Ex. __ (GMD-T)

BEFORE THE WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

In the Matter of the Pricing Proceeding for Interconnection, Unbundled Elements, Transport and Termination, and Resale	)	DOCKET NO. UT-960369
In the Matter of the Pricing Proceeding for Interconnection, Unbundled Elements, Transport and Termination, and Resale for U S WEST COMMUNICATIONS, INC.	)	DOCKET NO. UT-960370
In the Matter of the Pricing Proceeding for Interconnection, Unbundled Elemetns, Transport and Termination, and Resale for GTE NORTHWEST INCORPORATED	)	DOCKET NO. UT-960371

SUPPLEMENTAL TESTIMONY

OF

GREGORY M. DUNCAN

June 12, 1997

Ex.____(GMD-T)

GTE NORTHWEST INCORPORATED
SUPPLEMENTAL TESTIMONY OF
GREGORY M. DUNCAN
WUTC Docket Nos. UT-960369, UT-960370, UT-960371

Q. PLEASE STATE YOUR NAME AND ADDRESS.

A. My name is Gregory Michael Duncan. My business address is 777 South Figueroa Street Suite 4200, Los Angeles, California 90017.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed by National Economic Research Associates ("NERA") as Vice President.

Q. HAVE YOU PREVIOUSLY SUBMITTED TESTIMONY IN DOCKETS UT-960369, -370, AND -371?

A. Yes, I filed Direct Testimony on March 27, 1997, and I filed Rebuttal Testimony on April 25, 1997.

Q. DO YOU ADOPT THE ATTACHED REPORT AS YOUR TESTIMONY?

A. Yes.

ECONOMIC AND ALGORITHMIC ERRORS IN THE "UPDATED" HATFIELD MODEL RELEASE 3.1

Presented by

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June 13, 1997

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ALGORITHMIC ERRORS IN THE "UPDATED" HATFIELD MODEL RELEASE 3.1

I. EXECUTIVE SUMMARY

The Hatfield Model Release 3.1 (the Model) is a cost proxy model developed by Hatfield Associates, Inc. of Boulder, Colorado, at the request of AT&T and MCI. The Model purportedly predicts the economic, forward-looking, total element long run incremental cost (TELRIC) of unbundled network elements. TELRICs have been mandated by the Federal Communications Commission as the measure relevant for setting the prices of unbundled network elements (UNEs).[1]

Over the last twelve months, AT&T and MCI have filed five different versions and updates of the Hatfield Model with the Federal Communications Commission and various public utility commissions. We have extensively analyzed and evaluated each version of the Model and have uncovered a wide array of economic and algorithmic errors.

Our economic assessment of Hatfield Release 3.1, entitled "Economic Evaluation of the Hatfield Model, Release 3.1" and our algorithmic evaluation, entitled "Algorithmic Errors in the Hatfield Model, Release 3.1" describe the economic and algorithmic errors of the latest Hatfield Model.[2]

On April 25, 1997, as part of his rebuttal testimony on behalf of AT&T, MCI and MCIMetro, Dr. Mercer addressed some of the algorithmic errors and filed a "revised" version of the Hatfield Model, Release 3.1. Changes were made to the Model's database, its distribution module and its expense module.[3]

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[1] FCC First Report and Order, August 8, 1996, CC Docket No. 96-98, CC Docket No. 95-185 paragraph 29.

[2] Docket No. UT-960371

[3] Rebuttal Testimony of Robert A. Mercer on Behalf of AT&T, MCI, and MCIMetro before the Washington Utilities and Transportation Commission, Docket No. UT-960371, April 25, 1997 pages 3-6.

Once more, we have examined and evaluated this latest set of changes. Our findings indicate that seven (7) algorithmic errors have been corrected, two (2) new errors have been introduced, and eight (8) remain unchanged. None of the economic errors have been addressed, hence our economic evaluation of the Model still applies in its entirety.

Most notably, the "updated" version of the Hatfield Model still does not provide horizontal connecting cables, still includes incorrect calculations for the need of remote terminals, and still does not account for the need of sub-feeder cable in the case when the main feeder intersects the Census Block Group. In addition to these remaining errors, two new errors were introduced. These include the distortion of the CBG database and the application of a faulty "backbone tapering factor."

Based on our review of the "updated" Hatfield Model, we strongly recommend that the State of Washington *refrain* from adopting the Hatfield Model. Due to the wide array of economic and algorithmic errors, the "updated" Hatfield Model, Release 3.1, like its previous incarnations, still does *not* provide a proper basis for establishing valid and reliable costs and prices for unbundled network elements, either in the State of Washington or anywhere else.

We emphasize that the problems with the Model go well beyond using the right user-adjustable inputs. While correct input values are very important, the problems with the Hatfield Model run deeper. Even if all inputs were valid, the Model would still produce incorrect estimates of the "incremental costs that incumbents actually expect to incur in making network elements available to new entrants."[4]

[4] Federal Communications Commission, *Implementation of the Local Competition Provisions in the Telecommunications Act of 1996*, First Report and Order ("FCC Order"), CC Docket 96-98, August 1, 1996, ¶685.

II. INTRODUCTION

The implementation of the Telecommunications Act of 1996 has sparked wide interest and controversy over measuring forward-looking economic costs of supplying local telecommunications service.

Among the methods proposed for measuring such costs are a series of models produced by Hatfield Associates, Inc. of Boulder, Colorado—for a variety of inter-exchange carrier (IXC) clients and purposes—which are generically called "Hatfield Models." The most recent version of the Model (Hatfield Model, Release 3.1) has been submitted to the Federal Communications Commission by AT&T and MCI in the interconnection and universal service dockets.

