## What the BCM2 does

As is discussed in more detail in this chapter, BCM2 addresses, in part, each of these flaws *with the exception of the use of the CBG.*[91] The BCM2 also introduces many new algorithms, assumptions, and complexities regarding the deployment of outside plant. Clearly, as the model's complexity has grown, so too has the need for detailed descriptions of the rationale behind its various network design assumptions. In our April Report, we described several of the most important assumptions underlying the BCM, and pointed to the need for detailed documentation thereof as an important area for improvement. The Sponsors of BCM2 have moved in the proper direction with the materials that have been made available through workshops; however, there is a significant need for further elucidation if the BCM2 is to be useful as a policymaking tool.

As is shown below, the BCM2 continues to deploy plant apparently based upon arbitrary engineering rules rather than making the economically efficient choice, and also fails to recognize the significant economies of scale and scope associated with serving multiple CBGs through an integrated network infrastructure. Furthermore, the BCM2 has introduced substantially higher structure and placement costs than those incorporated in the original BCM, and seems to have selectively applied the concepts of "scorched node" and "scorched earth" in a manner that systematically overstates the forward-looking cost of providing universal service.

## 5.2 BCM2 adopts the BCM's basic methodology while including several enhancements in network architecture

The BCM2 relies upon the same basic methodology for the deployment of outside plant as did the BCM. The Census Block Group (CBG) is again the basic unit of analysis, and each CBG is assigned to the closest existing central office site. The BCM2 relies upon Bellcore's Local Exchange Routing Guide (LERG) to assign remote switches to actual remote switch sites and the switching module has been generally enhanced to include fixed and per line switch costs for five different switch sizes (see Chapter 4 above). In a departure from the BCM, the BCM2 accounts for the presence of additional residential lines through a user-adjustable "residential line multiplier." According to explanatory materials provided by the Sponsors, the default residential line multiplier of 1.21 is based upon the ratio of all residential lines reported at the end of 1994 as a ratio of 1990 households. The BCM2 also includes an estimate of business lines derived from a third party database of employees per CBG. Thus, the BCM2 considers business lines as well as second residential lines in the sizing of outside plant and switching, whereas the BCM did not account for

91. See Chapter 2, above, for further discussion of the implications of BCM2's "locked" design with regard to this issue.

second residential lines and accounted for business lines only in the calculation and attribution of switching costs.[92] The "Total CBG Lines Served" in the BCM2, therefore, equals the number of households multiplied by the residential line multiplier, plus the number of business lines.

The Sponsors indicated in their July 3 filing that the BCM made several assumptions that oversimplified the cost of providing local exchange service, particularly with respect to distribution plant in urban areas. As such, the treatment of distribution plant is *significantly* more complex in the BCM2 than in the BCM. As with the BCM, main feeder in the BCM2 is assumed to emanate from each central office along four main feeder routes with dedicated subfeeder extending to serve CBGs not in the path of the main feeder route. The BCM2 also retained the BCM's methodology for engineering individual main feeder segments to meet the capacity requirements of CBGs further out along the same main feeder route.[93] The BCM2 no longer bases the selection of copper or fiber feeder plant on a single hard-wired loop length of 12,000 feet. Rather, the "copper/fiber crossover point" in the BCM2 is a limited user-adjustable input, with options ranging from 9,000 to 18,000 feet at 3,000 foot intervals (see section 5.5, below). In addition, the decision to use copper or fiber feeder plant is also linked to the CBG's capacity requirement, which represents another enhancement over the copper/fiber crossover algorithm of the BCM.[94] CBGs with a capacity requirement that is lower than the "Maximum Size Distribution Cable" (3600 by default), *and* with total loop length lower than the specified copper/fiber crossover point, are assigned copper main feeder plant. CBGs not meeting one or both of these criteria are assigned fiber main feeder with the selection of "SLC" or "AFC" fiber made on the basis of capacity requirement as well.[95]

The BCM assumed that households were uniformly distributed throughout CBGs, an assumption which was criticized for overstating costs in relation to large, sparsely populated CBGs. The Sponsors have addressed this criticism by incorporating a third party database that reduces the area of CBGs with fewer than 20 households to the territory 500 feet on either side of the CBG's road network. The BCM also assumed that distribution plant was

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92. The BCM used the same DMS 100 digital switch for all central office sites with a default fixed cost of $647,526 and per line switch cost of $238.87. The presence of business lines was reflected through use of "Business Gross Up Factor" of 1.75 which increased the number of lines by 75%.

93. See discussion in the April Report, Chapter 3 at 22-25.

94. The formula for CBG capacity in this case is the "Total CBG Lines Served" minus the "Lines in CBG Provisioned as DS-1s" plus the 'Lines in CBG Provisioned as DS-1s divided by 12." This result is divided by the feeder fill factor that corresponds to the CBG's household density zone.

95. The choice between "SLC" and "AFC" fiber main feeder is a function of capacity as measured by the "Number of Feeder Legs" divided by the "Number of Terminal Locations per Feeder Leg," which is then divided by the Electronic Fill Factor (default level 0.85).

copper in all cases, and that four equally sized distribution legs were sufficient to meet the needs of each CBG. In contrast, the BCM2 includes a user specified "Maximum Copper Distribution Distance" (default level 12,000 feet) that may trigger the extension of feeder plant into the CBG. Feeder extends into the CBG if the CBG's width is greater than twice the Maximum Copper Distribution Distance. Also, the number of distribution legs is no longer capped at four in the BCM2. These enhancements, which required several new algorithms and assumptions, were made to ensure that distribution plant was deployed along each lot line.

