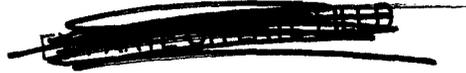


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96-98



Washington, D.C.
March 25, 1997

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street N.W., Room 222
Washington, D.C. 20554

RECEIVED

MAR 25 1997

Federal Communications Commission
Office of Secretary

Re: CC DOCKET 96-98

Dear Mr. Caton:

The Commission Staff hereby submits for the record in this proceeding, CC DOCKET 96-98, a paper entitled *The Use of Computer Models for Estimating Forward-looking Economic Costs*, authored by Federal Communications Commission staff members Jay Atkinson, Chris Barnekov, David Konuch, William Sharkey and Brad Wimmer, Federal Communications Commission Public Notices dated January 9, 31, and February 12, 1997, and initial and reply comments received in response to those Public Notices, as listed in Appendix A of this letter. These materials are hereby incorporated into CC Docket 96-98.

Commission Staff

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Letter to FCC Acting Secretary William Caton
March 25, 1997
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APPENDIX A

Initial comments filed in CPD file no. 97-2:

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Rural Utility Service
Southwestern Bell Telephone Company
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U S West, Inc.
United States Telephone Association
WorldCom, Inc.

Reply comments filed in CPD file no. 97-2:

AT&T Corp./MCI (Joint Comments)
Bell Atlantic Telephone Companies and NYNEX (Joint Comments)
GTE Service Corporation
GVNW Inc./Management
National Cable Television Association
Rural Telephone Coalition
Rural Utility Service
Southwestern Bell Telephone Company
U S West, Inc.
United States Telephone Association

**THE USE OF COMPUTER MODELS FOR
ESTIMATING FORWARD-LOOKING ECONOMIC COSTS**

A Staff Analysis

January 9, 1997

Jay Atkinson
Chris Barnekov
David Konuch
William Sharkey
Brad Wimmer

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The opinions and tentative conclusions expressed in this paper are those of the authors and do not necessarily reflect the views of the Federal Communications Commission or any of its Commissioners, or other staff.

I. INTRODUCTION

1. In the Telecommunications Act of 1996 ("1996 Act"),¹ Congress sought to establish "a pro-competitive, de-regulatory national policy framework" for the United States telecommunications industry.² This past year, the Commission has undertaken proceedings on universal service,³ interstate access charge reform,⁴ and local exchange competition⁵ to overhaul its current regulations in light of the 1996 Act. In these proceedings, the Commission has examined, in varying degrees, the use of forward-looking economic cost methodologies as a basis for determining universal service support levels, cost-based access charges, and pricing for interconnection and unbundled network elements.

2. Forward-looking economic cost computer models (also referred to as "cost proxy models" or "models") could enable regulatory authorities to estimate the forward-looking cost of network facilities and services without having to rely on detailed cost studies, prepared by incumbent local exchange carriers, that otherwise would be necessary. In addition, a publicly available cost proxy model could be useful to regulators by providing an independent check on the accuracy of incumbent LEC cost studies. This paper is intended to stimulate discussion on criteria for the evaluation of forward-looking cost proxy models in determining universal service support payments, cost-based access charges, and interconnection and unbundled network element pricing. At various points in this paper, we present the staff's current views on specific issues that have arisen in the course of our examination of the cost proxy models submitted in recent rulemaking proceedings. At other points, we identify issues and questions about which we have not reached any preliminary conclusions and that we are continuing to analyze. We anticipate that the Common Carrier Bureau shortly will issue a public notice seeking comments on the views, questions, and issues set forth in this paper.

II. BACKGROUND

3. The 1996 Act has fundamentally changed telecommunications regulation by

¹ 47 U.S.C. §§ 151 *et. seq.*

² S. Conf. Rep. No. 104-230, 104th Cong., 2d Sess. 1 (1996).

³ *In the Matter of Federal-State Joint Board on Universal Service*, CC Docket No. 96-45 ("Universal Service Proceeding").

⁴ *In the Matter of Access Charge Reform*, Notice of Proposed Rulemaking, FCC No. 96-488, CC Docket No. 96-262 (rel. Dec. 24, 1996)("Access Reform NPRM").

⁵ *Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, CC Docket No. 96-98, FCC 96-325 (released August 8, 1996) ("Local Competition Order"), Order on Reconsideration *Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, CC Docket No. 96-98, 11 FCC Rcd 13042 (1996), *petition for review pending sub nom. and partial stay granted*, *Iowa Utilities Board v. FCC*, No. 96-3321 and consolidated cases (8th Cir., Oct. 15, 1996), *partial stay lifted in part*, *Iowa Utilities Board et. al v. FCC*, No. 96-3321 and consolidated cases (8th Cir., Nov.1, 1996).

replacing the framework of government-recognized monopolies with one in which federal and state governments work in tandem to promote efficient competition and to remove entry barriers and regulations that protect monopolies.⁶ The 1996 Act, when fully implemented, should greatly reduce the legal, regulatory, economic, and operational barriers to entry in the local exchange and exchange access market, while preserving and advancing enhanced universal service goals. The local competition provisions of the Act confer three fundamental rights on potential competitors to incumbent local exchange carriers ("LECs"): the right to interconnect with other carriers' networks at rates based on cost; the right to obtain unbundled network elements at cost-based rates; and the right to obtain an incumbent LEC's retail services at wholesale discounts in order to resell those services.⁷ The Act also requires a fundamental restructuring of current regulatory mechanisms for funding universal service goals. The Commission, after receiving the recommendations of a Federal-State Universal Service Joint Board ("Joint Board"), is to define the services to be supported by federal universal service mechanisms, to support such services in a manner that is "explicit and sufficient," and to ensure that "every telecommunications carrier that provides interstate telecommunications services shall contribute, on an equitable and non-discriminatory basis, to the specific, predictable and sufficient mechanisms . . . to preserve and advance universal service."⁸ In its recently initiated access reform proceeding, the Commission seeks to reform its system of interstate access charges to make it compatible with the competitive paradigm established by the 1996 Act and with state actions to open local networks to competition.⁹

4. Recent decisions by the Commission and the Joint Board have found that forward-looking economic cost models hold promise as a regulatory tool. For example, the Joint Board recommended that a forward-looking economic cost computer model of the switched public telephone network be used to identify high cost service areas and help determine the level of universal service support payments.¹⁰ The Joint Board declined to adopt a particular model, but instead recommended that the Commission continue to work with the state commissions to develop an adequate model that can be adopted by the Commission by May 8, 1997.¹¹ Prior to a Commission decision in the universal service

⁶ *Local Competition Order* at para. 5.

