Engineering Evaluation of Cost Proxy Models for Determining Universal Service Support: Hatfield Model Version 3.0/3.1

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Introduction

The United States Telephone Association ("USTA") retained Price Technical Services and Austin Communications Education Services to provide an engineering evaluation of cost proxy models submitted in the Federal Communication Commission's ("FCC") Universal Service proceeding, CC Docket 96-45. These models are the Hatfield Model ("Hatfield Model"), sponsored by AT&T and MCI, and the Benchmark Cost Proxy Model ("BCPM"), sponsored by Sprint, US West and Pacific Bell. This report contains our engineering evaluation of the Hatfield Model Version 3.0/3.1, sponsored by AT&T and MCI.

We previously reviewed the Hatfield Model, Version 2.2, Release 2 and published the results of our analysis in an *ex parte* filing with the FCC on February 5, 1997. In that report, "in view of its importance to the Hatfield Model, we [began] our critique with an evaluation of the concept of structure sharing." We then reviewed "four aspects of the Hatfield Model Version 3.0/3.1: model structure, engineering assumptions, material assumptions and data inputs."[1]

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[1] Robert F. Austin, Ph.D. *Engineering Evaluation of Cost Proxy Models for Determining Universal*

In this report, we focus discussion on four elements: structure sharing, logic (including missing inputs), user inputs, and user interface. The question of structure sharing continues to dominate the Hatfield Model Version 3.0/3.1 and to limit its utility. We reiterate our original critique in this report because we believe the assumptions, while admittedly modifiable by users, indicate a significant skew in the philosophy of the Hatfield Model Version 3.0/3.1. For the same reason, we also consider model logic again because of the continued omission of several components necessary to provide telecommunications services and also necessary to operate the Hatfield Model Version 3.0/3.1.

Many issues we raised in our discussion of Version 2.2, Release 2 of the Hatfield Model have been addressed in Version 3.0/3.1. Consideration of the remaining issues related to engineering assumptions and materials assumptions may be consolidated in a discussion of user inputs. Therefore, we have combined these matters into a unified discussion of input values and assumptions. We believe this unified discussion will serve to focus attention on the remaining critical problems of the Hatfield Model Version 3.0/3.1.

Finally, one significant change in the Hatfield Model Version 3.0/3.1 from previous versions is the user interface. This interface and the underlying software have caused substantial problems for reviewers and have been the subject of much discussion nationwide. Thus, although we recognize that the Hatfield Model Version 3.0/3.1 may be revised repeatedly before general dissemination, we have included our observations on these issues.

Service Support: Hatfield Model 2.2, Release 2, Ex Parte Filing, Federal Communications Commission Docket No. 96-45, February 5, 1997, page 6.

Structure Sharing

NOTE: The discussion in this section is excerpted from our report on the Hatfield Model Version 2.2, Release 2.[2] The comments made here also apply to the Hatfield Model Version 3.0/3.1. Footnote references have been updated.

Introduction

The Federal-State Joint Board on Universal Service, CC Docket 96-45 ("Joint Board") published its Recommended Decision *on November 8, 1996. In that document, the Joint Board specified that the "technology assumed in the model should be the least-cost, most efficient and reasonable technology for providing the supported services that is currently available for purchase."*[3] *Furthermore, the Joint Board specified that: "All underlying data should be verifiable, engineering assumptions reasonable, and outputs plausible."*

While these specifications arguably may be in conflict in some instances, they certainly constitute an endorsement for sharing network construction costs among several companies where feasible. Both models address the subject of structure sharing explicitly in several tables and implicitly in their structure. In brief, the concept assumes that several companies could use some or all support structures in a telephone network simultaneously. For example, in theory several companies could attach aerial cables to a pole.

The number of companies that may attach facilities to a pole depends primarily on the height of the pole, the class of the pole, and the number of pre-existing attachments. The height of the pole is a factor because federal, state, and local laws and ordinances, as well as safety concerns mandate certain minimum clearances over roadways and railroad tracks below the cable spans. These and other parameters, such as the weight of the cable, dictate the minimum height at which users may attach cables to poles.

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[2] Robert F. Austin, Ph.D. *Engineering Evaluation of Cost Proxy Models for Determining Universal Service Support: Hatfield Model 2.2, Release 2, Ex Parte* Filing, Federal Communications Commission Docket No. 96-45, February 5, 1997, pages 7-15.

[3] Federal-State Joint Board on Universal Service, CC Docket 96-45, *Recommended Decision*, November 8, 1996, ("Joint Board Decision"), paragraph 277.

The same and other regulations prescribe the spacing of cables on a pole. In combination, these constraints determine the maximum theoretical number of cables that users may attach. Similarly, the class of the pole, which corresponds to the diameter of the pole (six feet above ground after pole placement), determines the total load that the pole may bear and the support guying required. Pre-existing attachments, by definition, occupy space to the exclusion of newcomers.