For both the BCM and the BCM2, the width of a square CBG--the so-called "Segment D" or "Base Side"-- is the foundation for the development of distribution plant. The BCM calculated each CBG's "Total Distribution Distance" by simply multiplying the CBG's width by .75 to reflect the average distribution distance within the CBG. This methodology did not consider the number of households in the CBG. The BCM2, does reflect the number of households in the development of distribution plant through calculation of the "Number of Lots per Base Side" and the "Base Lot Side Length." The Number of Lots per Base Side is simply the square root of the number of households while the Base Lot Side Length equals the width of the CBG divided by the Number of Lots per Base Side. These two values, together with the CBG's width, are used to calculate the CBG's "Maximum Distribution Distance" as well as the number and length of the CBG's distribution and feeder legs per CBG.[96]

In addition to second residential lines and business lines, the BCM2 also makes allowance for special access lines. Special access lines per CBG are estimated on the basis of the CBG's number of business lines through a user specified "Special Access Ratio." The default value for this ratio is 0.13, meaning that a CBG will have 0.13 special access lines per every business line. The BCM2 subtracts the number of special access lines from the "Total CBG Lines Served" to estimate the "Switched Lines in the CBG." Both of these values, that is the Special Access Lines and the Switched Lines in the CBG, yield an estimate for the number of lines in the CBG that are provisioned at the DS-1 level. According to explanatory materials provided by the Sponsors, CBGs with greater than 2,016 lines terminate a variable percentage of lines at the DS-1 level "to reflect costs of providing service to digital PBXs and providing wideband private line services." The "Number of Lines Provisioned by DS-1s" therefore equals the CBG's number of Special Access Lines

96. The Maximum Distribution Distance equals 1.5 times the CBS's width less two times the Base Lot Side Length. The number of distribution legs per CBG equals one if the CBG has fewer than 2 Lots per Base Side. Otherwise, the number of distribution legs equals the number of Lots per Base Side rounded up to the nearest even number and divided by 2. The number of feeder legs per CBG equals one if the CBG's width less 2 times the Base Lot Side Length is less than or equal to zero. Otherwise, the number of feeder legs equals the CBG's width minus 2 times the Base Lot Side Length divided by 2 times the "Copper Maximum Distribution Distance." The average number of distributions legs for the 4,621 CBGs in Washington State is 10 while approximately 5% of the CBGs in Washington State are assigned multiple feeder legs.

times the "Percent Special to DS-1" percentage in the "Voice Grade Ratio Table" that corresponds to the CBG's Total CBG Lines Served; plus, the CBG's number of Switched Lines times the appropriate "Percent Switched to DS-1" percentage in the same Voice Grade Ratio Table. The Voice Grade Ratio Table has been reproduced below in Table 5.1.[97]

Table 5.1

Voice Grade Ratio Table

| # Switched Lines in CBG | % Switched to VG | % Switched to DS | % Special to VG | % Special to DSI |
|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 |
| 2016 | 0.65 | 0.35 | 0.5 | 0.5 |
| 10000 | 0.5 | 0.5 | 0.3 | 0.7 |
| 20000 | 0.75 | 0.25 | 0.1 | 0.9 |

The calculation of SLC and AFC electronics expense is also significantly more complex in the BCM2 than in the BCM and requires several incremental calculations not included in the BCM. The added complexity is partially attributable to the potential for multiple feeder legs and terminal locations within a CBG and the fact that some CBGs terminate lines at both the DS-1 and the voice grade level. In column CZ of the "Main Logic" Sheet, the BCM2 calculates the "Number of Voice Grade Lines Equipped per Terminal Location." For CBGs served by the AFC fiber type, this formula divides the "Number of Lines per Feeder Leg" by the "Number of Terminal Locations per Feeder Leg" and then divides this result by the electronic fill factor and rounds up to the nearest multiple of six. For CBGs served by SLC fiber, the formula multiplies the "Switched Lines in the CBG" by the "Percent Switched to Voice Grade" from the Voice Grade Ratio Table that corresponds to the CBG's number of Special Access Lines; plus, the "Special Access Lines in the CBG" times the "Percent Special to Voice Grade" from the same Voice Grade Ratio Table. This value is divided successively by the "Number of Feeder Legs in the CBG," the "Number of Terminal Locations per Feeder Leg," and finally by the Electronic Fill Factor. The final result for SLC is rounded up to the nearest multiple of four.

The "Number of Voice Grade Lines Equipped per Terminal Location" described above, is key to the final calculation of AFC and SLC Electronics expense. The AFC Electronics

97. For Washington State, only 150 or about 3% of the CBGs had any lines provisioned at the DS-1 level.

expense is calculated by first looking up the fixed and per line costs in the "Digital Carrier Cost Table" that correspond to the CBG's Number of Voice Grade Lines Equipped per Terminal Location. This information has been reproduced below in Table 5.2. After multiplying the per line cost by the CBG's Number of Voice Grade Lines Equipped per Terminal Location and adding the appropriate fixed cost, this total is multiplied successively by the "Total Number of Terminal Locations in the CBG," the "Engineering and Installation Loading factor for electronics (default level of 35%), and the AFC Discount (default level of 0.9). The calculation of SLC Electronics expense is slightly more complex as with SLC fiber, the Number of Voice Grade Lines Equipped per Terminal Location is broken out into the "Number of SLC Systems at Full Capacity" and the "Number of Switched Lines in (an) Overflow SLC Terminal."