⁷ 47 U.S.C. §§ 251(c)(2)-(4), 252(d)(1).

⁸ 47 U.S.C. § 254.

⁹ In providing interstate long-distance service, interexchange carriers use local telephone companies' facilities to originate and terminate calls. The use of local telephone company facilities to originate and terminate long-distance calls is referred to as access service. Local exchange carriers receive access charges for providing interexchange carriers with access to the local exchange carrier's customers. *Access Reform NPRM*, FCC No. 96-488, CC Docket No. 96-262, para. 1.

¹⁰ *In the Matter of Federal-State Joint Board on Universal Service*, Recommended Decision, FCC 96J-3, CC Docket No. 96-45, (rel. Nov. 8, 1996) ("*Joint Board Recommended Decision*").

¹¹ *Joint Board Recommended Decision* at paras. 268-269.

proceeding, state members of the Joint Board will submit a report to the Commission on the use of proxy models and their application for funding universal service.¹² Similarly, in the recently initiated *Access Reform* proceeding, the Commission sought comment on using economic cost models to move interstate access charges toward economic cost.¹³

5. Staff consideration of economic cost models is proceeding on two tracks. In its *Recommended Decision* on universal service issues, the Joint Board urged the Commission to conduct a series of workshops to enable federal and state staff to work with industry participants to refine the models for universal service purposes. On December 12, 1996, the Commission issued a Public Notice scheduling a set of workshops for January 14-15, 1996, and sent a letter to model proponents requesting that they provide the Joint Board with further information about the models prior to the workshops. In this paper, we discuss the possible use of the models in the Commission's universal service, access reform, and local competition¹⁴ proceedings, and whether a single model, or combination of models, might be sufficient for all three purposes.

6. Parties have submitted for consideration by the Commission and the Joint Board several forward-looking, economic cost models. They include the *Cost Proxy Model* ("CPM"), filed jointly by Pacific Bell and INDETEC International in June;¹⁵ the *Benchmark Cost Model 2* ("BCM2"), submitted by Sprint and US West in July;¹⁶ and the *Hatfield Model, version 2.2, release 1* ("Hatfield 2.2.1"),¹⁷ submitted by AT&T and MCI in May. In late August, we received the *Hatfield model, version 2.2, release 2* ("Hatfield 2.2.2"), which is an updated version of Hatfield 2.2.1. These models originally were designed to determine high cost service areas and calculate universal service support payments, although they may also be

¹² *Id.* at paras. 281-282.

¹³ See *Access Reform*, FCC No. 96-488, CC Docket No. 96-262, Section VI.

¹⁴ Although certain of the Commission's local competition rules have been stayed by the United States Court of Appeals for the Eighth Circuit, numerous states have adopted the interim proxy prices contained in the Commission's *Local Competition Order*. Thus, a careful evaluation of the proxy models that these states could use to replace the interim proxies is likely to be of benefit to these states. In addition, such an evaluation would assist the Commission if it is called upon to act under Section 252(e)(5) of the Act.

¹⁵ *The Cost Proxy Model* (INDETEC International, 1996), submitted by Pacific Telesis Group on June 7, 1996.

¹⁶ *Benchmark Cost Model 2* (July 1996), submitted by Sprint Corp. and U S West, Inc., on July 24, 1996 ("BCM 2"). The BCM2 is a revision of an earlier *Benchmark Cost Model 1* ("BCM1"), submitted by MCI, NYNEX, Sprint and US West in December 1995. See *Benchmark Cost Model: A Joint Submission by MCI Communications, Inc., NYNEX Corporation, Sprint Corporation, U S West, Inc.* (December 1995), submitted by MCI Communications, Inc., NYNEX Corp., Sprint/United Management Corp., U S West, Inc. on July 24, 1996.

¹⁷ Hatfield 2.2.1 is an updated version of *The Cost of Basic Network Elements: Theory, Modeling, and Policy Implications* (Hatfield Associates, Inc., March 1996)("Hatfield 2"), submitted by MCI on March 29, 1996.

used in setting interconnection, unbundled network element, and transport and termination prices.

7. In this paper, in Section III, we discuss the criteria for evaluating the utility of economic cost models in determining universal service support payments, cost-based access charges, and in setting prices for interconnection and unbundled network elements. In Section IV, we discuss model structure and input requirements.

III. CRITERIA FOR EVALUATING THE UTILITY OF ECONOMIC COST MODELS

8. In this section of the paper, we discuss the criteria for evaluating forward-looking economic cost models.

9. *Use of Forward-looking Economic Cost as a Basis for Pricing.* In dynamic, competitive markets, firms base their actions on the relationship between market-determined prices and forward-looking economic costs. We define forward-looking economic costs as the costs that would be incurred if a new element or service were provided, or that could be avoided if an existing element or service were not provided, assuming that all input choices of the firm can be freely varied. This is often referred to as long-run economic cost. This "long run" approach ensures that rates recover not only those operating costs that vary in the short run, but also fixed investment costs that, while not variable in the short term, are necessary inputs directly attributable to providing the element or service. If market prices exceed forward-looking costs, new competitors will efficiently enter the market and bring pressure to bear on prices. If forward-looking economic costs exceed market prices, new competitors will not enter, and incumbent firms may decide to exit. These voluntary actions by firms produce efficient resource allocation by adjusting price and output until the value to consumers of additional output is just equal to the cost of the resources required to produce it. In contrast, basing prices on embedded costs would fail to establish the critical link between economic production costs and market prices, and would be inconsistent with the goal of efficient competition.¹⁸ Pricing based on forward-looking costs enables efficient providers to cover their costs and make new investments, while facilitating efficient market entry by potential competitors. We therefore believe that models should not include sunk or historically incurred costs. We also believe that this view is consistent with the Joint Board's conclusion that basing universal service support levels on the forward-looking economic costs of an efficient carrier will preserve and advance universal service by providing carriers with the correct signals for entry, investment, and innovation.¹⁹

¹⁸ *Local Competition Order*, para. 706. The Commission adopted a forward-looking incremental cost methodology known as Total Element Long Run Incremental Cost ("TELRIC") for use in setting interconnection and unbundled network element prices. *Id.* at para. 672. This provision is among those that have been stayed by the Eighth Circuit Court of Appeals.

¹⁹ *Joint Board Recommended Decision* at paras. 270, 275-276.