It seems reasonable to state those high relative rates of structure sharing would best serve the interests of the Hatfield Model's sponsors. In support of this statement, we note first that a high assumed rate of structure sharing would result in a calculated reduction of the average forward-looking costs of construction, hence a reduced cost for unbundled network elements. This would result in lower network "assembly" or "element leasing" costs (as opposed to construction costs) for the sponsors. In other words, the higher the rate of sharing that the model assumes, the lower the pro rata cost of new network construction that the model will calculate.

Second, a higher rate of proposed structure sharing infers the existence and current availability of a larger amount of structures for immediate use in network build-out by entrants to the market. If Entrant Local Exchange Companies ("ELEC") should decide to reject the pricing of unbundled network elements, they could demand access to this hypothetical structure capacity. If the Incumbent Local Exchange Companies ("ILEC") do not make capacity available, the ELECs could claim that the ILECs were intentionally and anti-competitively withholding this hypothetical capacity.

(Interestingly, in their supplementary Hatfield Model filing, the sponsors stated that: "Present structure owners could use their control of these scarce resources to restrict entry by potential competitors."[4] If the resources are indeed scarce, where is one to find the surplus capacity that the ELECs allege is available?)

Third, the structure sharing rates presented in the model imply that the ILECs have been prodigiously inefficient and profligate in their spending by failing to share structures at the rates recommended by the Hatfield Model sponsors. While this may be a comforting, albeit self-serving, assumption, it also, in most respects, is an unreasonable assumption. During the first 80 years of the life of the telephone industry, there were no

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[4] "AT&T and MCI Submission on the Hatfield Proxy Model," (*Ex Parte* Presentation - Proxy Cost Model Questions, CC Docket 96-45), January 7, 1997, page 20.

CATV companies to share structures. Therefore, the telephone companies did not build structures to share with them.

During the same 80 years, there were no dielectric, fiber optic cable transmission facilities that could safely share a duct or feeder route trenches with power cables. The ILECs shared poles where it was possible, given concerns about induction coordination, by attaching telephone cables to power poles, by organizing joint construction in appropriate areas, and by installing larger poles, under certain circumstances, and leasing capacity to the power companies.

Incorporating Structure Sharing in a Model

The Joint Board's specifications regarding universal service costs are clear and unequivocal. Only forward-looking costs may be considered. The scenario they specify dictates that, for modeling purposes, there are no existing telephone network structures or facilities. The scenario also specifies that models should assume that the locations of the existing wire centers persist. (Although with the benefit of 100 years of hindsight some observers may judge these wire center locations to be less than optimal, their selection for modeling is a neutral assumption: all models will work from the same given location to build new networks. In any event, their locations reflect the distribution of population reasonably well.)

One option for a cost model would be to consider the use of existing facilities placed by other industries. For the most part, the nation's CATV and power networks are in-place and in-service. (The Joint Board quite correctly does not suggest that a model of telephone network construction costs should assume "green fields" for every utility or be predicated on the complete reconstruction or new construction of these other utilities' networks.) If these utilities sized their structures to permit leasing of excess capacity to another company or companies, there might be capacity available for use by a new telephone company. The Hatfield Model does not appear to incorporate such ELEC costs (that is, leasing facilities from utilities other than ILECs), a shortcoming that we recommend for correction in future model releases.

In their supplementary Hatfield Model filing, the sponsors stated that: "It is more than reasonable to assume that, on a forward-looking basis, ... ILECs will be able to recover an increasing portion of their structure costs through joint ownership or rental arrangements."[5] *This appears to be an*

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[5] "AT&T and MCI Submission on the Hatfield Proxy Model," (*Ex Parte* Presentation - Proxy Cost

unreasonable assumption, given that the electric companies and CATV companies already have their networks built.

If, on the other hand, the ILECs were to place all new structures for their new, forward-looking network, we must assume they would size them in compliance with the FCC's constraints on the model, including the "least cost" constraint that precludes construction of surplus structure capacity. A design engineer might assume that under some circumstances the true "least cost" might be a shared new construction cost and that the telephone company should build and lease excess new, forward-looking structure capacity to reduce aggregate costs. In this case, the telephone company will face a marketing problem: the networks of the other utilities already exist. There are no other companies with whom to share these structures, except, perhaps, a hypothetical ELEC. (We must exclude the cases of new sub-divisions because the guidelines given to the model developers preclude considerations of future growth in demand.)

Practical Considerations

Beyond the philosophical issues associated, there are several tangible practical issues associated with structure sharing that the Hatfield Model ignores. Regarding aerial plant, currently accepted, industry-wide engineering practices dictate minimal use of aerial facilities. This design principal recognizes 1) the higher whole-life costs (including maintenance) of the facilities, 2) the exposure of the aerial facilities to more and greater environmental hazard, and 3) the zoning requirements of many local governments regarding design aesthetics. Consequently, the assumption regarding the mix of aerial, buried and underground plant is untenable. While the model does permit adjustment of this mix, the selection of the defaults shown in the model reflects antiquated thinking about outside plant design. It also obviates the usefulness of the Southern California Joint Pole Committee cited in the supplementary Hatfield Model filing.[6]

Regarding manhole-conduit system use, there are several cable placement problems ignored by the Hatfield Model. For example, there is a significant problem raised in the size of the manhole specified in the model. The model should specify a precast manhole with standard dimensions of 6 feet X 12 feet X 7 feet (excluding the mid-section), as recommended in the AT&T Outside Plant Engineering Handbook. Instead,

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Model Questions, CC Docket 96-45), January 7, 1997, page 20.