Our economic assessment of the Model, entitled "Economic Evaluation of the Hatfield Model, Release 3.1" and our algorithmic evaluation, entitled "Algorithmic Errors in the Hatfield Model, Release 3.1" have uncovered a wide array of economic and algorithmic errors.

The purpose of this supplement is to address the latest modifications to the Hatfield Model that were introduced in Dr. Mercer's rebuttal testimony on behalf of AT&T, MCI and MCIMetro. According to Dr. Mercer, the Model's database, its distribution module and two of its expense modules have been "corrected" due to "ongoing scrutiny to which the Model and databases have been subjected by Hatfield Associates, its clients, various regulatory staffs, and other parties."[5]

This supplement analyzes and evaluates these changes and addresses mechanical and logical errors in the distribution module, the feeder module and the database of the "updated" Hatfield Model, Release 3.1. None of the economic errors have been addressed; hence our economic evaluation of the Model still applies in its entirety.

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5 Rebuttal Testimony of Robert A. Mercer on Behalf of AT&T Communications of the Pacific Northwest Inc., MCI Telecommunications Corporation, MCIMetro Access transmission Services, Inc. before the Washington Utilities and Transportation Commission, Docket No. UT-960371, April 25, 1997, pages 3-6.

We have attempted to adjust for the algorithmic errors and to quantify the effects on Hatfield's estimated total cost of switched network elements, whenever this was feasible. The paper concludes with a visual illustration of the Hatfield Model's feeder and distribution network and its algorithmic errors.

The findings presented in this document add to the wide criticism of the Hatfield Model and serve as additional compelling evidence that the Model cannot and should not be used for setting prices of unbundled network elements or quantifying a subsidy for universal service.

III. Description of the Hypothetical Distribution Network

One of the most significant changes between the latest version of the Hatfield Model and its predecessors was the introduction of a new methodology to determine the layout and amount of distribution plant.

As described in the *Model Description*, pages 27 through 30, the Hatfield Model goes through a series of steps to determine the distribution architecture for each census block group (CBG). It commences this process by dividing each squared representation of a CBG into four quadrants. The Model then adjusts the total CBG area by an "empty fraction." This fraction is reported by PNR and Associates and supposedly represents the area of a CBG that is classified as "empty." If this fraction *exceeds* an arbitrarily set threshold of 50%, the Model assumes that the customers are located in *two* diagonally opposite quadrants within the squared CBG. In most cases, the fraction does not exceed this hard-coded threshold, and customers are assumed to be located in all *four* quadrants. Subsequently, the size of each quadrant is reduced uniformly so that the total occupied area in all quadrants is equal to the total CBG area minus the "empty fraction." This creates an image that the developers of the Model refer to as a "window pane."

As illustrated in Figure 1, the squared representation of a CBG is served by a sub-feeder cable. Connecting cables extend from the sub-feeder, in the center of the CBG, to each of the occupied quadrants. If the percent empty exceeds the 50% threshold *or* if the squared CBG is in one of the lowest three density zones, the Model assumes that 85% of the customers are "clustered" in the centers of the two diagonally-opposite quadrants (if the empty fraction exceeds 50%) or four quadrants (if the CBG belongs to the lowest three density zones). The remaining 15% are assumed to be located along streets and paths throughout the remainder of the quadrant and are served by "road cables." No complete documentation exists on these cables, but it is assumed that these are distribution cables that run along rural roads and paths. The size of the "clustered" area is determined by multiplying the number of customers by a "maximum lot size, acres" variable that is arbitrarily set at three (3) acres. The Model's description does not give any insight to the reasoning behind this limitation.

If the percent empty of a squared CBG does not exceed the 50% threshold *and* if the CBG does not fall in one of the lowest three density zones, the Model calculates the average lot size by dividing the "occupied" square mileage by the number of customer locations in the CBG. If the calculated average lot is smaller than three (3) acres ("town lot, acres" variable), distribution plant is applied to the *entire* area of *each* quadrant. If the calculated lot size is smaller than this constraint, then *all* customers are "clustered" in the center of each quadrant. The size of these "clusters" is calculated by multiplying the number of customers per quadrant by three (3) acres -- the artificial maximum lot size limitation.

