.01	$99.02	3.3%
5 to 200	$26.25	$25.96	$25.53	$24.98	$24.55	$24.05	20.0%
200 to 650	$14.92	$13.74	$13.03	$12.22	$11.68	$11.35	14.6%
650 to 850	$12.77	$11.56	$10.44	$9.68	$9.29	$9.04	5.8%
850 to 2550	$12.51	$11.29	$10.43	$9.93	$9.66	$9.57	36.8%
>2550	$10.19	$9.17	$8.65	$8.43	$8.44	$8.43	19.5%
Statewide Average Cost	$17.85	$16.94	$16.22	$15.69	$15.37	$15.15	100.0%

* Assumes Annual Cost Factor 2; results are for Washington State.
** The BCM's default copper/fiber crossover point is 12,000 feet.

As a second approach for testing the robustness of the copper/fiber algorithm, we tested the crossover point at the individual CBG level. Specifically, we duplicated the BCM's calculation of the "Total Loop Cost" for CBGs that were alone in a quadrant and which did not require sub-feeder segments.[167] We first identified CBGs in the Washington State input data that met the above criteria and which also had a total distribution distance (feeder and distribution) of slightly over 12,000 feet. The BCM had deployed SLC fiber feeder for all of these CBGs and the default "Grand Total Loop Cost" for these CBGs is shown below in Table 6.6. We then generated the "Total Loop Cost" for these CBGs using copper feeder and determined that it was significantly less costly to serve these CBGs with copper feeder

167. To simplify replication of the BCM, we selected CBGs that were "single CBG" quadrants and which did not require a sub-feeder segment. In other words, we chose CBGs that were directly in the path of the main feeder route and which did not share main feeder costs with other CBGs.

plant. Again, this analysis was conducted using the BCM's default SLC per line cost of $500 and the default SLC discount of 20%.[168] Appendix 8C summarizes results for the same analysis for CBGs which had a total distribution distance of approximately 15,000 feet, 18,000 feet, 21,000 feet, 24,000 feet and 27,000 feet.

Table 6.6

Analysis of BCM Main Feeder Selection and Alternative "Total Loop Cost" Assuming Copper Main Feeder

CBG #	Total Feeder and Distribution Distance	BCM "Grand Total Loop Cost"	Copper "Grand Total Loop Cost"	Savings	Percent
530419717004	12,194	$179,329	$101,895	$77,434	43%
53031950003	12,397	$131,017	$86,374	$44,643	34%
530419715002	12,420	$317,565	$179,482	$138,083	43%
530210208002	13,168	$314,366	$201,236	$113,130	36%
530050108021	13,585	$250,767	$169,915	$80,852	32%

Note: All CBGs are in Washington State and are "single CBG" quadrants with no sub-feeder segment. (Washington State Input Source Rows: 1790, 2224, 4366, 585, 1372).

The lesson from both the statewide runs and the individual CBGs analysis is clear — the BCM default inputs and assumptions do not yield a true economic crossover point for copper and fiber feeder plant at 12,000 feet. In fact the BCM's default inputs produce a total distribution distance copper/fiber crossover point that is at least more than double that length given that the average cost for Washington State is still declining at a crossover point of 24,000 feet. Furthermore, the BCM's algorithm for choosing the copper/fiber crossover point still includes the ambiguity injected by the use of total distribution distance (feeder and distribution) as the point of reference for selecting a main feeder technology as opposed to basing that selection on the main feeder distance alone. The BCM does calculate the main feeder distance for each CBG and so the copper/fiber crossover algorithm could easily be changed to reference the main feeder distance as opposed to the *total* distribution

168. CBGs chosen for this analysis had household densities greater than five and so were served by SLC and not AFC equipment.

distance. Furthermore, capacity plays an important role in the selection of an appropriate main feeder technology. The BCM's only recognition of the significance of capacity in the selection of feeder technology consists of the allocation of "AFC" to CBGs that are to be served by fiber and which are in the lowest household density class. However, a CBG's capacity requirement should figure into the initial choice between copper and fiber feeder plant and not just to the selection of various fiber electronics technologies as in the BCM.

As a final means of testing the BCM's 12,000 foot crossover point, we conducted further analysis of the cost comparison that is reflected in Table 6.6 in order to approximate the SLC electronics cost necessary to make 12,000 feet a true economic crossover point for copper and fiber main feeder plant. We used the same five CBGs that are shown in Table 6.6. In Table 6.7 below, we present the aggregate BCM "Grand Total Loop Cost" for these five CBGs and the aggregate Copper "Grand Total Loop Cost" as well as the total distribution cost. The distribution cost remains constant regardless of the main feeder technology. Therefore we subtracted the total distribution cost for the five CBGs so as to isolate the total main feeder expense using fiber and using copper. These total feeder costs for the five CBGs are shown in columns five and six of Table 6.7 We then recalculated the cost of fiber main feeder for the five CBGs assuming various per-line SLC electronics costs and a constant discount level of 20%. As shown in Table 6-7, a discounted SLC cost of $88 achieves an aggregate fiber main feeder cost for the five CBGs that closely approximates the total cost for these five CBGs assuming copper main feeder. This analysis further illustrates the fact that the BCM's default SLC electronics cost of $500 does not produce an economic copper/fiber crossover point at 12,000 feet, but instead, the effective, discounted SLC electronics cost necessary for an economic copper/fiber crossover point of 12,000 is less than $100.