[6] "AT&T and MCI Submission on the Hatfield Proxy Model," (*Ex Parte* Presentation - Proxy Cost Model Questions, CC Docket 96-45), January 7, 1997, page 21.

the model specifies a much smaller Type A handhole with dimensions 4 feet X 6 feet X 7 feet.[7]

A manhole with these dimensions does not provide the capacity suggested by the model as being available for sharing or lease. Indeed, it would be difficult for a manhole with these dimensions to accommodate multiple splices and cable entries as the number of cables and their sizes increase. As confirmed by the AT&T handbook, engineers should only use this manhole for "light, secondary conduit runs or buried cable runs."[8] *This practice serves to reduce the cost of manholes in the model's calculation, and therefore understates the true cost of network construction. More significant to the present discussion, it precludes the volume of sharing assumed by the model.*

Under certain circumstances, regulatory authorities or responsible outside plant planning design principles dictate the sharing of duct. In these cases, users must make substantial modifications to the model, including changes in the size and price of the manholes and in the number and cost of multiple ducts. Moreover, users would need to incorporate the costs attributable to "proving" the duct and to cable pulling in the duct. Neither cost is evident in the Hatfield Model.

The Hatfield Model does not properly apply additional cost burdens before assuming the split in costs associated with the conduit/direct buried/ aerial applications. There will be an increase in construction placement costs in most cases if trenches or other facilities are shared or jointly occupied. In most cases, a shared trench must be deeper and wider to accommodate the additional utilities that are participating in the shared or common trenching. This is a function of the requirements for minimum separation in horizontal and vertical planes mandated by the governing authorities.

*To expand on this subject, the AT&T Outside Plant Engineering Handbook specifies "**Joint trenching with power facilities should be employed only for distribution cables and service wires, not for feeder or trunk***

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[7] *Outside Plant Engineering Handbook*, August 1994, AT&T Network Systems Document Number 900-200-318, Winston-Salem, North Carolina (Republished October, 1996 by Lucent Technologies), Section 8. The sponsors of the model cite as support for this selection a publication called the National Construction Estimator, 44th edition, page 442.

[8] *Outside Plant Engineering Handbook*, August 1994, AT&T Network Systems Document Number 900-200-318, Winston-Salem, North Carolina (Republished October, 1996 by Lucent Technologies), page 8-43, Table "Precast General Use Manholes".

***cables**" [emphasis in original publication].*[9] *The same document also specifies the minimum separation distances that engineers must maintain between power and telephone plant to ensure public safety and the integrity of the facilities. The separation distance is 12 inches in most cases. More importantly, however, higher voltage power lines must be placed at a greater depth (for example, 42 inches for voltages over 50,000), which will increase the cost of trenching substantially.*[10] *In addition, some municipalities, counties and parishes require additional protection such as concrete caps, concrete encasement, or steel casings for shared facility use.*

Summary

The principle of "least-cost" dictates that ELECs and ILECs model their networks with facilities of dimensions and capacities suitable for present service rather than future service. Therefore, an ELEC or ILEC probably would perform forward-looking new construction with "least cost" poles that power companies could not share because of the short pole height. In any event, the power and CATV companies probably would not share these "least cost" poles because their systems already exist. The shorter pole size also would mean that ELECs that chose to attach to ILEC-owned poles might encounter difficulty ensuring road clearances at mid-span.

Similarly, the ELECs or ILECs would perform the forward-looking new construction using "least cost" manholes and fully occupied ducts. Under these circumstances, users obviously will invoke the ability to modify default values during actual cost studies. However, use of these default values by the sponsors of the Hatfield Model will skew the results of analysis during public discussion. The Hatfield Model's input and structure assumptions are inappropriate to the constraints imposed by reality.

Furthermore, we believe that users of the Hatfield Model should give some consideration to issues of public safety and security. The model does provide for user intervention in the presumed sharing rates. We believe that engineers should use this feature for reasons other than economic considerations. For example, Pacific Bell does not share conduit

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[9] *Outside Plant Engineering Handbook*, August 1994, AT&T Network Systems Document Number 900-200-318, Winston-Salem, North Carolina (Republished October, 1996 by Lucent Technologies), page 9-6.

[10] *Outside Plant Engineering Handbook*, August 1994, AT&T Network Systems Document Number 900-200-318, Winston-Salem, North Carolina (Republished October, 1996 by Lucent Technologies), page 9-7.

with gas companies or power companies. The risk of explosion or inadvertent exposure of, or damage to, a power cable is too great to justify the financial savings.

The Hatfield Model Version 3.0/3.1 contradicts itself when assigning percentages to the types of outside plant (that is, aerial, underground, or buried). In the Hatfield Model Version 3.0/3.1 documentation, the authors state that "in downtown urban areas it is frequently necessary to install cable in underground conduit systems, while rural areas may accommodate less expensive aerial or direct-buried plant".[11] Yet the input table that appears in page 30 of the documentation and the model itself assigns 85% of "downtown urban" areas plant to aerial and only 25% of rural areas to aerial. This could be interpreted as a manipulation of the data designed to reduce total costs. In reality, placing relatively more underground and buried plant in urban areas is the norm due to municipal regulations requiring "out-of-sight" plant. These regulations apply to both feeder and distribution plant.