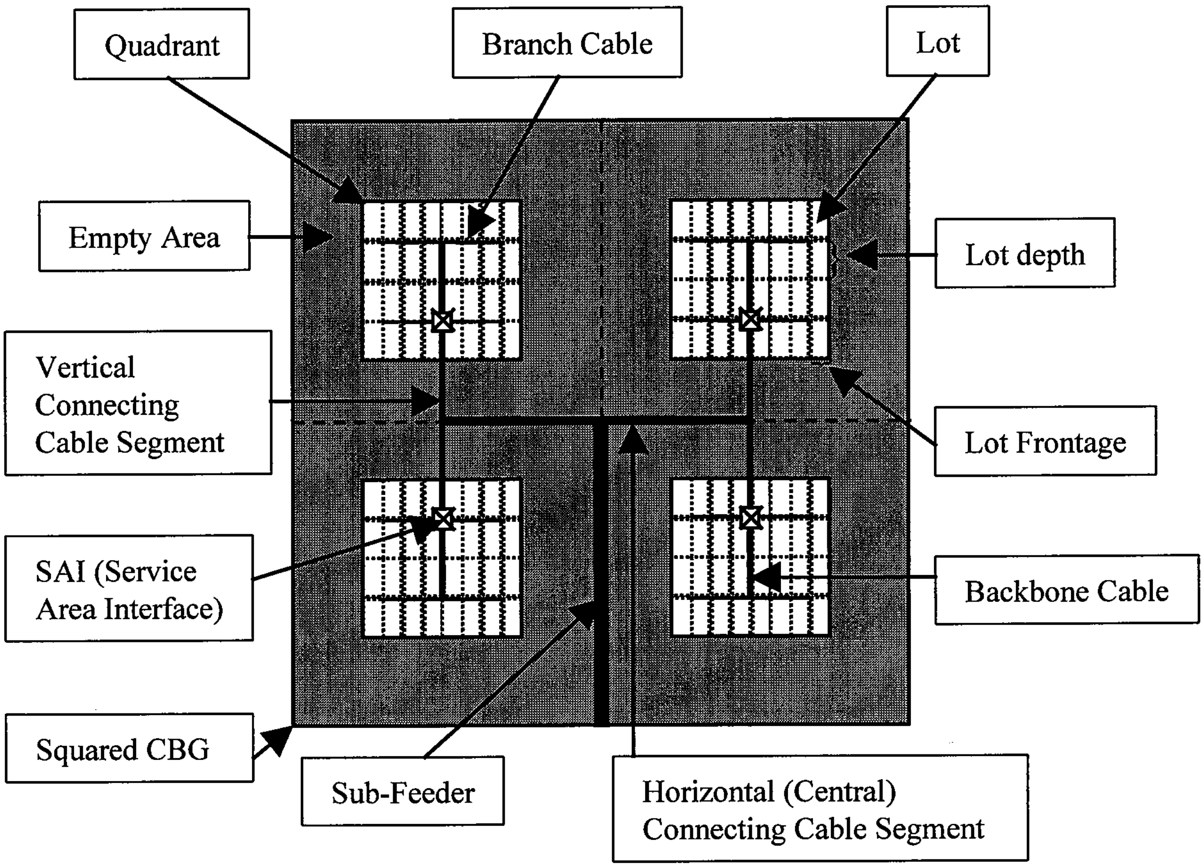
One special case remains. If a squared CBG has an area *less* than 0.03 square miles *and* a line density above 30,000, the Model identifies it as a "high-rise" CBG. In this case, the Model's description claims to make use of "riser-cable" (cable inside the building).

In each of these cases, a "distribution grid" consisting of a backbone cable, branch cables, and drop wires, serves customers that are clustered in the center of the CBG. Backbone cable extends vertically from the SAI box through the middle of each quadrant. Branch cables spaced two lots apart run horizontally from both sides of the backbone cable to within one lot size from the edge of each quadrant.

Figure 1

Hatfield Model, Release 3.1

Distribution Plant Architecture



In general, the grid construct purports to be an improvement over the methodology used in previous versions of the Hatfield Model. However, after a thorough examination of the distribution module, we have uncovered several critical errors in the modeling of the distribution facilities. These are discussed in the following section.

IV. Errors in the Distribution Module

The following is a brief description of the major algorithmic errors that appear in the Model's distribution module.

A. The Model's Tapering Of The Backbone Cable Is Incorrect.

As illustrated in Figure 1, backbone distribution cables begin at the SAI location in each quadrant and extend vertically to within one lot depth of the top and bottom CBG boundary.

As part of their Model "update," the developers have elected to taper the backbone cable. Theoretically, the tapering of a cable is the gradual decrease of the cable's cross-section as it increases in distance. The developers of the Hatfield Model implement tapering by creating a "backbone tapering factor" that is multiplied by the Model's calculations of total backbone cable investment. The tapering factor is 1 if the number of branches per cluster is less than two and 0.5 otherwise. In other words, whenever the number of branches per cluster exceeds two, the Model applies only one-half of the estimated backbone cable investment to its cost calculations. This methodology is wrong in many ways. First, as stated above, tapering applies to *cable size* and not to *cable investment.* Proper tapering involves the inclusion of smaller cable sizes the further one moves along the backbone cable. The Hatfield Model, however, retains its "untapered" cable size and essentially reduces the cable distance by half; hence creating a network that is not connected to its customers. Second, the tapering of the backbone cable would most certainly not involve a 50% reduction of cable investment. Even though increasingly smaller cables are placed, the structure and placement costs remain almost unchanged. The backbone cable still has to be placed and structurally supported from the SAI to the NID.

The faulty tapering approach in the Hatfield Model is an error of methodology as well as algorithm that cannot be simply fixed. To quantify the effects of this error, we opted to remove it entirely. Removing this error for GTE Northwest - Washington State increases the total cost of switched network elements from $20.08 to $21.01.

B. The Model Fails To Account For Portions Of The Connecting Cable.

The connecting cable is the cable that extends from the center of the squared CBG to the serving area interface (SAI) of each occupied quadrant. The SAI is the physical interface point between distribution and feeder cable and is depicted in Figure 1, above. The connecting cable consists of horizontal and vertical segments.

To calculate and report connecting cable length and investment, the Hatfield Model employs two different variables, "Overall Connecting Cable" and "Adj. Connecting Cable."[6] While the first variable is employed to calculate and report the Model's connecting cable *length*, the latter is used to derive *total investment* in connecting cables. It is unclear why two different variables are used for essentially identical computations.