Table 5.2

Cost for AFC/SCL 200/Light Span Equipment

| **Digital Carrier Cost** | **(Non-discounted material cost only)** | |
|---|---|---|
| 0 | 7700 | 250 |
| 48 | 8500 | 250 |
| 120 | 10500 | 250 |
| 240 | 77330 | 184 |
| 672 | 94909 | 184 |
| 1334 | 105409 | 184 |

## Structure and Placement Costs in the BCM2 are Significantly Higher than in the BCM

The BCM and the BCM2 employ three multipliers, or weighted cost factors, that partially account for the structure and placement cost of feeder and distribution plant under various circumstances. These three weighted cost factors are called the "Distribution Cable Multiplier," the "Feeder Cable Multiplier" and the "Fiber Multiplier" and in all cases they are multiplied by the segment's distance in feet to provide a partial estimate of structure costs. For example, the formula in the BCM2 that calculates the cost to place copper distribution plant in CBGs which have a household density of greater than 2,550 households per square mile and which have a "Rock Hardness" measure of "Normal," would include the "Distribution Cable Multiplier" of 13.31148. Similarly, the cost to place copper

distribution plant in a CBG with the same household density (> 2,550) but with a "Rock Hardness" measure of "Hard," would incorporate a higher "Distribution Cable Multiplier" (i.e., 23.5962). As seen from these examples, each of the three plant types (distribution plant, copper feeder, and fiber feeder) have three different "weighted cost factors" (one each for Normal, Rock Hard and Rock Soft conditions) for each of the six household density zones — that is a total of 18 weighted cost factors for each plant type, or a total of 54 weighted cost factors altogether.

The 54 weighted cost factors are themselves calculated on the basis of 24 "Structure Cost Multipliers" which are weighted by the percentage split between aerial and underground plant for each household density zone and for each plant type. Again this holds true for the BCM and the BCM2. A closer look at the "Structure Cost Multiplier"

Table 5.3

Comparison of BCM and BCM2 Structure Multipliers

BCM

**Urban Copper Cable Table**

| Cost Multiplier | | |
|---|---|---|
| Structure | UG $ | Aerial $ |
| RockH | 1.53 | 0.69 |
| RockS | 1.22 | 0.48 |
| Normal | 1.11 | 0.48 |

**Rural Copper Cable Table**

| Cost Multiplier | | |
|---|---|---|
| Structure | UG $ | Aerial $ |
| RockH | 0.66 | 0.8 |
| RockS | 0.35 | 0.54 |
| Normal | 0.21 | 0.44 |

**Urban Fiber Table**

| Cost Multiplier | | |
|---|---|---|
| Structure | UG $ | Aerial $ |
| RockH | 9.02 | 3.5 |
| RockS | 7.22 | 2.5 |
| Normal | 6.56 | 2.5 |

**Rural Fiber Table**

| Cost Multiplier | | |
|---|---|---|
| Structure | UG $ | Aerial $ |
| RockH | 3 | 4.25 |
| RockS | 1.45 | 2.9 |
| Normal | 1.02 | 2.3 |

BCM2

| Urban Copper Cable Table | | |
|---|---|---|
| Cost Multiplier | | |
| Structure | Below Ground $ | Aerial $ |
| RockH | 20.84 | 14.18 |
| RockS | 13.92 | 10.59 |
| Normal | 10.7 | 7.62 |

| Rural Copper Cable Table | | |
|---|---|---|
| Cost Multiplier | | |
| Structure | Below Ground $ | Aerial $ |
| RockH | 13.59 | 8.07 |
| RockS | 5.76 | 5.86 |
| Normal | 2.92 | 4.08 |

| Urban Fiber Table | | |
|---|---|---|
| Cost Multiplier | | |
| Structure | Below Ground $ | Aerial $ |
| RockH | 20.84 | 14.18 |
| RockS | 13.92 | 10.59 |
| Normal | 10.7 | 7.62 |

| Rural Fiber Table | | |
|---|---|---|
| Cost Multiplier | | |
| Structure | Below Ground $ | Aerial $ |
| RockH | 13.59 | 8.07 |
| RockS | 5.76 | 5.86 |
| Normal | 2.92 | 4.08 |

Tables for the BCM and the BCM2 reveals that these root inputs have increased significantly in the BCM2 over the values that were used in the BCM. For example, the Structure Cost Multiplier for underground copper cable in urban areas which exhibit "Rock Hard" conditions was $1.53 in BCM and has been increased to $20.84 in BCM2. The Structure Cost Multiplier for aerial copper cable in the same areas has increased from $0.69 in BCM to $14.18 in BCM2. These order of magnitude increases are consistent throughout the four Structure Cost Multiplier Tables for the BCM and the BCM2 which are reproduced above in Table 5.3.[98]

The BCM2's much higher structure cost multipliers therefore yield weighted cost factors in the BCM2 that are also significantly higher than those in the BCM.[99] As explained above, the 54 weighted cost factors are pulled from the "Weighted Cost Factor Table" in the "Table Inputs" Sheet of BCM2 and serve as the "Distribution Cable Multipliers," the "Feeder Cable Multipliers" and the "Fiber Multipliers." For each CBG, the "Feeder Cable Multiplier" and the "Fiber Multiplier" are weighted to reflect the presence of copper and/or fiber main feeder in the CBG's main feeder segment as well as the size of those main feeder cables. (See Table 5.4 below which contains the "Structure Allocation Table.") The weighted multipliers are multiplied by the length of the CBG's main feeder segment, for example, and thereby return a component of the structure/placement costs of the CBG's main feeder segment which is added to the material cost of the fiber and copper cable. A similar procedure is used in the calculation of the cost for sub-feeder and the "Distribution Cable Multiplier" is used in the calculation of the cost of Distribution cable.

98. See Appendix 5B, which demonstrates that the weighted cost factors are on average 917% percent higher than those in the BCM.