10. *Ability to Measure Costs Relating to a Narrowband Network.* We believe that a model for pricing services and unbundled network elements should, at a minimum, be able to estimate the full stand-alone cost of the minimum set of network elements capable of delivering traditional voice telecommunications service and narrowband data services, at currently acceptable quality levels, to customers of the public switched network and to private line users. We base this belief on the view that the inability to purchase elements required to provide these narrowband services creates a "bottleneck" that could prevent competitors from entering the market. We realize that incumbent local exchange carriers may choose to construct network facilities capable of providing services that require higher transmission speeds ("broadband" services). We are currently analyzing how we should evaluate the utility of models when an incumbent LEC is offering both narrowband and broadband network components.

11. *Use of Proxy Models for Multiple Objectives.* Proxy models may be utilized for multiple regulatory objectives, such as in a prescriptive approach to access reform, determining levels of universal service support in high cost areas, and the pricing of unbundled network elements. It is not clear from our analysis to date whether a single proxy model, or combination of models, can or should be used to achieve all of these objectives. For example, does a network specifically dedicated to universal service objectives differ in a significant way from the summation of network elements envisioned in Section 251? How should common costs be treated in the different applications -- e.g., universal service or access reform -- of the models? If broadband networks become prevalent, will a single model be capable of measuring costs of providing supported services (which are narrowband) and access services or unbundled network elements that are provided over a broadband network? What modifications, if any, would be required if models were used for multiple objectives.

12. *Consistency with Independent Evidence.* It may be possible to obtain independent estimates of the costs of some network elements as a check on the validity of model estimates. For example, to what extent would it be feasible and valid to compare estimates of loop costs with competitive bids for installing loops? Would cable systems' costs of installing similar elements provide a comparable estimate? Can econometric studies provide any check on model results?²⁰ Another option would be for parties to provide engineering studies for a representative sample of Census Block Groups ("CBGs")²¹ that would evaluate the networks derived by the models by comparing them to engineering plans used to build actual networks using today's technology. This approach would help us determine whether the models accurately estimate the level of facilities necessary to provide

²⁰ See *infra* Section IV(d).

²¹ CBGs are defined by the Bureau of the Census, and represent a basic unit of population analysis for that agency. See *infra*, Section IV(A)(1).

service, or whether the derived networks under or over-build facilities.²²

13. It may also be instructive to compare estimates calculated by the models with data from Automated Record Management Information Systems ("ARMIS"). As discussed in section IV of this report, all of the existing models report levels of forward-looking investment that are significantly lower than embedded levels of investment reported in ARMIS data. In addition, some of the models report significantly lower levels of expense than are reported in ARMIS data. We note that there are several possible explanations for these differences: (1) Technological change may have reduced the level of investment required to provide a satisfactory level of service. If these changes were unanticipated, they may have resulted in underdepreciation of incumbent carrier's assets. (2) Existing models may choose investment levels that are insufficient to provide satisfactory levels of basic local telephone service.²³ More broadly, as explained in detail below, the model proponents' network design assumptions and choices of inputs, such as fill factors and percentages of sharing of structures, can significantly affect the costs estimated by the models.²⁴ (3) Input prices may have fallen over time, so that forward-looking costs are less than embedded costs for equivalent levels of network plant. (4) LECs may have engaged in systematic overinvestment or other non-cost minimizing behavior.

14. To understand further the source of the differences in investment, detailed engineering analyses of existing networks and the networks derived by Hatfield, CPM, and other cost proxy models, as discussed above, would be useful. It would also be instructive to compare physical measures of network investment, such as loop length, as reported by the models, with independent sources of such data. Finally, an examination of telephone plant price indices should be useful in measuring the effect of changing input prices. We believe that these, or other methods, may provide a useful independent check on the accuracy of a model's estimates of the costs of providing the network services or facilities at issue.

15. *Potential for Independent Evaluation.* We believe that the algorithms and judgments made by a proxy model's designer or operator should be clearly identified and explained so they can be independently evaluated by state or federal regulators. We recognize, however, that this criterion could be satisfied in different ways. For example, a model could utilize only publicly-available information. This would allow full independent evaluation, but may sacrifice some accuracy. Alternatively, models could utilize proprietary information (such as vendor pricing data), which would be made available to third parties in

²² For example, we could choose a number of CBGs for such studies to evaluate.

²³ Certain parties have alleged that the Hatfield model may underbuild facilities. See, e.g., NYNEX Response to request for further comment at Attachment B, p. 2, CC Docket No. 96-45 (Letter to FCC Chairman Reed Hundt from Frank J. Gumper, NYNEX Vice President, Regulatory Planning, June 11, 1996). Others assert the BCM2 model, by utilizing unrealistic fill capacity and design architecture assumptions, overestimates the cost of providing telecommunications service. Further comments of AT&T Corp. at 24-25, CC Docket No. 96-45.

²⁴ See Sections B(2) and B(3) below.

regulatory proceedings under protective order. This approach may produce more accurate results but could be administratively more cumbersome to evaluate. We are currently analyzing the relative advantages and disadvantages of these approaches.

16. *Flexibility.* Some states may possess detailed information about important model inputs, such as discount prices offered by switch vendors, that model designers could only estimate. In addition, states may possess detailed information on local conditions, such as zoning restrictions and labor rates, that they may wish to add as inputs to a model. We believe that cost proxy models should permit states to utilize such information where available. Also since the models may be used at different levels of aggregation (e.g., state density zones for pricing purposes, as compared to wire centers or CBGs for universal service), a model should be sufficiently flexible to permit a user to vary model inputs. In our view, the more model inputs that users can vary, the more useful a model will be.

IV. MODEL STRUCTURE AND INPUT REQUIREMENTS

17. An economic cost proxy model for estimating the cost of network elements starts with an engineering model of the physical local exchange network, and then makes a detailed set of assumptions about input prices and other factors. Such models estimate the total monthly cost for each network element. In this section, we explore both model design and models' use of variable input factors for network investment, capital expenses, operating expenses, and common costs. We seek to identify advantages and disadvantages of existing models. We will also consider alternative modeling assumptions and algorithms.

A. Underlying Structure of Models

1. Existing Wire Center Approach.

18. Each of the currently available models is based on an assumption that wire centers will be placed at the incumbent LEC's current wire center locations. Subject to this constraint, all remaining network facilities are assumed to be provided using the most efficient technology currently in use. We note that the Recommended Decision of the Federal-State Joint Board on Universal Service included "the understanding that the models will use the incumbent LECs' wire centers as the center of the loop network for the reasonably foreseeable future."²⁵ While the constraint to existing wire center locations is not fully consistent with a forward-looking cost methodology, we believe that a cost proxy model should, in the near term, include the above assumptions in estimating the cost of unbundled network elements and supported services, and that these assumptions are consistent with the Recommended Decision of the Joint Board.