Our review of these variables revealed two algorithmic errors. First, in determining the connecting cable *length*, the Model only accounts for the *horizontal* segment and omits the length of the *vertical* segment. Second, in determining the *investment*, the Model only accounts for the *vertical* segment and omits the costs for the *horizontal* cable segment and its structures. In either case, the Hatfield Model generates a network that fails to connect its customer to the wire center.

To illustrate and substantiate this point, consider the Model's calculation of "Overall Connecting Cable" and "Adj. Connecting Cable."

> *Overall connecting cable length* =
> IF (E2=1,inputs! F25,1)*2640*SQRT ('CBG input data'! I2)
>
> Or in words:
>
> *Overall connecting cable length* =
> If (there is indication of difficult terrain, then apply the value of the user-adjustable "distance multiplier-difficult terrain" variable, otherwise = 1) * ½ side of the CBG (in feet).

Thus, under "normal" terrain conditions, the "Overall Connecting Cable Length" equals one-half of the side of the CBG.

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[6] Hatfield Model, Release 3.1 "updated", distribution module, "calculations" worksheet, columns AW and AX.

Adj. Connecting Cable Length =
IF (AW2/2-SQRT (P2*S2/T2)/2<0,0,AW2/2-SQRT(P2*S2/T2)/2)+2*M2

Or in words:

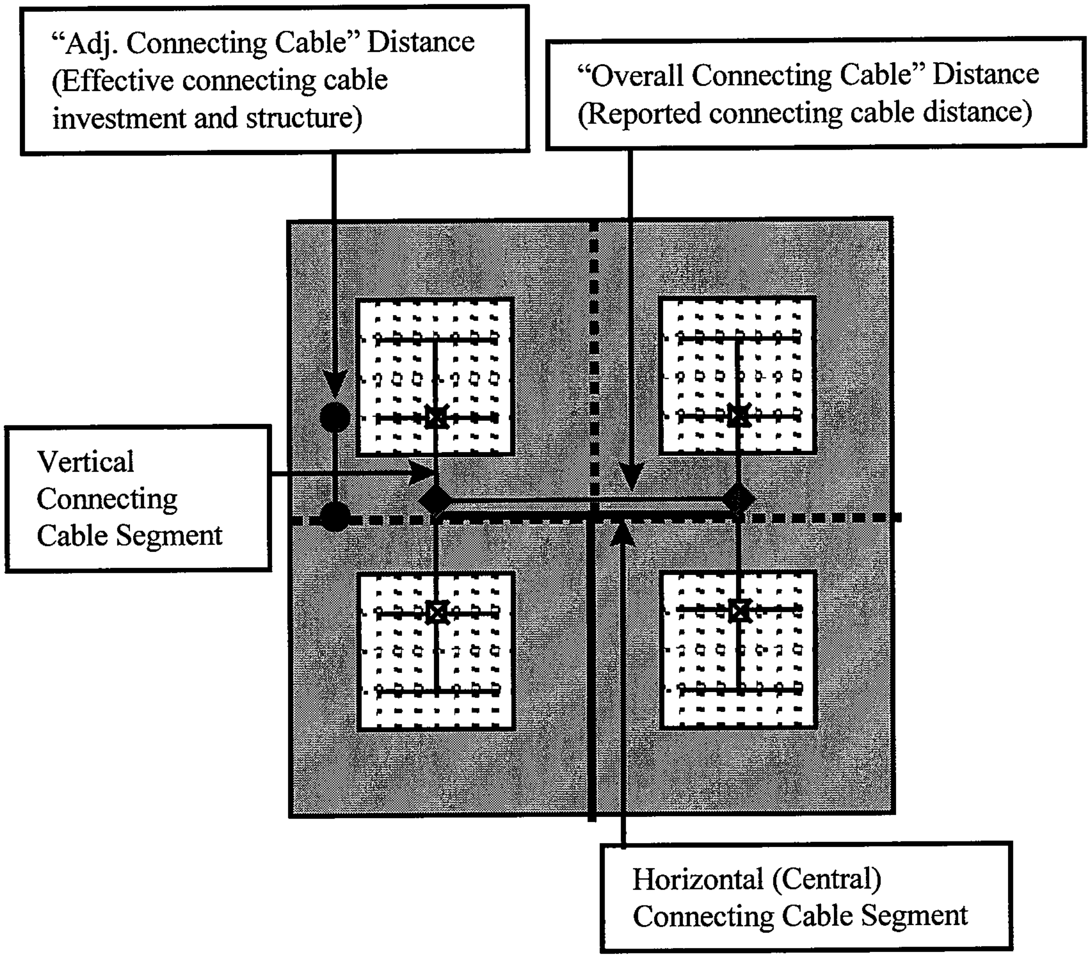
Adj. Connecting Cable Length =

If ½ overall connecting cable length – ½ side of the cluster < 0, then the adj. Connecting Cable Length = 0. Otherwise, ½ overall connecting cable length – ½ side of the cluster + 2 frontage lengths.

Figure 2 depicts the resulting connecting cable distance and investment. For simplification purposes, we have assumed a "non-high rise" CBG with normal terrain.

Figure 2

Effective Connecting Cable Length and Investment



As can be readily seen, significant portions of both reported cable distance and investments are missing. We have quantified the effects of these errors for GTE Northwest - Washington State and found that total loop cost increased from $13.85 to $16.07, an increase of 16%, while Hatfield's estimate of the total cost of switched network elements increased from $20.08 to $22.25, an increase of roughly 11%.