99. See Appendix 5B.

Table 5.4

Structure Allocation Table

| Cable Sizes | Cable Structure % | Fiber Structure % |
|---|---|---|
| 0 | 50 | 50 |
| 200 | 55 | 45 |
| 900 | 60 | 40 |
| 2400 | 65 | 35 |
| 4200 | 75 | 25 |

Thus, we have identified in the Weighted Cost Factor Table a significant driver in the higher costs produced by the BCM2. Indeed, as a means of isolating the effect of the BCM2's higher structure cost multipliers we substituted the weighted cost factor table from BCM into the BCM2 and processed the state of Washington with all else equal. The result was a decrease in the statewide average monthly cost of $9.20 or 31% from the default level of $29.41.[100]

## The BCM2 Includes Several New Multipliers that Factor into the Calculation of Structure/Placement Costs

As described above, the weighted cost factors alone account for significantly higher costs than those produced by the BCM. However, *in addition*, the BCM2 includes several other multipliers that serve to increase the average statewide monthly cost. For example, the BCM2 includes three "Copper Size Factors" and a single "Fiber Size Factor" that serve as additional "structure cost multipliers" for larger sizes of copper or fiber cable. In the case of copper plant, the "Copper Size Factor 1" has a default level of 1.2 (or 20%) and applies to copper cables that are between 400 and 900 pair capacity. The "Copper Size Factor 2" and "Copper Size Factor 3" have default levels of 30% and 40% respectively and apply to cables with capacity between 900 and 1500 pairs and cables with capacity greater than 1500 pairs. The single "Fiber Size Factor" has a default level of 20% and is used for fibers larger than 60 strands The Copper and Fiber Size Factors are used in the same manner as the weighted cost factors described above. That is, they are multiplied by the length of the feeder or distribution segment in question if the cable size warrants. As such,

100. See Appendix 5A, for the results sheet from this run.

these factors may further weight the "Fiber Multiplier" and the "Copper Multiplier" by as much as an additional 20 or 40 percent.

We isolated the impact of the Copper and Fiber Size Factors by reducing the default levels to 1.0 in all cases and found that the statewide monthly average cost for Washington State dropped $0.15 all else equal.[101]

The BCM2 also includes an "Underground Pull Cost" factor which is labeled in the user input table as the "cost per foot to pull underground cables into conduit ducts." This particular multiplier only comes into play when a CBG employs one or more of the maximum size copper or fiber cable types, whether in the feeder or distribution plant. The "UG Pull Cost" factor has a default level of 0.77 and is multiplied by the CBG's number of maximum size cables and then by the segment's length.

Other structure/placement cost elements that are new to the BCM2 include both a Copper and Fiber Splice Ratio and a Copper and Fiber In Line Ratio. The Copper and Fiber Splice Ratios are labeled in the user input table as loading factors for the splicing of copper (or fiber) plant and have default values of 0.07 and 0.045 respectively. The In Line Ratios account for the cost of in line pedestals and cross connects and have respective default levels of 0.1 and 0.07 for copper and fiber. The materials cost of copper main feeder, for example, is multiplied by one plus the Copper Splice Ratio and the Copper In Line Ratio. The materials cost is then multiplied by the "Copper Cost Ratio" of 80% which reflects the default "Copper Cable Discount" of 20%."

The BCM2 also includes a "Loading Factor for Outside Plant" with a default level of 1.05. This variable is multiplied by the CBG's total main feeder and subfeeder cost including structure costs [102] Also, as mentioned above, an "Engineering and Installation" factor with a default level of 35% represents the cost for the engineering and installation of electronics.

## 5.3 A comparative analysis of the various proposals for fill factors in the outside plant

One of the cost drivers in a cost proxy model is the fill factor used for deploying outside plant. As was the case for the original BCM, the fill factors in the BCM2 are *objective*, not actual fill factors. Accordingly, the model deploys plant that typically results

101. See Appendix 5A.

102. See Column (BW) "Total BG $ after Reallocation" in the "Main Logic" sheet.

in the *actual* fill factor being lower (but never higher) than the objective fill factor.[103] The public policy issue that relates to this network design decision is that universal service funding requirements should not be based upon the cost of a network that contains excess capacity built to facilitate ILEC strategic service offerings over and above the provision of single line residential service. The following table compares the objective fill factors that have been proposed in the original BCM, BCM2, and the HM.[104]

103. By running the original BCM on the California set of CBG data for California, we were able to determine the actual utilization resulting from the use of an objective 95% fill factor for the feeder: the actual utilization was 89% (as a result of the use of discrete cable sizes). Similarly, we derived an actual utilization of 71% for the distribution, assuming that the objective fill was 95%.

104. The CPM is not a bottoms-up, engineering/planning model in which cable is sized to meet demand. Consequently, the CPM does not have any objective fill factor inputs for comparison.

Table 5.5

Comparison of Outside Plant Fill Factors
(Objective Fill Factors)

| Feeder | | | |
|---|---|---|---|
| **Density Zone** | **BCM** | **BCM2** | **HM** |
| 1 | .65 | .75 | .65 |
| 2 | .75 | .80 | .75 |
| 3 | .80 | .80 | .80 |
| 4 | .80 | .85 | .80 |
| 5 | .80 | .85 | .80 |
| 6 | .80 | .85 | .80 |
| Distribution | | | |
| **Density Zone** | **BCM** | **BCM2** | **HM** |
| 1 | .25 | .40 | .50 |
| 2 | .35 | .45 | .55 |
| 3 | .45 | .55 | .60 |
| 4 | .55 | .65 | .65 |
| 5 | .65 | .75 | .70 |
| 6 | .75 | .80 | .75 |

Notes: Hatfield Version 2.2, Release 1.
The CPM is not a bottoms-up, engineering/planning model in which cable is sized to meet demand. Consequently, the CPM does not have any objective fill factor inputs for comparison.

The average cost produced by the BCM2, using all of the BCM2's default values, is $29.41 for the state of Washington. Running the BCM2 with one set of changes, i.e., using the slightly lower default fill factors assumed by BCM, yields a higher average cost for Washington State of $30.01. Thus, examined in isolation, the substitution of BCM's lower

fill factors into the BCM2 causes the monthly cost to increase by approximately $.60[105] The use of HM's fill factors in the BCM2 (and making no other HM changes) yields a national average cost of $29.27[106]

As shown below in Table 5.6, the BCM2 includes main feeder cable sizes of 50 and 25, whereas the smallest main feeder cable size in the BCM had capacity for 100 pairs. The BCM2 also includes three new distribution cable sizes (25, 18 and 12) that are smaller than the BCM's smallest distribution cable size of 50. Given that these smaller cable sizes cost less than the previous smallest cable size of the BCM, cable costs generated by the BCM2 should be generally lower as the BCM2 will assign copper cables that match the CBG's capacity requirement with greater precision.