The level of structure sharing proposed in the Hatfield Model Version 3.0/3.1 is, in many respects, more unrealistic than that proposed in Version 2.2, Release 2 of the Hatfield Model. The sharing assumptions made in Version 2.2, Release 2 of the Hatfield Model were clearly unrealistic. For example, Version 2.2, Release 2 assumed 33 percent of the aerial plant structure cost would be assigned to the ILEC or ELEC. In other words, the Hatfield Model Version 2.2, Release 2 model assumed that three companies would use a single structure. The Hatfield Model Version 3.0/3.1 assumes an even more unrealistic sharing level of 25 percent. It is absurd to assume that in all situations, all poles will be 40 feet tall and will have four utilities and/or carriers attached, for reasons elaborated elsewhere in this report.

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[11] Hatfield Model Release 3, February 7, 1997, model documentation, pages 27 and 30.

Model

Introduction

It appears that the Hatfield Model Version 3.0/3.1 contains no individual hidden cells. In general, however, the logic of the Hatfield Model Version 3.0/3.1 is not readily apparent. The Hatfield Model Version 3.0/3.1 embeds the logic within multiple worksheets and cells whose cross-references are unclear, particularly in the case of duplicate values.

Missing Inputs

As in the previous release of the model, the Hatfield Model Version 3.0/3.1 does not consider all the units necessary to build a functioning telephone network. The cumulative effect of these omissions and related errors (for example, the Hatfield Model Version 3.0/3.1 ignores many costs associated with the units that it does define) is to understate significantly the cost of constructing a network. These omissions result in the Hatfield Model Version 3.0/3.1 being unsuitable to its stated purpose without major revisions.

One significant example is the omission of Puerto Rico from the database for the Hatfield Model Version 3.0/3.1. This precludes consideration of one of the largest telephone companies in the country.

Another significant omission is Operational Support Systems ("OSS"). The true cost of a network must include the cost of numerous support systems, including switching software systems and their associated routing tables and databases. Other functions for which an operating company must develop and use support systems include the following:

- customer care
- job management
- alarm management
- network management

- circuit management
- account management
- work force management
- network distribution mapping
- inventory
- charging and billing systems
- fault management
- materials management

The costs of these systems, which we estimate to be approximately five to eight percent of the network construction costs, should be included in the cost of building a network. It is unclear from the model's documentation if the Hatfield Model Version 3.0/3.1 considers these costs. In this regard, the only costs that the Hatfield Model Version 3.0/3.1 specifically cites are the cost of office support equipment and the cost of operator systems.

Duplicate Inputs

The Hatfield Model Version 3.0/3.1 consists of a combination of Microsoft Excel spreadsheets and a Microsoft Access database. There are several instances in which variables appear in multiple Microsoft Access database tables. Examples include:

- A variable for the "average number of lines per business location" (avg_lines_per_bus_loc) appears in the distribution inputs table and the expense inputs table.
- A variable for "conduit costs per foot" (cond_invest_per_ft, conduit, and conduit_invest_per_ft) appears in the feeder inputs table, the wire center inputs table, and the distribution inputs table.
- A variable for "pole installation labor cost" (pole_labor) appears in the feeder inputs table, the wire center inputs table and the distribution inputs table.
- A variable for "pole material cost" (pole_invest pole_material, and pole_materials) appears in the distribution inputs table, the wire center inputs table and the feeder inputs table.
- A variable for "pole spacings" (pole_spacing_0, pole_spacing_5,

pole_spacing_100, pole_spacing_200, pole_spacing_650, pole_spacing_850, pole_spacing_2550, pole_spacing_5000 and pole_spacing_10000) appears in both the distribution inputs table and the feeder inputs table.

- A variable for "spare ducts" (spare_tubes_per_route, spare_tubes_per_rt and spare_tubes_per_section) appears in the feeder inputs table, the wire center inputs table and the distribution inputs table.
- A variable for "proportion of underground" is defined for different population densities in the distribution inputs table (ug_fract_0, ug_fract_5, ug_fract_100, ug_fract_200, ug_fract_650, ug_fract_850, ug_fract_2550, ug_fract_5000 and ug_fract_10000) while the wire center inputs table contains a single variable (underground_fract). An analogous problem arises for buried cable.

While there is no intrinsic reason not to repeat these values, there is a concern that changes in one location will not necessarily ripple through the Hatfield Model Version 3.0/3.1 to other locations. For example, a user may change a value in one table, but not in other tables because of the mistaken impression that there is no need to make repetitive changes. Moreover, in at least one case (the "underground fraction"), it is unclear whether the density-specific or average value takes precedence in calculations.

We recommend that a prompt should be presented to users to ensure they understand that an action in one area may or may not affect other areas. From this prompt, the user can be guided to other areas that require modification for the sake of consistency.