C. The Calculations For The Need Of Remote Terminals Are Incorrect.

A CBG is served by either a fiber or copper feeder cable. Fiber feeder and a digital loop carrier system are installed where the total main feeder and sub-feeder length exceeds a 9,000-foot threshold. If the Model installs fiber feeder, two cases apply. If the longest distribution cable, extending from the center of the CBG to the farthest customer, is greater than 18,000 feet, the Model extends fiber-connecting cables to a DLC remote terminal and SAI located at the center of each cluster.[7] Contrarily, copper connecting cables are "installed."

To determine if fiber connecting cables and remote terminals are required, the Model calculates the distance from the center of the CBG to the farthest customer. Due to the incorrect calculations of connecting cable, however, this distance is significantly understated. Consequently the need for remote terminals is understated, leading to an understatement of cost.

Adjusting for this error for GTE Northwest – Washington State increases the total cost of switched network elements from $20.08 to $20.39.

D. The Hatfield Model Builds The Majority Of Its Network On An Understated Service Area

As described in Section III, the Hatfield Model makes use of a "Maximum Lot Size, Acres" variable and a " Town Lot Size, Acres" variable, both of which are set at a national default of three (3) acres. The maximum lot size variable is "the maximum effective lot size in a CBG, above which it is assumed that the population is clustered into areas whose effective lot size is the default value." The town lot variable is the "lot size of subscribers residing in towns when the Model determines that clustering in towns is appropriate."[8]

Contrary to the Model's documentation, quoted above, the town lot size and the maximum lot size variables are *not* user adjustable. Though the Model's input screen allows

[7] Hatfield Model, Release 3.1, Model Description, Hatfield Associates, Inc, Boulder, Colorado, p. 33

[8] Hatfield Model, Release 3.1, Appendix B, Hatfield Associates, Inc., Boulder, Colorado, p. 18.

the user to change the values, the changes do not carry through to the database or to the resulting calculations. Instead, when a change is made to the *town* lot size, the Model immediately modifies the *maximum* lot size to equal the value that was input from the town lot size. This inadvertent *maximum* lot size is used and the change in the *town* lot size is ignored; its value reverts back to its default value of three (3) acres.

This error has a serious impact on the TELRIC estimates. By limiting the lot size to three (3) acres, the Model significantly reduces the area on which it "engineers" its distribution network and consequently understates costs.

The effects of this error are best illustrated visually and are presented at the end of this paper.

V. Errors in the Feeder Module

The following section includes a brief description of algorithmic errors in the feeder module. Whenever feasible, the discussions include quantification of the errors to illustrate the effects on Hatfield's estimated cost of its hypothetical network.

A. The Model Does Not Include Sub-Feeder Cable For CBGs Whose Perimeter Fall Along Main Feeder Routes

In Hatfield's hypothetical network, sub-feeder cable extends at a right angle from the main feeder to the center of the CBG. Connecting cables run from the sub-feeder to a point one-quarter distance from the edge into each occupied quadrant.

For CBGs whose perimeters fall along a main feeder route, the Model does not include a sub-feeder in its calculations for distribution plant.[9] In previous versions of the Model, there was no need for sub-feeder in this particular instance. Release 3.1, on the contrary, always requires a sub-feeder to reach the center of the CBG, where it meets with the connecting cables.

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[9] Hatfield Model, Release 3.1, Distribution Module, "Calculations" Tab, Column "G" calculates the "external sub-feeder." This is the part of the sub-feeder that runs from the main feeder to the CBG boundary. Column "G" in the "Output" Tab adds the "internal" portion (the distance between CBG boundary and CBG center) of the sub-feeder only if the "external" sub-feeder is not zero. In other words, the Model includes a sub-feeder only if there is a positive distance from the main feeder to the CBG boundary, thus omitting sub-feeder investments in the case where the main feeder intersects a CBG.

The omission of sub-feeder in the case stated above leads to an understatement of feeder cable, and hence, an understatement of cost. Adjusting for this error for GTE Northwest - Washington State increases the estimated total cost of switched network elements from $20.08 to $20.80.

B. The Hatfield Model Does Not Properly Share The Cost Of Copper Cables Along The Main Feeder.

The Model allocates the costs of the maximum size fiber feeders to all CBGs that route off the main feeder. Copper feeder is treated in a different fashion. When the Model encounters maximum size *copper* feeder cable in the main feeder network, it erroneously assigns the entire cost of the maximum cable to the first CBG it serves. Consequently, too much cost is allocated to CBGs closer to the central office and too little to CBGs at the end of the main feeder route.

C. The Model Ignores The Impact Of Terrain On The Main Feeder Estimations.

Unlike the distribution module, where the Model attempts to account for the impact of difficult terrain, we could not find any evidence of the inclusion of the terrain impact on costs or length in the feeder module. The impact of this omission for GTE Northwest - Washington State is estimated to increase the total cost of switched network elements from $20.08 to $20.13.

D. The Hatfield Model Omits Part Of The Distribution Network For Copper-Fed CBGs.

As delineated above, if a CBG's feeder exceeds the fiber feeder threshold *and* contains less than 24 lines per quadrant, it is served by copper feeder. For these particular CBGs, the Hatfield Model fails to provide *all* feeder network components for part of the loop. This part consists of the portion of copper cable, conduit, and manholes that run *parallel* to fiber, where the fiber is the serving technology.