19. We recognize, however, that over time an existing wire center model may

²⁵ *Joint Board Recommended Decision*, FCC No. 96J-3, para. 277.

become less representative of actual conditions faced by new entrants and incumbents. For example, after existing wire center locations were chosen by incumbent LECs, larger capacity switches became available. Because of ongoing advances in technology, facilities-based new entrants, and incumbent LECs, may in the future choose a much different network topology that will result in different forward-looking costs than today's network. We therefore believe that the models' assumption regarding the locations of LEC wire centers could be relaxed at some future time.

20. We also recognize that when the existing wire center approach is used, the specific interpretation of this assumption may affect the final cost estimates produced by a model. Therefore, we are continuing to explore various interpretations of the fixed wire center assumption. For example, we are examining whether the placement of remote switching units should be restricted to existing wire center locations, and if the models should assume that every wire center includes a (host or remote) switch. At this time we believe that the models do not need to assume a switch must necessarily be placed in each of the incumbent LEC's current wire centers. Such an assumption restricts the models' ability to estimate accurately the forward-looking costs of an efficiently designed network.

21. Similarly, wireless technologies may in the future be capable of providing narrowband telecommunication services at a lower cost than wireline technologies. We therefore are examining how models should incorporate wireless technologies into their estimates of forward-looking costs. We are currently considering whether there should be a cost-cutover, or threshold cost per loop that would trigger the use of wireless technology instead of wireline. We are not, however, aware of any study that attempts to estimate what this threshold should be.²⁶

2. *Geographic Unit of Analysis*

22. The BCM2 and Hatfield 2.2.2 models both use, as the basic unit of analysis, the CBG, as defined by the Bureau of the Census.²⁷ Each CBG contains approximately 400 households, and therefore the number of square miles contained within a CBG varies inversely with population density. The CPM, by contrast, uses a geographic grid structure.²⁸ The CPM's geographical unit is 1/100th of a degree of latitude and longitude (approximately 1/4 square mile), which its sponsors characterize as a "grid."²⁹ This allows the CPM the

²⁶ The Commission also solicited comments on this question in its universal service rulemaking.

²⁷ See BCM2 at 2-3; Hatfield 2.2.2 at 1. The census block group is the smallest geographic area for which the decennial census publishes sample data. The total number of block groups delineated for the 1990 decennial census was 229,466. *Geographic Areas Reference Manual*, U.S. Department of Commerce, Bureau of the Census, 1994, p. 11-1.

²⁸ See Pacific Bell, Further Comments on Cost Proxy Models at 12-13, CC Docket No. 96-45.

²⁹ *Id.*

flexibility to model the cost of various types of serving areas, such as wire centers or political jurisdictions, as well as CBGs.³⁰ A grid structure may be preferable because it allows households to be matched more accurately with existing wire centers. The large number of grids relative to CBGs, however, increases the computing costs of running the model. This may require a simplification in the computations undertaken for each grid in order to offset the increase in computing costs caused by the large number of grids. Such simplifications could lessen the accuracy of a model's estimates.

23. Having recognized the relative advantages of these two approaches, we are continuing to investigate whether models should use either the grid or the CBG as their basic unit of analysis. Specifically, we recognize that when using a model to determine the size of universal service subsidies, a more precise geographic unit of analysis may be preferable, especially in rural areas, because the cost of providing telecommunications services may vary widely within a given area.

24. These issues also lead us to question whether the models provide for the appropriate number and size of pricing zones when reporting aggregate cost estimates above the CBG or grid level. We believe that if a model is used for pricing unbundled network elements or in setting cost-based access charges, the cost differences within each zone should be insignificant, compared to the differences across zones. Furthermore, if models are used for multiple objectives, we are concerned that any differences in the definition of zones may lead to uneconomic arbitrage.³¹ We are continuing to examine whether other aspects of the models that pertain to geographic deaveraging of rates should be considered.

3. *Specification of Demand*

25. An accurate estimate of the cost of serving a CBG or any other serving area depends on a reliable forecast of customer demand patterns within the area, and the number of residential and business lines. Each model relies on census data to determine residential demand. However, because census data does not report the number of business lines,³² model designers must use indirect methods to estimate business demand. The potential for error in estimating business and residential demand creates certain difficulties. First, as noted below,

³⁰ *Id.*

³¹ 47 CFR Part 51.507 sets out the Commission's rule requiring geographic deaveraging of rates for unbundled network elements. It requires states to establish different rates for elements in at least three defined geographic areas within a state to reflect geographic cost differences. The implementation of this rule is currently subject to the stay imposed by the United States Court of Appeals for the Eighth Circuit. *See supra* note 5.

³² Hatfield 2.2.2 at 10. As discussed below, Dun and Bradstreet report data on the number of daytime employees by CBG.

fill factors or utilization rates may be expected to vary between business and residential lines.³³ Second, loop lengths are typically shorter for business lines than for residential lines. Thus, unless the differences in costs associated with different fill factors for business and residential areas happen to offset exactly the differences in costs associated with differences in loop lengths, the cost of serving an area will depend on the ratio of business to residential lines. An understanding of the magnitude of these competing effects, however, requires an accurate estimate of the number of business and residential lines in a particular area.³⁴ The authors of Hatfield 2.2.2 assert that incumbent LECs maintain data on the number of business lines in a CBG, but refuse to make this information available.³⁵

26. Hatfield 2.2.2 incorporates access line demand data from the Operating Data Reports, ARMIS 43-08, submitted to the Commission annually by all Tier 1 LECs.³⁶ The Hatfield 2.2.2 model therefore incorporates data on the number of: (1) residential access lines, both analog and digital; (2) business access lines, which include analog single lines and multi-line analog and digital lines, PBX trunks, Centrex trunks, hotel and motel long-distance trunks, and multi-line semi-public lines; and (3) special access lines.³⁷ Hatfield 2.2.2 computes residential lines in each CBG by multiplying the number of households in a CBG by the ratio of total residential lines, as reported by ARMIS, to the total number of households in a study area.³⁸ Similarly, Hatfield 2.2.2 multiplies the ratio of total reported business lines to total employees in a study area by the total number of employees in a CBG, as reported by Dun and Bradstreet, to estimate the number of business lines in a CBG.³⁹ The BCM2 and CPM use similar approaches to estimate the number of business lines in an area. Each of the models' approaches to estimating business and residential loop demand appears to have drawbacks that may lead to significant modeling inaccuracies. We expect that different industries have different demands for telephone use per employee. For example, service industry demand for telephone service is most likely greater than demand in the

³³ See *infra* para. 41. Fill factors or utilization rates of loop plant are the percentage of a loop plant's capacity that is used in the network. Utilization rates are necessarily less than 100 percent so that capacity is available for growth or, in the event of breakage, to avoid outages. Lower utilization rates mean that carriers deploy more unused capacity, which increases the cost of loop plant.