Logic

The Hatfield Model Version 3.0/3.1 contains unreasonable, unrealistic, and decidedly not "forward looking" assumptions concerning the relative mix of aerial, buried,

and underground facilities. For example, the Hatfield Model Version 3.0/3.1 assumes that 85 percent of all distribution facilities will consist of aerial plant placed in areas that have population densities of more than 10,000 households per square mile. There are numerous contemporary engineering considerations that dictate use of underground or buried plant in preference to aerial plant in such areas. Moreover, many, if not most, cities and towns with population densities of this magnitude now require the placement of "out of sight" (underground or buried) facilities.

The default mix for the distribution plant thus is unbalanced and impractical. The mix shown for copper and fiber feeder is more appropriate for both feeder and distribution. However, even these feeder cable percentages are questionable and biased. The percentages serve to reduce front-end costs, while ignoring or increasing whole life costs, a philosophical bias appropriate to an ELEC.

Input Values and Assumptions

Cable

As we noted in our earlier report,

> *The Hatfield Model does not include provisions for small cable sizes for copper feeder and distribution cables. This will prove to be a problem for many small and medium size operating companies that will be sizing distribution systems in more rural areas where 12 pair copper cable and 18 pair copper cable are economical and rational choices for system design. (This would not be an issue with fiber feeder, which would reduce the impact on transmission quality in the copper distribution portion of the loop.)*[12]

Moreover, the Hatfield Model Version 3.0/3.1 does not provide an opportunity for users to select several larger cables that are in widespread use (for example, 2,100-pair cables and 2,700-pair cables).

The Hatfield Model Version 3.0/3.1 supplementary filing and related documentation allege that the model makes provisions for changes in gauge in the distribution system.[13] However, there does not appear to be a mechanism for incorporating the effects of such changes on material costs in the design process. There are no variables in the database to accommodate such a change. Thus, although there appears to be a mechanism for inputting changes, there is no mechanism within the master database for preserving this information for subsequent analysis or repeated application.

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[12] Robert F. Austin, Ph.D. *Engineering Evaluation of Cost Proxy Models for Determining Universal Service Support: Hatfield Model 2.2, Release 2, Ex Parte* Filing, Federal Communications Commission Docket No. 96-45, February 5, 1997, page 21.

[13] "AT&T and MCI Submission on the Hatfield Proxy Model," (*Ex Parte* Presentation - Proxy Cost Model Questions, CC Docket 96-45), January 7, 1997, page 2.

The cable costs that the Hatfield Model Version 3.0/3.1 specifies apply to the least cost cables. The loops that the Hatfield Model Version 3.0/3.1 designs will require heavier gauge cables. In their supplementary filing, the sponsors of the Hatfield Model Version 3.0/3.1 note that the model assumes that cables with 2,400 or fewer pairs contain 24 gauge copper wires. They also note that the Hatfield Model Version 3.0/3.1 assumes that cables with more than 2,400 pairs contain 26 gauge copper because "24 gauge copper cables are not manufactured in sizes larger than 2,400 pairs." This will skew cable costs and affect transmission characteristics significantly.

The costs of installing buried cable are understated substantially, especially for all density zones from 0 to 100 households. The already unrealistically low cost per foot for trenching becomes ludicrous when that cost is divided according to the structure sharing proposed in the Hatfield Model Version 3.0/3.1. This is a particular problem given that the Hatfield Model Version 3.0/3.1 defaults to 75% buried cable for these areas.

Copper cable costs are not well documented or easily interpreted in the Hatfield Model Version 3.0/3.1. Although the costs used in the Hatfield Model Version 3.0/3.1 include labor costs, these costs are not well documented. Moreover, they assume the same labor costs for all types of plant. For example, the costs do not reflect the difference in price to place and splice aerial cable versus buried cable.

The cost of fiber cable should be different depending on the method of placement (underground, aerial, or buried). Factors such as the composition of the cable, external sheath type, and the type of internal strength member contribute to these differences. In addition, current engineering practice may dictate use of extruded duct for buried cable (for example, Tamaqua duct). Self-supporting aerial cable would be more expensive than normal cable. Also, it is not clear if the costs for aerial cable

include the cost of Kevlar (or similar) strand, to maintain a fully dielectric system. The system should recognize the fundamental differences in fiber cable costs and be easily modifiable.

Conduit

As noted in our previous report on the Hatfield Model 2.2, Release 2, the Hatfield Model Version 3.0/3.1 contains several flaws related to conduit system design. Among these flaws are the following issues cited in our previous report.

> *The Hatfield Model assumes a very low constant price per foot for conduit. This single cost makes no provision for bends, sweeps, ells, unions, caps, solvents, or PVC cement. The model appears to make no provision for unusual situations in conduit systems, such as areas requiring galvanized iron pipe ("GIP") or black iron pipe ("BIP") laterals, risers, or river crossings.*[14]

The cumulative price impact of these and related problems is masked by the low default value for the percentage of underground facilities. In the real world, where the percent of underground facilities will rise dramatically, the relative impact of this problem will increase substantially.