To illustrate this point, consider the following example. CBG 1's feeder is less than the fiber feeder threshold and is therefore served by copper. CBG 2's feeder is beyond the threshold and is fed by fiber technology that runs parallel to the copper feeder for CBG 2. CBG

3, even though beyond the threshold, has less than 24 lines per quadrant and is therefore fed by parallel copper feeder. In its calculations, the Hatfield Model omits all feeder investment components from CBG 2 to CBG 3. In other words, for the route segments where fiber feeds the CBG, there are no parallel runs of copper technology.

The omission of these crucial network components lead to a clear understatement of costs. The severity of this problem depends on the number of these copper-fed low density CBGs and differs from state to state.

VI. ERRORS IN THE DATABASE

In its latest set of changes, the developers of the Hatfield Model elected to change the content of the database. An inspection of the "updated" database for GTE Northwest - Washington State revealed that the number of households has been decreased in an unexplained fashion.

The change in household count is entirely unwarranted and erroneous for several reasons. First, the developers chose to change only the number of households, leaving the number of lines per CBG unchanged. This is inconsistent with the Model's documentation that clearly states that the line count estimate per CBG "is based on the number of households in each CBG."[10] Hence, if one changes the number of households, the number of lines per CBG should change as well. Second, the Model's documentation states that "the Census database supplied by PNR identifies the number of households located in various types of buildings."[11] Thus, one could expect to find the sum of the number of households in each building type to equal the *number of households* in the Model's database. While this was true for the "original" filing of Release 3.1, this does not hold true for the "updated" version. In some instances, the "updated" database contains CBGs with hundreds of lines, hundreds of households in various types of housing units, while having zero households in total.[12]

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[10] Hatfield Model, Release 3.1, Model Description, page 21.

[11] Ibid. page 31.

[12] For an example of this occurrence, see WA CBG 530050101001 in the Hatfield Model's "updated" database. This CBG reports 130 residential lines, 133 households in "1-hu detach" housing units and zero number of households.

We have adjusted for this apparent mistake by replacing the "updated" database with its "original" counterpart. Consequently, total cost of network elements for GTE Northwest - Washington State increased from $20.08 to $20.18.

VII. Miscellaneous Algorithmic Errors in the Hatfield Model

A. The Hatfield Model Incorrectly Shows A Change In Estimated Loop Cost When Non-Loop Inputs Are Changed.

In the course of our analysis, we have encountered numerous situations where we changed the value of a *non-loop* "user-adjustable" input, such as switching costs, and observed a change in loop costs, such as distribution cost estimates. Time constraints did not permit us to investigate this occurrence in more detail. However, this is a strong indication of additional algorithmic errors, not yet identified.

B. The Hatfield Model Does Not Run When Any Of The User-Adjustable Inputs Are Set Close Or At Zero

In addition to the potential errors identified above, we have discovered that setting "user-adjustable" inputs close to or at zero will cause the Model to "crash." By this we mean that the Model's macrocode will not execute if *any* of the "user-adjustable" inputs are set at zero. It is unclear whether this is an error in the Model's algorithm or whether the developers of the Model intentionally prevent the user from inputting zero for any of the "user-adjustable" values.

VIII. Visual Illustration of the Modeling and Algorithmic Errors in the Hatfield Model

To illustrate the inaccuracy of the Hatfield Model's network design and the effects of some of the algorithmic errors in the Model, we have mapped the Hatfield Model's estimated feeder and distribution network for a randomly selected CBG.

CBG 80719832003 in Colorado has an area of 143 square miles and contains 80 switched access lines. Based on a study by PNR and Associates, 16% of this CBG is considered "empty." The distribution module of the Hatfield Model divides the CBG into four quadrants and reduces these quadrants equally to reflect the 16% of the total CBG area that is classified as "empty." Within these quadrants, it then distinguishes between "in-town" and "out-of-town" customers. A distribution grid serves customers residing "in town", while "out-of-town" customers are served by "road cables." This particular CBG falls into the lowest density zone. Hence, the Model arbitrarily assigns 85%, or 68 switched access lines, to clusters or "towns." The remaining 15%, or 12 lines, are treated as "out-of-town."