Table 5.6

Comparison of BCM and BCM2 Cable Sizes

| | BCM | BCM2 |
|---|---|---|
| Smallest Copper Feeder Cable Sizes | 100 | 100<br>50<br>25 |
| Smallest Copper Distribution Sizes | 50 | 50<br>25<br>18<br>12 |
| Fiber Cable Sizes | Same | Same |
| Maximum Size Copper Feeder and Distribution | Same | Same |

In making decisions as to the appropriate fill factors to use in a cost proxy model, regulators should draw a clear distinction between those fill factors that may be selected by ILECs for reasons *other than providing primary basic residential service* and the fill factors

105. See Appendix 5A.

106. See Appendix 5A.

associated with the provision of basic local exchange service.[107]

## 5.4 Inclusion of the drop, pedestal and network interface device costs

The BCM2 includes network elements such as drop and pedestal that were not included in the BCM. The BCM2 assigns one drop to each household in a CBG. The cost for each drop consists of a fixed "Network Interface Device" cost with default level of $30.00 and a distance-sensitive component of $0.10 per foot which is multiplied by the CBG's "Length Within a Lot." The number of pedestals per CBG equals the number of distribution legs squared. As described in Section 2.2, above, the number of distribution legs is roughly equivalent to the square root of the CBG's number of households divided by two.

For Washington State, the average number of pedestals per CBG is 111, each of which has a default cost of $48.22. As with other cost drivers, we isolated the impact of the cost for drop and pedestals on the statewide average monthly cost by reprocessing Washington State with the "Drop Cost per Foot," the "NID Cost" and the "Pedestal Cost" reduced to $0. This adjustment reduced the average monthly cost from the default level of $29.41 to $28.84, a reduction of $0.57.[108]

## 5.5 The default BCM2 still does not base its choice between copper and fiber in the feeder plant upon maximizing economic efficiency

The Sponsors have revised the *design* of the BCM2 with respect to the fiber/copper crossover point, but have left unchanged *the default value* for this critical network design assumption. Although the BCM2 now allows a user some limited choice in this aspect of the network design, as our analysis below demonstrates, the Sponsors appear to have made no attempt themselves to select the most *economic* specification for basic local exchange service, or to offer the user the possibility of doing so.

### The change in the design of the model is inadequate

The Sponsors have, without explanation, limited the user's options to four crossover points: 9,000, 12,000, 15,000 and 18,000 feet. At a minimum, regulators should question why the selection has been limited to four discrete points and, moreover, why a user is not being permitted to examine the effects of distances greater than 18,000 feet. The Sponsors

107. See Chapter 6, below, for further discussion of this point.

108. See Appendix 5A.

have offered no justification for introducing this limitation into the model.[109] In their July 3, 1996 letter to the FCC accompanying the submission of the model, the Sponsors describe the "enhancement" as follows: "The break point between copper and fiber, which had been 'hard-coded' in BCM, is now subject to adjustment by the user." There is no additional explanation.[110] This is a critical design flaw in BCM2 that should be remedied.

## The Sponsors' default value is economically irrational for the service being modelled

We tested the implicit assumption of 12,000 feet chosen by the Joint Sponsors through the performance of a sensitivity analysis for the state of Washington.[111] Table 5.7 below demonstrates that the default crossover point falls decidedly short of the economic crossover point. While the default used in BCM2 yields a statewide average monthly cost of $29.41, substitution of the higher copper/fiber crossover points results in lowering this cost to $28.70 and $28.14 for the 15,000 foot and 18,000 foot crossover points, respectively. The trend line established by this sensitivity analysis clearly indicates that an even higher crossover point may, in fact, be the most economically viable *for a network that is being deployed for the limited purpose of providing basic universal service access.*[112] Even if ILECs choose to deploy fiber at 12,000 feet for strategic and/or total network engineering requirements, this choice is not properly included in a cost proxy model that is being used to identify and compute universal service funding requirements. Instead, the modelled

109. In the methodology accompanying BCM-2, the section concerning assumptions for loop technology includes this description: "Feeder cable (cable placed so that it can be supplemented at a later date) is deployed as analog copper plant where the total loop distance is less than the user-specified maximum copper cable length." The footnote accompanying this sentence simply states: "The user may specify maximum copper distances of 9,000 feet, 12,000 feet, 15,000 feet or 18,000 feet." (*Benchmark Cost Model 2 Methodology*, p. 4.)

110. Letter to William F. Caton at 4.

111. With the exception of the copper/fiber crossover point variable, BCM2 default values are used for all other variables. Because the model sponsors have continued to use the default crossover point, this revision to the model (i.e. the allowance of selection of crossover points) apparently has no impact on the average cost yielded by the Sponsor's run of the BCM2 (relative to the original BCM).

112. Selection of lower crossover points may be efficient when viewed in the larger context of the full range of ILEC services that the feeder/distribution network is intended to support. However, in the context of BCM2 and the current universal service funding debate, the influences of other (non-basic) services are immaterial and irrelevant to the network costing process. The Sponsors of the BCM2 appear to have missed this fundamental point: They may well believe that 12,000 feet is the "correct" crossover point for a full-service ILEC network, and they may well be right in this assessment. However, if a network that is capable of efficiently supporting basic primary residential access line service can be most efficiently built (on a forward-looking basis) using an 18,000 foot — or even a 30,000 foot — crossover point, then that is the relevant design parameter for a universal service cost proxy model.

network should only reflect those network deployment decisions that are economic for the service being modelled.[113]

The ALJ presiding over the California PUC's universal service proceeding recently reached a similar conclusion. The ALJ rejected the CPM's assumption of a 12,000 foot crossover point (referred to as a 9000 foot fiber feeder "cut-off point," measured with respect to feeder only) in favor of a 15,000 foot crossover point (i.e., a 12,000 feeder cut-off point).