The Hatfield Model Version 3.0/3.1 assigns the wrong input cost for installing conduit. Instead of assigning cost from the "conduit placement per foot" field, it uses costs taken from "buried placement/foot" field. This is a significant error; in the household density range of 5,001 to 10,000 per square mile, for example, the buried placement cost per foot is $13.00 and the conduit placement per foot is $50.10.

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[14] Robert F. Austin, Ph.D. *Engineering Evaluation of Cost Proxy Models for Determining Universal Service Support: Hatfield Model 2.2, Release 2, Ex Parte* Filing, Federal Communications Commission Docket No. 96-45, February 5, 1997, page 23-24.

Design

All relevant state authorities dictate quality of service parameters. Among the most significant, relevant quality of service parameters is the requirement for the provision of service within certain time frames. System designs must comply and any reasonable engineering model must be adaptable to this requirement. Because of its exclusive focus on "scorched node" construction, it does not appear that the Hatfield Model Version 3.0/3.1 satisfies this demand for flexibility in scheduling new service in high growth areas.

In their supplementary filing, the sponsors of the Hatfield Model Version 3.0/3.1 stated that: "Extensive use of fiber-fed Integrated Digital Loop Carrier ("DLC") in the feeder, with its attendant 0 dB loss at the Remote Terminal point, provides for a robust feeder facility." [15] How do they achieve 0 dB loss? This accomplishment would constitute a significant advance over current technology unless the designers are assuming signal regeneration between the central office and the remote terminal. Because no costs are specified for such regeneration, we believe the zero loss argument is spurious.

After exceeding the capacity of a cable, the Hatfield Model Version 3.0/3.1 automatically selects the next larger cable size, rather than selecting a second cable. This is not sound engineering and certainly is not least cost engineering. This will be most significant at the 2,400-pair cable size breakpoint, where there is also a default transition in wire gauge from 24 gauge to 26 gauge.

Fill Factors

Hatfield Model Version 3.0/3.1 assumes that fiber feeder cables have a fill factor of

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[15] "AT&T and MCI Submission on the Hatfield Proxy Model," (*Ex Parte* Presentation - Proxy Cost Model Questions, CC Docket 96-45), January 7, 1997, page 19.

100%. This feeder fill is unreasonable: no competent network engineer would build a real network in this manner. Such a network would be unable to handle short-term demand fluctuations caused by competition.

There is no difference between Hatfield Model Version 2.2, Release 2 and The Hatfield Model Version 3.0/3.1 in the manner in which cable fills are derived. The Hatfield Model Version 3.0/3.1 states that fills are MDF fills, meaning that the fills are a ratio of the total working lines at the wire center and the total number of pairs (all routes/quadrants combined) terminated on the main distributing frame. Assuming a particular MDF fill rate and then using that fill rate to size sections of plant is incorrect and inappropriate, especially with a fill factor as high as that assumed in the Hatfield Model Version 3.0/3.1. In reality, the MDF fill rate must be lower than in any of the cable sections because an accumulation of the effects of all breakage and spare uses occurs at the MDF. Typically the farther out a location is in a route, the higher are the fill rates. To assume an 80% fill rate at the MDF would be to assume a rate close to, or equal to, 100% in the last section of a route.

Labor Rates

There is no documentation of the labor rates. The cable costs appear to include labor dollars, but we cannot confirm this with certainty. Without isolating the labor costs, it is impossible to confirm their accuracy. Moreover, it will be impossible to confirm their applicability by region to incorporate variations in labor rates.

An EF&I labor rate of $55 per hour is far too low regardless of whether company personnel or independent contractors are doing the work. This is a problem of increasing significance. Increasing competition among companies building new networks is creating increased demands for the services of skilled technicians and craftspeople. This, in turn, is causing an increase in the costs of these services. (We note parenthetically that analogous market forces are beginning to affect the

prices for optical fiber cables also.)

Land

We believe that the Hatfield Model Version 3.0/3.1 misstates average land costs. The costs for land for the smaller sites appear to reflect the cost for rooms, which assumes existing facilities. This may or may not be reasonable in the rural areas.

The Hatfield Model Version 3.0/3.1 implies that the cost of land (price per square foot) increases with the amount of land purchased. The land area for COs is usually the same: arguably, the larger the CO, the closer the walls are to the fence (because of standardization in parcel sizes and purchasing practices). The designers of the Hatfield Model Version 3.0/3.1 should give greater consideration to actual land costs to establish a more meaningful set of default values.