Table 6.7

Approximation of SLC Electronics Cost Necessary for Economic Copper/Fiber Crossover Point at 12,000 Feet

Average Total Feeder and Distrib. Distance*	BCM "Grand Total Loop" Cost	Copper "Grand Total Loop" Cost	Total Distribution Cost	BCM "Total Feeder Cost"	Copper "Total Feeder" Cost
12,753	$1,193,044	$738,901	$574,225	$618,819	**$164,676**
SLC Base Cost	$120	**$110**	$100	$90	
SLC Discount	20%	**20%**	20%	20%	
Final SLC Cost	$96	**$88**	$80	$72	
Total Fiber Main Feeder Cost	$178,931	**$167,355**	$155,779	$144,203	

* Average Total Feeder Distribution Distance and aggregate costs are based upon the data for the five CBGs presented in Table 6.6.

This section has identified the serious flaws in the BCM's assumption regarding the cost for digital loop equipment and the economic crossover for deploying fiber in the feeder plant. Both of these related problems with the BCM can and should be corrected, the effect of which will be to *lower* the average cost that the BCM computes per CBG. For example, using the BCM costs for digital loop equipment, but changing the crossover point to 21,000 feet (from the default value of 12,000 feet) reduces monthly average cost by approx $1.40.

As demonstrated by the analysis in this section, the per-line costs for SLC and AFC digital loop carrier equipment are significant inputs to the final per line cost for fiber main feeder. As such these per-line SLC and AFC electronics costs should be viewed critically in determining the cause of the copper/fiber crossover anomaly revealed in the above analysis. The SLC and AFC costs of $500 and $550 per line respectively are user inputs to the Loop Module as are their respective discounts for SLC and AFC Electronics of 20% and 10%, however, these figures are not substantiated in any way in the Joint Submission. Because of the difficulty in obtaining more accurate cost data, we also examined SLC and AFC price data based upon approximations made by Hatfield Associates, Inc. (HAI) in the

California USF proceeding,[169] i.e., undiscounted costs for SLC and AFC of $250 and $500, and discounts of 40% and 25%. We conducted a sensitivity analysis based upon these data and determined that the result of changing these data (and making no other corrections to the BCM) is to *lower* the average monthly cost by approximately *$5.00* to an average cost of $11.94.[170] Clearly these inputs are critical components of the final cost results.

6.5 The assumption of uniform household density should be revisited

Among the areas of possible enhancements that the Joint Sponsors have identified is a modification to the existing BCM assumption of uniform household density. The Joint Sponsors indicate that the assumption of uniform household density may not be sustainable in CBGs with density of less than one household per square mile.[171] Indeed, while in the plains, there could be uniform household density, in most other parts of the country, cluster developments are more likely.

The Joint Sponsors have indicated that they plan to address this problem as follows:

> For CBGs with less than 20 households per square mile the road network within the CBG will be identified. A buffer will be established around each road as an approximation of the area within the CBG where households have the highest probability of being located. Buffers will be set according to the following parameters: 10-20 Households/Sq. mil. — 500 ft; 5-10 Households/Sq. mi. — 1000 ft; <5 Households/Sq. Mi. — 1500 ft. This buffer area will be used to form a new polygon for purposes of network design.[172]

This revision is clearly essential to correct the overstated distances for outside plant that the current version of the BCM now computes (and thus the overstated costs) and appears to be a reasonable method for addressing what would otherwise be a serious flaw in the

169. California PUC, Universal Service Fund Proceeding, *A Discussion of Input Assumptions Used in the Hatfield Proxy Model, op. cit.*, footnote 27.

170. See Appendix 8B.

171. Joint Submission, September 12, 1995, at 38.

172. *Ex parte* submission, February 21, 1996, *op. cit.*, footnote 75.

model.[173] This correction will clearly lower the results of the cost proxy model and should be incorporated before the BCM is adopted as a policy making tool.

173. If feasible, this revision should include a data overlay that entirely excludes areas that have roads that serve areas that are entirely uninhabited (e.g., logging areas) and that possibly includes areas such as national parks that may well be inhabited (e.g., by forest rangers).