> The testimony of AT&T/MCI witness Selwyn is compelling. He points out that Pacific's feeder plant planning practices have been in transition from the provisioning of POTS to the provisioning of advanced narrowband and broadband digital services. His testimony traces the reasons why Pacific's fiber feeder cut-off point have been reduced from 12,000 feet to 9000 feet. The 9000 feet cut-off would not make sense in low density, rural zones, where demand and capacity requirements are smaller. *Additionally, a cut-off of 9000 feet would shift the costs associated with higher bandwidth services onto the costs of providing basic service.* As a result, we believe that the CPM's estimate of loop investment costs are overstated, and does not accurately represent the least cost, forward looking, method of providing residential basic service.[114]

113. See our April and May reports for further discussions of this and related points.

114. CPUC R.95-01-020/I.95-01-021, *Proposed Decision of ALJ Wong*, August 5, 1996, at 122 (emphasis supplied).

Table 5.7

Sensitivity Analysis of the
Copper/Fiber Crossover Point
Washington State

| | Total Distribution Distance (Feeder and Distribution) Measured in Feet | | | | | | |
|---|---|---|---|---|---|---|---|
| **Density Class** | **9,000** | **12,000*** | **15,000** | **18,000** | **21,000** | **24,000** | **Percentage of Households** |
| <= 5 | $110.83 | $110.80 | $110.79 | $110.73 | N/A | N/A | 1.0% |
| 5 to 200 | $47.57 | $47.47 | $47.29 | $47.11 | N/A | N/A | 21.8% |
| 200 to 650 | $27.56 | $26.86 | $26.02 | $25.16 | N/A | N/A | 14.2% |
| 650 to 850 | $27.84 | $26.67 | $25.81 | $24.96 | N/A | N/A | 5.4% |
| 850 to 2550 | $25.58 | $24.40 | $23.40 | $22.62 | N/A | N/A | 36.3% |
| >2550 | $22.72 | $21.73 | $21.15 | $20.86 | N/A | N/A | 21.2% |
| BCM2 Statewide Average Cost | $30.25 | $29.41 | $28.70 | $28.14 | N/A | N/A | 100% |
| BCM** Statewide Average Cost | $17.85 | $16.94 | $16.22 | $15.69 | $15.37 | $15.15 | 100% |

* The BCM2's default copper/fiber crossover point is 12,000 feet for BCM and BCM2.
** The BCM average cost reflects the forward-looking cost factor.

The Sponsors have maintained that the copper/fiber crossover point cannot be higher than 18,000 feet due to the transmission limitations of a copper loop.[115] However, the

115. BCM2 seminar conducted on August 7, 1996 in Newark, New Jersey. Inasmuch as loops of distances in excess of 18,000 feet have been placed (are still in widespread use) in the public switched network for many decades before fiber optics were even invented, this claim — at least with respect to basic residential access — is

(continued...)

BCM assumes the use of 24 gauge copper in the feeder[116], and thus, as stated in our May report, there would be no requirement to alter the gauge copper for longer feeder distances.[117] In any event, the Sponsors have failed to provide any justification or documentation regarding this critical point.

Ultimately, decisions as to the economic crossover point to reflect in a cost proxy model should be informed by decisions regarding the appropriate circuit equipment costs

As we discussed in our April and May reports, the economic choice as to the rational distance for deploying fiber rather than copper is influenced by the costs and discounts assumed for the subscriber loop equipment (that is necessary when fiber is deployed, but is unnecessary when copper is deployed). Therefore, regulators should *first* decide upon the appropriate costs to use in a cost proxy model for the equipment, and then determine the economic crossover point for deploying fiber.

## 5.6 Despite the inclusion of business lines and additional residential lines, the average cost computed by the BCM2 is *higher* than the results of the BCM

By contrast with the BCM, which did not reflect additional residential lines and only accounted for business lines in the allocation of non-traffic-sensitive switch costs, the BCM2 sizes both switches and outside plant to serve, in addition to primary residential line service, additional residential lines and businesses.[118] In Washington State, the model results show that approximately 57% of the lines are primary residential lines and the remaining lines reflected in the BCM2 are other lines. All else being equal, including these additional 1.4-million lines reduces the monthly cost computed by the BCM2 for several reasons, e.g., fixed structure costs are allocated over a greater number of lines, cable sizes

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115. (...continued)
disingenuous at best. Copper loops in excess of 18,000 feet may create transmission problems for non-basic services such as ISDN, but can certainly be used for POTS, which is after all the subject of the BCM2 and of the universal service funding proceedings.

116. *Joint Submission*, December 1, 1995, page IV-5.

117. *The BCM Debate: A Further Study*, p. 15.

118. Although these additional lines are reflected in the model for the purpose of deploying plant and computing the average cost per CBG, the BCM2 computes universal service only for one line per household.

are larger, thus reducing unit costs, etc.[119] However, as is demonstrated in Chapter 3, because businesses and additional residential lines are the major source of the non-plant-related expenses (such as marketing), the inclusion of non-primary residential lines in the cost proxy model drives up the non-plant-related expenses, above the amount that would be necessary for a stand-alone residential network.

We conducted a sensitivity analysis by changing the residential multiplier to 1.00 (from the default value of 1.21) and zeroing out the business lines (i.e., we ran a stand-alone residential network), simply to gauge the impact of this revision in the BCM2.[120] The monthly cost increases by $10.01 from the default value, to an average cost of $39.42.[121] One aspect of this result that is startling is that the original BCM (with the exception of the allocation of non-traffic-sensitive switch costs) did not reflect additional residential lines or business lines and thus one would expect, all else being equal, that the cost of the BCM would have been approximately *$10 more* than the results of the default BCM2, i.e, approximately $39.41, because the original BCM largely modelled a stand-alone network. Instead, using the historical cost factor for the sake of comparability, the average cost for Washington State using the BCM was $23.36, approximately *$6 less* than the default result for the BCM2 of $29.41.