³⁴ Alternatively, the differences in fill factors and loop lengths, and thus the cost of providing service to a particular area, may depend upon the density of customers, not the type of customers, in a particular area.

³⁵ Hatfield 2.2.2 at 13.

³⁶ Tier 1 local exchange carriers are companies having annual revenues from regulated telecommunications operations of \$100 million or more. *Commission Requirements for Cost Support Material To Be Filed with 1990 Annual Access Tariffs*, Order, 5 FCC Rcd 1364 (Com. Car. Bur. 1990).

³⁷ Hatfield 2.2.2 at 12.

³⁸ Hatfield 2.2.2 at 13.

³⁹ *Id.* Hatfield 2.2.2 includes data from Dun and Bradstreet that, when coupled with ARMIS data, can be used to estimate the number of business lines in each CBG.

manufacturing sector. We are continuing to explore whether there are alternative publicly available databases that might be used to estimate business demand for loops.

27. The Hatfield 2.2.2 model also uses data on the total number of employees in a CBG to estimate the number of special access lines and public access lines, where the latter includes lines associated with pay phones, but excludes customer-owned pay phone lines, in that area.⁴⁰ The BCM2 makes an allowance for special access lines through a user-specified "Special Access Ratio."⁴¹ The default value for this ratio is 0.13, which means that there are 0.13 special access lines per every business line.⁴² Using these estimates, the BCM2 estimates the number of lines in the CBG provisioned at the DS-1 level. ETI reports that the BCM2 sponsors assume that CBGs with greater than 2,016 lines terminate a variable percentage of lines at the DS-1 level to "reflect the costs of providing service to digital PBXs and providing wideband private line services."⁴³

28. We believe that models should include the total demand for telecommunication services, which, at a minimum, should include the demand for first and second residential lines, business lines, public access lines, and special access lines. We are in the process of evaluating how second residential lines and business lines, as well as broadband loops should be incorporated in a model used to estimate the forward-looking cost of network elements and supported services. We note, however, that these different types of lines may be provided using shared equipment, and the exclusion of any lines may lead to an overestimation of per-line costs when economies and scale and scope are present in the delivery of telecommunications services. We also note that all three models rely on current demand patterns to estimate the demand for loops, rather than employing forward-looking estimates of loop demand. Because it is costly to increase a network's capacity or to build plant that will be under-utilized, we believe that the use of current demand, such as that found in ARMIS, rather than a forecast of demand over the service life of the network may lead to significant modelling inaccuracies.

4. Specification of Network Elements

29. In general, cost proxy models seek to estimate the forward-looking economic cost of a network used to provide local telephone services. Different models, however, may

⁴⁰ See Hatfield 2.2 at 13-14 (Hatfield sponsors note that the demand for special access and public access lines are correlated with business demand, and therefore use employee data to estimate the demand for these lines).

⁴¹ Further Comments of the National Cable Television Association, Inc. at Attachment A, p. 60, CC Docket No. 96-45 (*Converging on a Cost Proxy Model for Primary Line Basic Residential Service, A Blue Print for Designing a Competitively Neutral Universal Service Fund*, Susan M. Baldwin, Lee L. Selwyn, Economics and Technology, Inc., August 1996)("ETI").

⁴² *Id.*

⁴³ *Id.*

estimate the cost of networks that are not comprised of exactly the same network components. We believe, therefore, that model sponsors should be required to state precisely the elements included in the network and the services those elements are capable of providing. We are continuing to evaluate the appropriate set of network elements that model sponsors should include in any model used to price interstate access, supported services, or unbundled network elements in the near future. In general, we believe that models should be updated or modified as the range of services, and network elements used to deliver these services, evolves over time.

30. Hatfield 2.2.2 estimates the cost of providing the following network elements: Loop Distribution; Loop Concentrator/Multiplexer; Loop Feeder; End Office Switching; Operator Systems; Dedicated Transport; Common Transport; Tandem Switching; Signaling Links; Signal Transfer Point ("STP"); and Service Control Point ("SCP"). The original Benchmark Cost Model, BCM1, was designed to produce "benchmark" costs for the provision of local telephone service. As one of its sponsors has noted, the model was designed to identify high cost areas for the purpose of universal service funding, and not to set prices of network elements.⁴⁴ Consequently, BCM1 did not explicitly model many components of the local exchange network necessary to provide local service. Proponents of the BCM2 model argue that it has been modified to correct for the deficiencies of the BCM1, and that the current version of the model includes all elements necessary to provide local telephone service.⁴⁵ The BCM2, however, does not currently provide forward-looking cost estimates for unbundled elements. The CPM was also designed to identify the costs of universal service support, although CPM proponents claim that current versions of the model are able to identify specifically the costs of the following unbundled network elements: Loops; Local Switching, which includes the non-traffic sensitive cost of line ports and traffic-sensitive switching costs; and Tandem Switching.

B. Modeling of Network Investments

31. To model the forward-looking cost of an efficiently designed network, cost proxy models must accurately estimate the quantity of facilities required for an efficiently designed network to deliver the services at issue. Each of the three existing models on record claim to produce such estimates. When applied to regional Bell Operating Companies as a whole, Hatfield 2.2.2 estimates a total forward-looking investment in network facilities of \$769 per line, BCM2 estimates a corresponding value of \$960, and CPM a value of \$1057. Each of these values is substantially lower than the per-line investment of \$1609 reported in 1995 ARMIS data for the RBOCs. The differences between forward-looking model investments and ARMIS investment could be attributed to various factors, including

⁴⁴ U S West reply at 7, CC Docket No. 96-45.

⁴⁵ BCM2 at 5.

insufficient model investment,⁴⁶ the model proponents' network design assumptions and choices of inputs, technological change, changing input prices, or overinvestment by incumbents.