Loop

The Hatfield Model Version 3.0/3.1 incorrectly claims its general outside plant design methodology duplicates procedures followed by outside plant planning engineers throughout the industry. There are numerous instances in which the Hatfield Model Version 3.0/3.1 violates those rules by permitting loops longer than 12,000 feet, by placing multiple wire gauges in the distribution and by loading the distribution portion of the network.[16]

Besides many unrealistic input values, the Hatfield Model Version 3.0/3.1 includes loop design errors and engineering assumption cost mismatches that result in meaningless output cost levels. The Hatfield Model Version 3.0/3.1 produces de-

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[16] *Outside Plant Engineering Handbook*, August 1994, AT&T Network Systems Document Number 900-200-318, Winston-Salem, North Carolina (Republished October, 1996 by Lucent Technologies), especially "Section 5 - Transmission" pages 5-1 to 5-27.

signs that either do not reach many of the subscriber locations or reach them with a pair of wires that cannot produce a dial tone. Moreover, the designs that the Hatfield Model Version 3.0/3.1 produces do not comply with a least one sponsor's specifications for resistance design.[17]

The 18,000 foot (and longer) loops require load coils which in turn preclude such services as higher speed modem links, ISDN, and the use of carrier frequencies to carry T-1/DS-1 type services to the customer. Without specific, detailed long loop design cost adjustments due to factors such as gauge changes, loading, and loop amplifiers, the Hatfield Model Version 3.0/3.1 has significantly under designed the loop.[18] The long loop adjustment information is not stored as a variable in the database. Thus, although there appears to be a mechanism for inputting changes, there is no mechanism within the master database for preserving this information for subsequent analysis or repeated application.

Moreover, additional problems would result now that 22 gauge and 19 gauge cables theoretically are being used. Those coarse gauge cables do not come in all sizes that are in the cable tables. For example, the standard 19-gauge cables range in size from 25 pairs to 300 pairs. This means that if a 600 pair, 19-gauge cable is required, two separate cables plus two ducts or two spaces on a pole must be occupied. There is no allowance for these additional costs and limitations in the Hatfield Model Version 3.0/3.1.

Without loading, the loop would be inadequate for data traffic. Even though data

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[17] *Outside Plant Engineering Handbook*, August 1994, AT&T Network Systems Document Number 900-200-318, Winston-Salem, North Carolina (Republished October, 1996 by Lucent Technologies), especially "Section 5 - Transmission" pages 5-1 to 5-27.

[18] *Outside Plant Engineering Handbook*, August 1994, AT&T Network Systems Document Number 900-200-318, Winston-Salem, North Carolina (Republished October, 1996 by Lucent Technologies), page 5-13 and following.

traffic may not be a supported service (except to schools, libraries and hospitals), it certainly is an expected service that must be provided regardless of subsidy or support.

Citing a recent article or V.34 modem, the Hatfield Model 3.0/3.1 designers stated:

> The presence of loading coils on long loops will not inhibit the operation of a properly-implemented V.34 modem. Such modems operate at a maximum speed of 33.6 kbps, although they will "fall back" to somewhat lower rates, e.g., 28.8 kbps or less, under adverse channel characteristics. One may expect that these modems will operate at a rate of at least 24 kbps on virtually any loop, including long loaded loops.[19]

If the modems are "properly-implemented," we "may expect" the modems to operate, albeit at "somewhat lower rates." Without debating the accuracy of this assessment, it is reasonable to observe that no ELEC firm would be willing to accept and pay full price for such a defective circuit when the time comes to purchases network elements. This would be a far more meaningful evaluation of the viability of a long loaded loop.

Loop design requires that different gauge cables or other alternatives be used but the Hatfield Model Version 3.0/3.1 does not permit changes in gauge for this purpose. [NOTE: Although the documentation alleges that changes in gauge are supported, there are no identifiable data base fields for gauge and no mechanism for incorporating changes.]

The method of loop design used in the Hatfield Model 3.0 represents an improve-

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[19] Hatfield Model 3.1 Model Description, page 32, footnote 26, citing Forney, G. David, Jr., Les Brown, M. Vedat Eyuboglu, John L. Moran III, "The V.34 High-Speed Modem Standard," *IEEE Communications Magazine*, December, 1996, p. 28.

ment over the method used in Version 2.2, Release 2. However the model still can create loops that will not transmit an acceptable signal. In the Hatfield Model Version 3.0/3.1, the attempt to account for long loops understates provisioning costs. Moreover, the loop lengths assumed to be serviceable from a DLC are too long. A DLC system cannot power 178,000-foot loops, even with the extended range plug-ins. The extended range plug-in can power up to 1500 ohms. The maximum distance that a plug-in can handle is approximately 85,000 feet assuming exclusive use 19-gauge wire (16.3 ohms per 1000 feet) and including loading (14 load points at 9 ohms each). In reality, loops beyond 94,000 feet (9000 feet feeder plus 85,000 feet beyond DLC) simply will not function.

Version 2.2, Release 2 of the Hatfield Model generated extremely long loops for which there was no additional provisioning. Only 26 gauge and 24 gauge cables were assumed, without loading, gain devices, or extended range DLC plug-ins. Long loops over 18,000 feet would not function properly with either an all copper network or a network derived from a DLC.

Hatfield Model Version 3.0/3.1 corrects some of these problems. Now the network may function up to a distance of 85,000 feet on an "all copper" loop or up to 94,000 feet, if 9000 feet is used as a breakpoint for transition from fiber to copper on a fiber/DLC-derived network. However, it will not operate at the distances that have been asserted by Hatfield Model Version 3.0/3.1 designers.