Appendix 6 | COMPARISON OF WIRE CENTER AND CBG BASED SUPPORT

Comparison of Wire Center and CBG Based Support

Block Grp #	Office	Company	# Households	Annual Cost2	HH*Annual Cost2	>$20 Benchmark2	>$30 Benchmark2	>$40 Benchmark2
80379534002	AVONCOMA	MOUNTAIN BELL - CO	144	$ 601.76	$ 86,652.76	$ 52,093	$ 34,813	$ 17,533
80379534004	AVONCOMA	MOUNTAIN BELL - CO	177	$ 186.29	$ 32,974.17	$ -	$ -	$ -
80379534003	AVONCOMA	MOUNTAIN BELL - CO	595	$ 273.11	$ 162,502.74	$ 19,703	$ -	$ -
80379534005	AVONCOMA	MOUNTAIN BELL - CO	266	$ 439.77	$ 116,979.53	$ 53,140	$ 21,220	$ -
80379534006	AVONCOMA	MOUNTAIN BELL - CO	771	$ 419.32	$ 323,291.93	$ 138,252	$ 45,732	$ -
			Wire Center:					
			Total Cost		**$ 722,401**			
			Total Threshold	**($20 * 12 * HH)**	**$ 468,720**		**CBG Based:**	
			Total Threshold	**($30 * 12 * HH)**	**$ 703,080**			
			Total Threshold	**($40 * 12 * HH)**	**$ 937,440**			
							Total Support	**$20 Threshold**	**$ 263,187**
			Total Support	**For 20**	**$ 253,681**		**Total Support**	**$30 Threshold**	**$ 101,764**
			Total Support	**For 30**	**$ 19,321**		**Total Support**	**$40 Threshold**	**$ 17,533**
			Total Support	**For 30**				
					Difference		**Percent Difference**	
					$20 Threshold	**$ 9,506**	**3.70%**	
					$30 Threshold	**$ 82,442**	**426.70%**	
					$40 Threshold	**$ 17,533**	**N/A**	

Source: Benchmark Cost Model, Colorado Input File, Rows 25 and 29

7 | INTERPRETING AND APPLYING THE RESULTS OF THE BENCHMARK COST MODEL

7.1 The appropriate benchmark for determining USF eligibility and quantifying the level of support

For the cost results produced by the BCM to be put to actual use, a critical determination must be made as to the proper "benchmark" for determining USF requirements. An examination of diverse state universal service proceedings implicitly raises questions of (1) how to define the appropriate benchmark to determine eligibility for high cost support, and (2) how to determine the aggregate amount of high cost support to which an area is entitled. As discussed in the previous sections, the approach adopted by the BCM is to determine an area's eligibility for USF support by comparing the proxy cost of serving that area with a pre-established price. In the BCM, as presently structured, the entire difference between the average cost per access line for the area and the predetermined threshold price represents the universal service support requirement for that area.[174] Thus, the BCM determines eligibility for high-cost support and the amount of the entitlement essentially in a single step. The BCM also does not specify any jurisdictional responsibility for the allocation of these above-average costs, but rather is presumably intended to compute the entire USF support that is potentially required.

By contrast, the existing federal high cost program makes an initial determination as to eligibility for high cost support, before separately addressing the amount of support to be allowed. To determine *eligibility* for support, the existing federal high cost program compares the national average *cost* of the residential access line with an individual carrier's average costs for each of its study areas.[175] In order to determine the *level* of support that is to be provided to any given carrier, a sliding scale of assistance is determined based upon factors such as the number of lines in the study area and the degree to which the carrier's

174. The "study" area under the BCM is the CBG.

175. A study area is the area within a single state jurisdiction where a LEC provides local telephone service. No changes have been permitted in study area boundaries since November 15, 1984, except with special permission of the Commission. See 47 C.F.R. Part 36, Appendix-Glossary (1993).

average line cost exceeds the national average by at least 15%.[176] Thus, the existing federal high cost fund does not make up the entire difference between the carrier's average cost and the national average cost, rather it makes up only a portion of that difference.

Identifying high cost areas is not the only way to get a perspective on universal service requirements, however. Rather than comparing *cost* data to some threshold level (either price as with the case of the BCM or average cost as is the case with the existing high cost fund), some states, such as Vermont and Wisconsin, have decided to make their universal service funding decisions dependent upon how the *price* of basic service compares to an affordability benchmark, without any *direct*[177] consideration of cost to serve. In a report recently submitted to the Vermont General Assembly, the Vermont Public Service Board included draft legislation that would define a high cost area as one in which "the price of basic service to customers is in excess of 150 percent of the state average."[178]

The Vermont Board is proposing a price-based approach for determining where high cost support should be targeted:

> The price to the customer should be regarded as the fundamental variable of universal service. If the customer's price goes up, the customer will be less likely to keep his or her telephone service. The cost to the carrier is relevant only insofar as it affects the customer's price.[179]

In making this recommendation, the Board noted the link between existing prices and the incumbent LEC's embedded costs (particularly in the absence of competition), observing that:

> In the absence of effective local competition, however, there is an important reason not to distribute high cost assistance based upon forward-looking costs. The local rate charged to a customer as the result of the embedded costs is far more significant in the customer's decision to keep or drop telephone service than is the theoretical cost of a new competitor.[180]

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176. See Table 7.3, below.

177. As discussed later in this section, cost is considered indirectly when the rate is set or approved.

178. Vermont PSB, *Universal Service in a Competitive Era: A Report to the Vermont General Assembly by the Vermont Public Service Board*, January, 1996, Attachment: Draft Legislation, at 3. The rate would include dial tone, the end user common line charge, and average local measured service charges. *Id.*, at 64, note 141.

179. *Id.*, at 61.

180. *Id.*, at 60.