32. In this section we examine the methodology used by the different models to estimate the quantity and type of physical facilities that an efficiently designed network would deploy. Several commenters have asserted, in proceedings where cost proxy models have been discussed, that such models do not generate networks capable of delivering telecommunications services. These commenters, however, have generally provided neither a detailed analysis of the models' flaws nor put forth any alternative proposals that would improve the models. Similarly, although sponsors of models claim to design networks capable of delivering telecommunications services, they have provided little independent evidence to verify their claims.

1. Loop Plant - Feeder and Distribution

33. The largest portion of a network's investment consists of its investment in loop plant. It is therefore vitally important that models estimate accurately the cost of loop plant sufficient to satisfy demand. "Loop plant" consists of all network facilities, including wires, telephone poles or conduits, drops, etc., connecting the end office switch and customers' premises. It would be helpful to our analysis for all model sponsors to list and define the loop plant components derived by their models. For example, the Hatfield model estimates the cost of loop plant by estimating the cost of the following elements: network interface devices;⁴⁷ wire drops;⁴⁸ block terminals;⁴⁹ distribution cables;⁵⁰ and feeder facilities.⁵¹

34. The BCM2 and Hatfield 2.2.2 both rely, at least in part, on the original BCM1 to estimate the feeder and distribution plant required by an efficiently designed network to

⁴⁶ See *supra* note 23.

⁴⁷ As defined by Hatfield 2.2.2, the network interface device forms the demarcation point between the local carrier's network and a customer's inside wiring, and is where the drop wire terminates. Hatfield 2.2.2 at 5.

⁴⁸ The drop wire extends from the network interface device at the customer's premises to the block terminal at the distribution cable that runs along the street to the customer's property line. *Id.*

⁴⁹ The block terminal is the interface between the drop wire and the distribution cable. *Id.*

⁵⁰ Distribution cables run from each block terminal to the serving area interface, where feeder plant ends and the distribution cables begin. *Id.*

⁵¹ Feeder facilities consist of cables, which may be copper wires or optical fibers, extending from the wire center to the serving area interfaces, and structure components, such as poles, trenches, and conduit. Feeder facilities also may include digital loop carrier equipment. *Id.*

meet demand.⁵² The BCM1 used data from the Census Bureau, the National Exchange Carriers Association, and United States Geological Service Satellite Survey to estimate population densities, and the length of feeder, sub-feeder and distribution portions of the loop. In addition, the BCM1 incorporated data that accounted for the effect of terrain on the cost of outside plant. In calculating loop distances, BCM1 assumed that CBGs are served from the nearest existing wire center, and that all CBGs are square and that households are uniformly distributed. In addition the BCM1 assumed that four main feeder routes leave each wire center with sub-feeder routes placed at 90 degree angles from the main feeder route. BCM1 assumed that feeder plant reached only the border of a CBG and that four equidistant legs of distribution plant served the interior of the CBG. Using these estimates, BCM1 estimated the per-foot cable investment for distribution and feeder and allocated feeder costs to multiple CBGs.

35. In a California proceeding, GTE asserted that the BCM1 underestimated loop plant because it assumed that CBGs are square, households are uniformly distributed, and that feeder plant runs only to the edge of the CBG.⁵³ GTE contended that these assumptions were especially troublesome when applied to rural areas.⁵⁴ GTE also criticized the BCM1 for using ratios, which were multiplied by investments in cable, to estimate investment for structures (e.g., poles, manholes, conduit) that support the loop plant. As a result of this approach, structure costs are directly related to the cost of cable.⁵⁵ Thus, a decrease in the price of cable would result in a decrease in the BCM1's estimate of structure investments, even if the cost of building these structures remained unchanged.

36. The BCM2 and Hatfield 2.2.2 retain many of the BCM1's basic features, but both have incorporated modifications in response to criticisms of the BCM1. For example, both models estimate structure costs on a per-foot basis, rather than multiplying total investment by a factor.⁵⁶ Both the BCM2 and Hatfield 2.2.2 also alter the BCM1's methodology for addressing the effect of terrain on loop costs.⁵⁷ The BCM2 includes a variable that captures the effect of a terrain's slope and increases the length of a CBG's loop

⁵² See generally BCM1, Section IV.

⁵³Comments of the California Public Utilities Commission, CC Docket 96-93, Attachment, *Proposed Decision of ALJ Wong, Rulemaking on the Commission's Own Motion into Universal Service and to Comply with the Mandates of Assembly Bill 3643, R.95-01-020; Investigation on the Commission's Own Motion into Universal Service and to Comply with the Mandates of Assembly Bill 3643, I.95-01-021* (California Public Utilities Commission rel. January 24, 1994)(*California Decision*) at 103.

⁵⁴ *Id.*

⁵⁵ GTE Comments on Cost Models at 19, CC Docket 96-45.

⁵⁶ See BCM2 at 4; Hatfield 2.2.2 at 29.

⁵⁷ See Hatfield 2.2.2 at 29; BCM2 at 5.

plant when the slope variable exceeds a specified minimum value. Hatfield 2.2.2 increases the length of feeder and distribution cables in rocky areas.⁵⁸ Additionally, the Hatfield 2.2.2 and BCM2 both replace the BCM1's assumption of four equal distribution legs with an approach that allows the number of equidistant legs to vary.⁵⁹

37. The Hatfield 2.2.2 updates BCM's 1990 data with 1995 household counts and adds data on the number of employees per CBG.⁶⁰ The Hatfield 2.2.2 model also assumes that digital loop carriers ("DLCs") are integrated into the switch, and its sponsors state that this is consistent with current LEC practices.⁶¹ We are currently attempting to verify that integration of DLCs and switches is the least-cost method of delivering telecommunications services.

38. BCM2's sponsors claim that the assumption that households are distributed uniformly across the CBG is not reasonable in low-density areas. The BCM2 therefore assumes that all households fall within 500 feet of either side of the road in CBGs with less than 20 households per square mile.⁶² The BCM2 excludes the areas outside of this 500 foot buffer zone and assumes that the population is uniformly distributed throughout the remaining areas. By excluding areas outside of this 500 foot buffer zone, the BCM2 estimates the cost of constructing a network for an area that is smaller than the actual CBG's surface area and has a uniformly distributed population. BCM2 also includes a user specified "Maximum Copper Distance" that may trigger an extension of feeder plant into the CBG if the CBG's width is greater than twice the Maximum Copper Distance.⁶³ Additionally, the BCM2 assumes that customers with loop costs greater than \$10,000 would be served more efficiently by a wireless system and has, therefore, capped per-loop investment at \$10,000.⁶⁴

39. The CPM uses a methodology similar to the BCM2 and the Hatfield 2.2.2 model to estimate the loop plant required to meet demand for telecommunication services. As discussed above, the CPM uses a grid, rather than a CBG, as its geographical unit of

⁵⁸ The justification for this approach is that network engineers are more likely to increase loop length to avoid difficult terrain factors rather than incur additional expense in deploying cable on the shortest possible route.