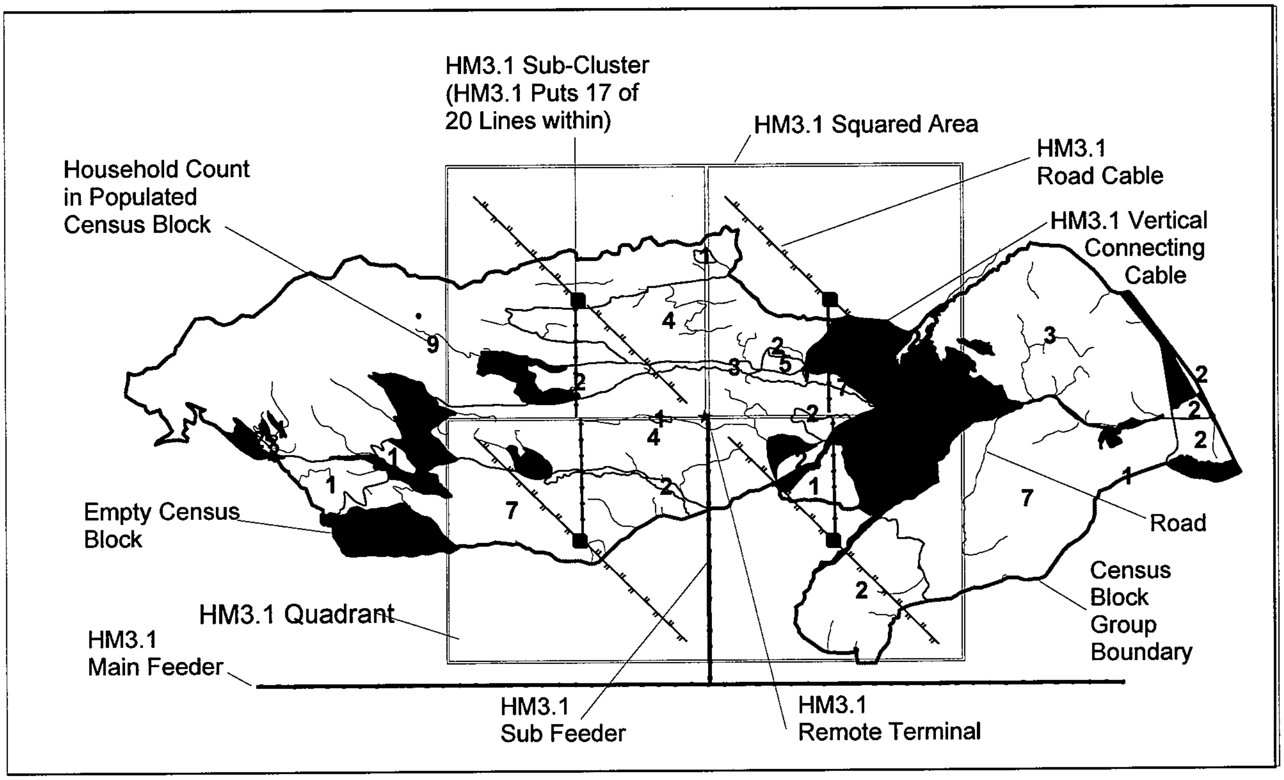
For this particular CBG, the Hatfield Model calculates a cluster area for 68 of the 80 switched access lines equal to 0.22% of the CBG's total area. In other words, the Hatfield Model suggests that 85% of all lines in this CBG are concentrated in less than 1% of the total CBG area, while the remaining 15%, or 12 lines, populate the remaining 99.8% of the quadrant.[13] The resulting feeder and distribution plant is depicted in Figure 3, below.

[13] In addition to this error, the Model does not adjust drop cable for out-of-town customers. The Model assumes that the average distance that these customers are from the lot front is 150 feet -- the same distance as is assumed for town customers. This error leads to a further understatement of Hatfield proposed TELRIC estimates.

Figure 3

Visual Illustration of Hatfield's Resulting Feeder and Distribution Network

Colorado CBG 080719832003



This example illustrates several of the Hatfield Model's algorithmic and modeling errors. First, and foremost, clustering 85% of its customer into less than 1% of total CBG area is clearly inappropriate. There seems to be no evidence of any clustering of customers. To the contrary, customers in the CBG above seem to be distributed rather uniformly across the CBG. Second, the "window pane" distribution plant method will lead to a clear under-provision of the ILEC's distribution plant. The Hatfield Model assumes that "empty" areas do not need any distribution plant. However, as depicted above, in order to connect customers from one end of the CBG to the other, it is mandatory to build the distribution plant through "empty areas." Third, the example illustrates that the Model will significantly underestimate the number of pair miles of distribution cable needed. This stems from the fact that the majority of the Hatfield Model's estimated cable sheath is comprised of connecting cables and road cables with relatively small cross-sections. Only a minute part of its distribution plant actually stems from the distribution grid that serves the *actual* customers in the clustered areas. Thus, in order to connect the customers to the distribution plant, one would need either cable with larger cross-sections or more multiplexers. In either case, the Hatfield Model significantly underestimates the amount of distribution plant needed. Finally, the Hatfield Model does not account for part of the connecting cable and does therefore not connect its customer to the distribution network.

IX. Cumulative Quantification Of The Errors

In an effort to replicate the Hatfield Model's *intended* algorithms, we have manually calculated the distribution plant for a randomly selected CBG in GTE Northwest – Washington State's service area. The following table contrasts the resulting distribution network if one were to replicate the Model's calculations as stated in the Model's description to the resulting network as calculated automatically by the Model. The large discrepancy between the two calculations indicates the presence of a number of serious algorithmic errors. Table 3 clearly illustrates that the Hatfield Model in its current format does not generate the hypothetical network laid out in the *Hatfield Model Release 3.1, Model Description.* While several of the errors and omissions have been pointed out above, many others might be "buried" in the Model's thousands of equations.

Table 3

Comparison of the Hatfield Model's Computer Simulated Network To a Network Calculated Manually Using Identical Algorithms GTE Northwest --Washington State

Data Item	Manually: HM3.1 Limit on Acreage	HM3.1 Default Scenario	% HM 3.1 of Manually (limit)
(1)	(3)	(4)	(6) (4)/(3)
CLLI	ACMEWAXA	ACMEWAXA	-
CBG Input Data			
CBG Number	530730008021	530730008021	-
Area in Town	0.85	0.85	-
Locations	550	550	100%
Total Households & Businesses	155	155	100%
Total Area (square miles)	36.73	36.73	100%
Input data			
Empty Area (square miles)	15.07	15.07	100%
Populated Area (square miles)	21.67	21.67	100%
Calculated Lots and Clusters			
Area of Clusters (square miles)	2.47	2.47	100%
Lot Size (sq. ft.)	130,680	130,680	100%
Lot Front (ft.)	256	181	71%
Lot Depth (ft.)	511	722	141%
Calculated Lengths			
Main Feeder	7,271	7,271	100%
Sub Feeder Outside of CBG	0	0	100%
Sub Feeder Within CBG	6,448	0	0%
Horizontal Connecting Cable	8,000	0	0%
Vertical Connecting Cable	6,437	6,243	97%
Backbone length	3,127	3,626	110%
Branch cable length	1,819	1,894	104%
Total Length to Customers	33,102	18,834	57%
Remote Terminal Necessary?	Yes	Yes	-
Number of branches per cluster	10	12	83%

We have quantified the *cumulative* effects of the errors identified in this paper on the Model's "TELRIC" estimates and found that the total cost of switched network elements increased by roughly 30% from $20.08 to $26.15. Table 4 provides a summary of our findings. Appendix A explains how each of the columns in the distribution module was modified.