Finally, were one to subtract the $8.34 per month associated with non-plant-related expenses from the stand-alone result (because the vast majority of these expenses are driven by services other than primary residential access lines), the cost would then be $31.08.

## 5.7 The Sponsors have carried the goal of a forward-looking cost model to an absurd extreme

The BCM2 Sponsors seem to have selectively applied the concepts of "scorched node" and "scorched earth" in a manner that results in an overstatement of the universal service funding requirement. Under a "scorched earth" design philosophy, it is assumed that the entire network is constructed from scratch without constraints of any sort. Switching nodes are configured optimally based upon prospective switching technologies, and are sized deployed without regard for any existing switch locations. The BCM (and BCM2) does not,

119. Chapter 6, below, discusses the importance of flowing back to primary line residential customers the benefits of the economies of scale and scope inherent in the ILECs' networks.

120. See Appendix 5A.

121. This analysis is based upon the default objective fill factors. As is discussed in our April report, in fact, the objective fill factors for a stand-alone residential network would be significantly higher than that required for a network that is engineered to serve the more volatile business and additional residential line demand.

however, purport to be a "scorched earth" model. Rather, it employs a "scorched node" design philosophy in which the basic network structure and architecture is retained, but where *individual network elements* are replaced with state-of-the-art components. In the context of determining the forward-looking costs of providing universal service, "scorched node" will necessarily result in a higher aggregate cost, all else being equal, than "scorched earth," because the design flexibility of the former is necessarily constrained.

A key rationale for the adoption of a "scorched node" design is that in reality many network elements would not be replaced even if a new network were to be constructed from scratch. One such category of elements is supporting structures, including poles and conduits. These facilities generally have adequate capacity to accommodate additional interoffice, feeder and distribution facilities, and are geographically tied to existing ("scorched node") switch locations. Moreover, capacity on these facilities is routinely provided to other telecommunications carriers, including cable TV systems, CAPs, and IXCs.

In BCM2, however, and despite its continued use of "scorched node" for switch sizing and placement, the model assumes that all supporting structure must be built from scratch, and develops a reproduction cost estimate for these elements as if they do not presently exist. While such an approach might arguably be appropriate in the context of a "scorched earth" model, it is entirely inconsistent with the "scorched node" philosophy: If one were going to rebuild all supporting structures as if none were presently in place, then there is no reason why one need retain existing switch locations as a design constraint. With respect to switching, "scorched node" produces higher costs than "scorched earth," but with respect to structures, precisely the opposite occurs. Hence, by selecting "scorched node" for switching and "scorched earth" for structures, the BCM2 systematically develops costs that exceed those that would exist under either design approach consistently applied.

The incorporation of new variables and cost elements in the BCM2, allegedly to better reflect the cost of *urban* areas, may cause the *average* cost to increase, but it should not affect the average cost of *high-cost* areas, and thus should not affect the magnitude of the universal service funding requirement. Each run of the BCM2 produces a two-page summary including, among other things, information that is disaggregated for each of the six density zones. The disaggregated information includes the following data for each of the six zones:

- Sum of the number of households
- Sum of the number of lines
- Average loop length
- Average loop cost per line
- Average of total investment per line
- Average of monthly cost

The disaggregated information, however, fails to indicate the level or frequency of universal service support. The results would be a more valuable policymaking tool if the following information were included separately for each density zone:

- Sum of households receiving support (assuming a user-specified price threshold)
- Amount of universal service support requirement (assuming a user-specified price threshold)

This type of information would enable an interested party to which parts of a state, universal service support would be flowing. We have provided examples of precisely this type of analysis in Chapter 7, below.

## 5.8 The incorporation of a variable to reflect the slope of the terrain is not, *per se*, unreasonable, but the actual values that have been attributed to this factor should be substantiated

The developers of the BCM2 have added measures of slope to the input data in the form of "Minimum Soil Slope" and "Maximum Soil Slope" values for each CBG. If one or both of these values are above user-specified "Minimum Slope" and "Maximum Slope" Triggers, then the BCM2 increases the length of the CBG's feeder and the maximum distribution measure thereby increasing the cost of these network elements. For example, if the CBG's minimum soil slope is greater than the "Minimum Slope Trigger" then the CBG's main feeder segment length, for example, would be lengthened by 10% (the default Minimum Slope Factor). If the same CBG also has a maximum soil slope value that is greater than the "Maximum Slope Trigger," then the CBG's main feeder segment length would be increased by the "Combined Slope Factor" which has a default level of 20%. The user may alter the impact of slope by adjusting the "Slope Factors" in the User Input Section of the Table Inputs Sheet.

For Washington State, slope is a factor under the default slope triggers in 11% of the CBGs. We tested the overall impact of the slope factors on the average statewide monthly cost and found that eliminating the cost impact of slope all else equal dropped the average cost for the State of Washington by $0.36.[122]

The addition of an element to reflect the costs of serving steep areas, is not, *per se*, unreasonable. However, there is minimal explanation for the particular factors used for the three different classifications of slope. In terms of priority for regulators' scrutiny, however, our analysis indicates that the impact of slope on the average monthly cost is

122. See Appendix 5A.

negligible.

## 5.9 The BCM2 still fails to make an adjustment for subscribership

One of the several flaws that we identified in the original BCM that is perpetuated in the BCM2 concerns the treatment of the approximate 5% of households that are not connected to the public switched telephone network. Because the goal of universal service requires the availability of basic telephone service for all households, the universal service fund needs to cover the costs of those customers for whom facilities are available but who, because they do not subscribe to service, do not contribute any revenue to the operation and maintenance of the network. We recommend that regulators make this adjustment in a cost proxy model in order to more accurately reflect the cost of achieving national universal service goals.