⁵⁹ See Hatfield 2.2.2 at 15; BCM2 at 4. Hatfield 2.2.2 also places service area interfaces where feeder plant ends and distribution plant begins, midway between the edge of a CBG and its centroid.

⁶⁰ See Hatfield 2.2.2 at 9.

⁶¹ AT&T Further Comments on Cost Proxy Models at 25, CC Docket 96-45.

⁶² See BCM2 at 4.

⁶³ See ETI at 59-60.

⁶⁴ See BCM2 at 3.

analysis.⁶⁵ The CPM assumes that each grid is served by the wire center that is currently serving the majority of customers located in that grid. The CPM uses the latitude and longitude of each grid's centroid and the actual location of switches to calculate loop distances.⁶⁶ These distances are then used to determine the amount of outside plant facilities that are needed and what type of loop technology will be used.⁶⁷ The CPM then incorporates population density, terrain, soil type, and other geological factors to estimate the cost of loop plant.⁶⁸ The CPM relies on the relationship between these factors and the cost Pacific Bell has incurred when placing loop plant in areas with, for example, a particular population density or soil type, to determine the effect these factors will have on the cost of provisioning loop plant. The cost estimates derived by the CPM therefore reflect the particular characteristics of Pacific Bell's embedded network.⁶⁹ The BCM2 and Hatfield 2.2.2 models, by contrast, attempt to estimate the cost of providing loop plant that would be incurred by an efficient provider given current wire-center locations. The BCM2 and Hatfield 2.2.2 models employ algorithms based on what their sponsors claim estimate the minimum forward-looking cost of deploying loop plant. To the extent that changing market and technological factors make past decisions for deploying loop plant non-optimal, the CPM's approach does not accurately estimate the forward-looking cost of deploying loop plant.

40. The BCM2, Hatfield 2.2.2, and CPM have all attempted to estimate the costs of low-density areas more accurately than the BCM1, and have adopted different algorithms to do so. In order to evaluate fully these different approaches, we believe that model sponsors should provide us with independent evidence that their approach leads to an accurate estimate of the forward-looking cost of providing telecommunications service in rural areas.

2. Loop Plant - Fill Factors

41. All the models include assumptions regarding feeder and distribution utilization rates (also called "fill factors"). In each model, lower utilization rates increase total loop investment because the increase in capacity associated with lower fill factors increases the amount of loop plant used to deliver telecommunication services. Thus, the choice of fill factor can have a significant effect on total cost. While all models allow user inputs for these quantities, it is not obvious what levels should be used as inputs. In a well-engineered network, it is necessary to include unused capacity when constructing loop plant to reduce the likelihood of outages in the case of breakages and to account for growth in demand. Furthermore, optimal fill factors should vary over the service life of the plant, increasing as

⁶⁵ See, *supra* para. 22.

⁶⁶ See Pacific Bell, Further Comments on Cost Proxy Models at 12-13, CC Docket No. 96-45.

⁶⁷ *Id.*

⁶⁸ *Id.*

⁶⁹ ETI at 15.

demand grows until more plant is put into service. While the BCM2 and Hatfield 2.2.2 have chosen very similar default fill factors, neither has provided a detailed justification for these values. For example, neither of the sponsors has justified the differences in the default fill factors between feeder and distribution plant. In addition, the sponsors have not explicitly stated whether a fill factor should be determined by taking the average fill used over the projected service life of the plant, whether fill factors should differ for fiber plant and copper plant, and whether optimal fill factors should take account of anticipated competitive interactions among firms.

42. Fill factors also may differ between business and residential markets. In residential markets, LECs traditionally place between one and one-half and two wire pairs per home in order to be able to provide a second or third line to premises without incurring construction costs. Thus, fill factors that are less than 50 percent may be reasonable for residential markets. In business-dominated wire centers, the rate of utilization depends on the proportion of businesses using Centrex service rather than PBX terminal equipment, because PBXs serve to concentrate traffic between the customer and the central office. Customers using PBX equipment therefore require fewer lines than customers using Centrex service. Depending on the relative use of Centrex to PBX equipment, and LECs' plans for marketing Centrex services, business fill rates could be either lower or higher than residential fill rates. We are therefore not convinced that the models accurately incorporate the effect that the ratio of business to residential lines will have on optimal fill factors.

43. In general, we believe that model sponsors have not adequately justified the default fill factors that they have utilized. We believe that model sponsors should include an analysis that addresses the effect that a variety of factors will have on fill rates. For example, in addition to the factors mentioned above, sponsors should discuss how fill factors should vary according to population density, network reliability standards, and the effect of special service obligations associated with a carrier's eligibility for universal service support payments.

3. Loop Plant - Cable and Structures

44. Having estimated the length of loops, all three models estimate the forward-looking cost of this loop plant. With respect to cable investments, all three models use default input prices to estimate the cost of loop plant, but allow users to specify different input prices. We believe that a model should be supported by independent evidence that the default prices chosen for cable, fiber, and other loop-related facilities, such as drops, pedestals, and network interface devices, are equal to the actual market prices of these inputs. We also note that the model sponsors have not indicated whether their default prices include any quantity discounts that may be offered when purchasing these inputs. In general, we expect that the prices for inputs, such as cable and fiber, that would not be subject to non-disclosure statements by their vendors, should be based on publicly available prices.

45. All three models also estimate the forward-looking cost of installing loop plant,

which includes the cost of building or obtaining access to structures that support the loop plant. Structures for cable plant consist of aerial, buried, and underground (*i.e.*, cable in conduit) facilities. The BCM2 and Hatfield 2.2.2 models assign different default values for the proportions of each type of installation and for the cost of installing each type of cable. These differences can have a significant effect on estimated model costs.⁷⁰ We believe that the treatment of forward-looking structure costs raises difficult modelling issues, and that none of the models is satisfactory in this regard. A crucial variable is the proportion of plant that is installed in new developments (where installation costs are relatively low) to plant installed for existing business and residential users. We recommend that model sponsors provide additional independent evidence on the appropriate mix of aerial, buried, and underground cable for use in a forward-looking cost study.