Table 4
Error Quantification
GTE Northwest – Washington State

Scenario (1)	Errors Adjusted (2)	Total Cost of Switched Network Elements (3)	Change from Default Run ($) (4) (3) – (20.08)	Change from Default Run (%) (5) (4)/(20.08)	Module & Columns Modified (6)
1	None (Default Run)	$20.08			None
2	Local Switching Function	$22.43	$2.35	11.7%	Switching Module, Wire Center tab: E
3	Scenario 2 + backbone tapering	$23.36	$3.28	16.3%	Scenario 2 + Distribution Module, Calculation tab: AD
4	Scenario 3 + horizontal connecting cables	$25.52	$5.44	27.1%	Scenario 3 + Calculation tab: AX
5	Scenario 4 + remote terminal calculation	$25.24	$5.16	25.7%	Scenario 4 + Calculation tab: AZ
6	Scenario 5 + Sub-feeder omission	$25.98	$5.90	29.4%	Scenario 5 +Output tab: G
7	Scenario 6 + terrain impact in feeder	$26.03	$5.95	29.7%	Scenario 6 + Output tab: F
8	Scenario 7 + database distortion	$26.15	$6.07	30.2%	Access Database

X. CONCLUSION

Our review of the Hatfield Model has revealed numerous economic and algorithmic reasons for not using the Hatfield Model Release 3.1 to determine TS/TELRICs. One of the most vexing problems is that the Hatfield Model has never been tested against real data, as might be expected of any estimation model. Trying to use the Model in spite of this fact is a little like asking paying customers to fly on a plane which has never been flown or even tested.

Beyond the lack of external verification and empirical validity, we have identified explicit economic and conceptual flaws. These flaws render the Model unlikely to produce any accurate and reliable estimates of TS/TELRICs. Moreover, the Model is static rather than dynamic which leads, among others things, to unrealistically high fill factors. An equally troubling aspect of the Model is its fundamental assumption that the telecommunications industry will not face increased market uncertainty and that LECs have had, and will continue to have, perfect foresight of all market conditions.

The Model does not even satisfy the minimum economic criteria required of properly constructed cost models—that increasing all prices by a common proportion must increase TS/TELRICs by exactly the same amount.[14]

Besides these economic errors, our analysis has identified a number of algorithmic errors in the current version of the Hatfield Model. A review of the Model's algorithm revealed major mechanical inconsistencies, such as the omission of network components.

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[14] To illustrate this point, consider following example: The owner of a lemonade stand uses lemons, sugar and water as ingredients for his lemonade. One glass of lemonade contains 2 lemons, 1.5 tablespoon of sugar and 1 glass of water. For the purpose of this exercise assume that lemons are $0.80 a piece, 1 table spoon of sugar is $0.05 and the water is $0.08. Thus wholesale price of one glass of lemonade is (2*0.8)+(1.5*0.05)+(1*0.08) = $1.755. Let's assume that overnight all input prices, i.e. the price of lemons, sugar and water increased by 10%. Now a glass of lemonade at the wholesale level costs (2*0.88)+(1.5*0.055)+0.088 = 1.931. Hence, increasing all input prices by 10% results in an increase of exactly 10% in total costs. This is one of the basic requirements of a cost functions and is termed "linear homogeneity in input prices." The Hatfield Model does not fulfill this very basic requirement and increasing all input prices in the Hatfield Model results in an increase of total cost of only 8.21%. In terms of this example, the Hatfield Model suggests that (2*0.88)+(1.5*0.055)+0.088 = 1.907.

While the impact of these flaws and errors on the Model's estimates range from minor to highly significant, together they reinforce a central point: The Hatfield Model is severely flawed and can not be trusted to determine the TELRICs of unbundled network elements, nor can it be used to set the prices for these elements.

APPENDIX A: ALGORITHMIC CHANGES TO THE HATFIELD MODULES

Variable	Column	Modification
Switching Module, Wire Center Investment tab:		
Installed EO Switching per Line	E	Replaced the Hatfield generated switching cost function with a switching cost function based on actual GTE switch contracts.
Distribution Module, Calculations tab:		
Backbone Taper Factor	AD	Remove this factor entirely.
Adj. Connecting Cable Length, ft	AX	Added ½ "overall connecting cable length, ft" (AW)
Maximum Distance from Center	AZ	Added "Adj. Connecting Cable Length, ft"
Output tab		
Sub-Feeder Distance	G	Removed "If" statement
Main Feeder Distance	F	Multiplied by a variable that is equal to 1 if normal surface is encountered and equal to the "distance multiplier – difficult terrain" if difficult terrain is encountered.
Database		
Household problem	All	Replace "updated" database with "original" database.