It appears that the model increases DLC plug-ins 25% for loops 55,000 feet in length to 98,999 feet in length. It appears that there is no additional cost for plug-ins for loops that are 99,000 feet in length to 177,999 feet in length. Finally plug-in costs are increased an additional 25% for loops over 178,000 feet in length. For all loops exceeding 900 ohms, a plug-in cost adjustment is required to reflect the increased cost of placing extended range plug-ins. The extended range plug-ins increase

powering to 1500 ohms.

Two major problems exist in this area with Version 3.0/3.1 of the Hatfield Model. One is the omission of specific cost increase data for extended range plug-ins; an understated multiplier is used instead. The cost for the extended range plug-ins is approximately twice the cost of the 900-ohm plug-in. The second problem is that the increase doesn't occur until 55,000 feet: the loop will not function at distances between 50,500 feet and 55,000 feet. At 55,000 feet there would be 9 points of load (9 ohms per load). Assuming an all 19-gauge wire loop and 16.3 ohms of loss per 1000 feet, the total loss would be 977.5 ohms.

Hatfield Model Version 3.0/3.1 SAI costs and tables have changed considerably from the previous version of the model. Two tables still are used but the types of SAIs have changed. The types are now termed "Indoor SAI" and "Outdoor SAI". The documentation refers to electronics associated with SAIs with fiber feeder but there is no documentation on how costs associated with fiber feeder are incorporated into the cost tables.

One significant question is what the designers mean by the term "Indoor SAI"? The indoor SAI cost appears to imply a building terminal where feeder cable is cross-connected to house cable.

The Hatfield Model 3.0 documentation refers to SAIs in large buildings as requiring only inexpensive "punch down blocks", hence the cheap costs associated with "Indoor SAIs".[20] This assertion, and the associated cost, is not completely accurate. While it is true that these types of cross-connects do have punch down blocks, they also must include protector blocks that are not inexpensive. (The type 190A1-100

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[20] Hatfield Model Release 3, February 7, 1997, model documentation, page 42.

installed cost is approximately $572 per block per 100 pair.) These protectors are required to stop foreign power from entering buildings and causing fires (among other problems). The Hatfield Model Version 3.0/3.1's method of placing "Indoor SAIs" would result in fire hazard and could result in burning down the businesses the sponsors wish to serve.

The Hatfield Model Version 3.0/3.1 assumes that SAIs that are associated with fiber/DLC sites are housed in the same cabinet.[21] For "Low Density DLC" sites this may not be a problem. However, for large ("TR-303 DLC") DLC sites this could pose a significant problem. There is no current technology cabinet manufactured that will house all the necessary equipment. This equipment would include a 2016 Fiber DLC system, 3-1,200 pair or 6-600 pair connecting blocks, a splice chamber large enough for a total of 7200 copper wires, and 144 "710" splice connectors (assuming 1800 working lines at 89% fill of the DLC and 100% fill of the SAI). This arrangement of combining a large DLC system with the SAI would be more suitably housed in a hut or a controlled environmental vault ("CEV"). The use of either structure would add significant costs to the facilities.

The Hatfield Model 3.0 presents a somewhat improved analysis of total DLC investment costs, but still understates these costs. A 672 basic system without plug-ins is priced at $69,000 in Hatfield Model Version 3.0/3.1. The costs for rights-of-way and DS-1 plug-ins appear not to have been included. Certain other related costs (for example, cabinet costs) are grossly understated (see discussion above). However, as if to compensate for the Hatfield Model Version 3.0/3.1's higher, but more accurate, cost for a 672 system, the Hatfield Model Version 3.0/3.1 adds only $18,000 for each additional 672 channels of capacity instead of doubling the costs as in Version 2.2, Release 2.

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[21] Hatfield Model Release 3, February 7, 1997, model documentation, page 41.

In addition, TR-303 has been misrepresented, as this technology currently is proprietary and specific to individual vender environments and equipment. For example, only SLC 2000 (Lucent) equipment can communicate with an AT&T (Lucent) switch via TR-303. The predominate savings is in the switch and not in the DLC equipment costs. The problem within the model appears to be a function of confusing TR-08 with TR-303, both of which are integrated systems.

In reality, TR-303 can be actually more expensive than TR-08 or TR-57 (universal) when handing-off loop elements to ELECs, especially when demand is low. To hand-off traffic from the switch interface uses up a DS-1 port in that switch interface, reducing its useable capacity. In other words, this "loopback" increases costs by reducing capacity. The alternative of handing-off loop elements at the COT or FOT either as a DS-0 or, if demand is high enough, as a DS-1, is much more economical. Of course a switch vendor would prefer a LEC to occupy additional switch ports, thus purchasing more switch equipment which is considerably more expensive.

Manholes and Pullboxes

In Hatfield Model Version 3.0/3.1 the same size manhole is used in all density zones. The material cost used ($1,865) indicates that the size of the precast manhole is four feet by six feet by seven feet and that the manhole will accommodate four ducts. Assuming one duct as a spare for maintenance and restoration, there are only three ducts available for cable placement. High-density areas will require more than three cables or 12,600 cable pairs in the feeder portion of the network. Each 10,000-plus subscriber CBG will require three full size copper cables (allowing for fill adjustment) to serve it if the CBG is within the copper breakpoint. Therefore manhole assumptions and costs are grossly underestimated.