46. Different assumptions about sharing of structure costs can also have a significant effect on estimated model costs. Hatfield 2.2.2 allows users to specify the percentage of structure costs that are assumed to be shared with other users of these structures.⁷¹ Thus, Hatfield 2.2.2 includes only a fraction of total structure costs -- the default value is one third. BCM2 does not provide for such sharing, and includes the total cost of such structures. We believe that the default assumptions of BCM2 (no sharing) and Hatfield 2.2.2 (equal sharing by three utilities) are both simplistic, and that further investigation is needed by model sponsors on the sharing fraction that is most appropriate for the estimation of forward-looking costs.

47. Some parties have argued that, as a consequence of the fixed wire center assumption, the computation of forward-looking structure costs should take account of existing sunk investments in structure facilities. Consistent with the Universal Service Recommended Decision, we believe that proxy model estimates of structure investment, like all other model investments, should be based on forward-looking costs without regard to sunk investment. Because of this approach, as discussed in more detail below, we believe that choosing an accurate estimate of the economic life for these structures is crucial to estimating accurately the forward-looking cost of loop-plant structures.

4. Switching Investment

48. Having determined the number of lines assigned to a wire center, the BCM2 and Hatfield 2.2.2 determine the number and size of the switches to be placed in these wire centers. The BCM2 determines switching capacity based on the number of lines to be served by the switch and the nationwide average of dial equipment minutes ("DEMs").⁷² The BCM2

⁷⁰ See, for example, AT&T Further Comments on Cost Proxy Models, at 25, CC Docket No. 96-45.

⁷¹ Hatfield 2.2.2 at 35.

⁷² BCM2 methodology at 17.

assumes that LECs install one of four different switch sizes or a remote switching unit.⁷³ BCM2 assigns fixed switching costs based on the number of lines served by the switch, and assigns a variable per-line investment of \$100 for each line served by the switch.⁷⁴ Hatfield 2.2.2 determines the investment in switches and interoffice transport based on the number of lines and DEMs, along with Bellcore assumptions on, among other things, busy hour call attempts.⁷⁵ Hatfield 2.2.2 uses data from a McGraw-Hill study of the central office equipment market to derive average per-line prices for switching investment.⁷⁶ Hatfield 2.2.2 also includes separate costs for the buildings, land, and other inputs to determine investment in switching.⁷⁷ The CPM determines switch size based on the population density in a grid and uses Bellcore's switching cost information system ("SCIS") to estimate the investment in switching.⁷⁸ While Hatfield 2.2.2 and BCM2 appear to take different approaches to estimating the forward-looking cost of switching, their estimates are very similar. We note, however, that the models do not currently identify any other factors, such as expected growth in demand, that may affect the switching capacity installed in an efficiently designed network.

49. The Hatfield 2.2.2 and BCM2 sponsors both assert that switch vendors typically grant carriers substantial discounts when selling switches, and require carriers to sign nondisclosure covenants that require carriers to keep actual prices for which switches are sold confidential.⁷⁹ These sponsors also make similar claims for other electronic equipment, such as digital loop carriers. Hatfield 2.2.2 typically assumes higher discounts than BCM2.⁸⁰ The proprietary nature of these discounts does not allow us to determine what level of discount should be applied to switching and electronic equipment prices in these models. We recommend that models should be supported by information on the actual level of discounts, provided the information remains proprietary.

50. The BCM2 assumes that the total cost of switching increases with the number of lines served by a switch.⁸¹ Hatfield 2.2.2 assumes, by including flat-rated port charges, that

⁷³ See ETI at 43.

⁷⁴ ETI at 42.

⁷⁵ Hatfield 2.2.2 at 22-28.

⁷⁶ Hatfield 2.2.2 at 24. (Hatfield notes that these per-line average prices represent investments over all types of switching, including remote switching systems. See Hatfield 2.2.2 at 24, n. 29).

⁷⁷ *Id.*

⁷⁸ *California Decision* at 128.

⁷⁹ See ETI at 43.

⁸⁰ *Id.*

⁸¹ See ETI at 42.

a portion of a switch's cost is sensitive to the number of lines served by a switch, but that these costs do not vary according to the number of minutes switched. The models all assume that the proportion of a switch's cost that is not traffic sensitive is constant across all switches in the network. Ameritech, however, claims to the contrary that this percentage varies according to the type of switch.⁸² If these non-traffic sensitive costs are not constant across all switches, we expect that cost-minimizing carriers would install switches whose costs are largely traffic or non-traffic sensitive depending on the type of traffic that will be switched in an area. For example, in an area that switches a large amount of traffic with long holding times, it may be cost minimizing to install a switch whose costs are largely non-traffic sensitive. We are, therefore, not convinced that the models' current treatment of non-traffic sensitive switching costs produces an accurate estimate of the relative proportion of traffic-sensitive and non-traffic-sensitive costs.

5. Other Investments

51. Hatfield 2.2.2 explicitly models the interoffice network, including the SS7 network, by calculating the distance between existing wire centers and using assumptions concerning traffic patterns.⁸³ BCM2 gives much less detail and simply accounts for the interoffice network by increasing total investment by a small percentage.⁸⁴ We believe that Hatfield 2.2.2's approach of modeling the cost of each element of the interoffice network is superior to BCM2's approach of adding a lump sum to its estimate of loop plant and end office switching investment.

C. Modeling of Expenses

52. A cost proxy model ultimately produces an estimate of the annual or monthly cost of producing interstate access service, supported services, or a set of network elements. Annualized cost consists of the sum of the return on equity, taxes, interest, depreciation, network operations and support expense, customer operations, and corporate overhead. In a comparison of Hatfield 2.2.2, BCM2, and CPM, we find that differences in estimated monthly cost per line are substantially greater than the differences in the model's estimates of total investment.⁸⁵ Hence the expense side of a model can have a significant effect on its final cost estimate.

⁸² Access Reform Recommendation, Ameritech, Oct. 9, 1996, at Attachment.

⁸³ See Hatfield 2.2.2 at 23-28.

⁸⁴ See ETI at 45.

⁸⁵ For the seven regional Bell operating companies, average investment per line is equal to \$769 in Hatfield 2.2.2, \$960 in BCM2, and \$1057 in the CPM. Average monthly cost per line is equal to \$18.58 in Hatfield 2.2.2, \$41.12 in BCM2 and \$29.14 in the CPM.