## 5.10 The BCM2 appropriately excludes large portions of uninhabited land in its deployment of a network

The BCM2 addresses the deficiency that had existed in the original BCM. The original BCM assumed a uniform household density which resulted in an overstatement of costs, particularly in those areas with large portions of uninhabited land. As explained in Section 5.2, above, the use of a road map overlap enables the model to exclude appropriately these large portions of land.

# Appendix 5A | RUNS RELATED TO OUTSIDE PLANT

**State: Washington**

**Date:** 7/24/92
**Time:** 11:40:27 AM

Assumptions:
BCM1 values substituted
in Cost Factor Table
(i.e., structure cost multipliers)

| Aggregate Support | | ARMIS |
|---|---|---|
| At $20 = | $ | 83,190,829 |
| At $30 = | $ | 24,718,768 |
| At $40 = | $ | 8,619,515 |
| At $50 = | $ | 3,873,706 |
| At $60 = | $ | 2,082,081 |
| At $70 = | $ | 1,211,414 |
| At $80 = | $ | 837,813 |
| Annual Benchmark Cost = | $ | 798,943,127 |
| State Average Monthly Cost= | $ | 20.21 |

| Density | Households | Lines |
|---|---|---|
| Less 5 | 19,098 | 26,849 |
| 5 to 200 | 408,594 | 634,397 |
| 200 to 650 | 266,499 | 487,515 |
| 650 to 850 | 101,986 | 181,135 |
| 850 to 2550 | 681,340 | 1,181,569 |
| Greater 2550 | 397,991 | 782,457 |
| Total | 1,875,508 | 3,293,923 |

| | ARMIS |
|---|---|
| Cost Category | Households |
| $0<=$ 5 | - |
| $5<=$10 | - |
| $10<=$15 | 583,264 |
| $15<=$20 | 250,932 |
| $20<=$25 | 623,963 |
| $25<=$30 | 174,774 |
| $30<=$35 | 118,676 |
| $35<=$40 | 61,151 |
| $40<=$45 | 26,630 |
| $45<=$50 | 12,379 |
| $50<=$55 | 10,057 |
| $55<=$60 | 3,040 |
| $60<=$65 | 4,052 |
| $65<=$70 | 2,674 |
| $70<=$75 | 735 |
| $75<=$100 | 2,193 |
| $100<=$150 | 697 |
| $150<=$200 | 127 |
| $200<=$250 | 141 |
| $250<=$300 | - |
| $300<=$500 | 23 |
| $500<=$1000 | - |
| $1000+ | - |
| Total Households | 1,875,508 |

| Loop Category | Households |
|---|---|
| 0 <= 5Kft | 194,576 |
| 5Kft <= 10Kft | 473,673 |
| 10Kft <= 15Kft | 432,323 |
| 15Kft <= 20Kft | 283,523 |
| 20Kft <= 25Kft | 171,102 |
| 25Kft <= 30Kft | 106,537 |
| 30Kft <= 40Kft | 102,024 |
| 40Kft <= 50Kft | 51,096 |
| 50Kft <= 60Kft | 21,986 |
| 60Kft <=70Kft | 14,541 |
| 70Kft <= 80Kft | 10,481 |
| 80Kft <= 90Kft | 7,398 |
| 90Kft <= 100Kft | 3,685 |
| 100Kft <=150Kft | 2,511 |
| 150Kft <= 200Kft | 52 |
| 200Ktf+ | - |

| Loop Information | Length |
|---|---|
| Minimum Loop Length | 756 |
| Maximum Loop Length | 165,901 |
| Average Loop Length | 15,199 |

| | | |
|---|---|---|
| Maximum Monthly Cost | $ | 364.26 |
| Average Monthly Cost | $ | 20.21 |
| Lines Above $10K Loop Inv | | 174 |

**State: Washington**

| Density | Summary Results | | Weighted |
|---|---|---|---|
| Less 5 | Sum of # Households | | 19.098 |
| | Sum of # Lines | | 26.849 |
| | Average of Loop Length | | 70.190 |
| | Average of Loop $ per Line | | $2.256 |
| | Average of Total Invstmnt $/Ln | | $2.681 |
| | Average of Monthly Cost1 | | $ 62.03 |
| 5 to 200 | Sum of # Households | | 408.594 |
| | Sum of # Lines | | 634.397 |
| | Average of Loop Length | | 29.933 |
| | Average of Loop $ per Line | | $951 |
| | Average of Total Invstmnt $/Ln | | $1.116 |
| | Average of Monthly Cost1 | | $ 30.71 |
| 200 to 650 | Sum of # Households | | 266.499 |
| | Sum of # Lines | | 487.515 |
| | Average of Loop Length | | 15.436 |
| | Average of Loop $ per Line | | $481 |
| | Average of Total Invstmnt $/Ln | | $598 |
| | Average of Monthly Cost1 | | $ 20.42 |
| 650 to 850 | Sum of # Households | | 101.986 |
| | Sum of # Lines | | 181.135 |
| | Average of Loop Length | | 13.082 |
| | Average of Loop $ per Line | | $384 |
| | Average of Total Invstmnt $/Ln | | $494 |
| | Average of Monthly Cost1 | | $ 18.34 |
| 850 to 2550 | Sum of # Households | | 681.340 |
| | Sum of # Lines | | 1.181.569 |
| | Average of Loop Length | | 11.279 |
| | Average of Loop $ per Line | | $346 |
| | Average of Total Invstmnt $/Ln | | $453 |
| | Average of Monthly Cost1 | | $ 17.49 |
| Greater 2550 | Sum of # Households | | 397.991 |
| | Sum of # Lines | | 782.457 |
| | Average of Loop Length | | 7.629 |
| | Average of Loop $ per Line | | $211 |
| | Average of Total Invstmnt $/Ln | | $313 |
| | Average of Monthly Cost1 | | $ 14.69 |