Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Federal-State Joint Board on	)	CC Docket No. 96-45
Universal Service	)	
	)	
Forward-Looking Mechanism	)	CC Docket No. 97-160
for High Cost Support for	)	
Non-Rural LECs	)	

FIFTH REPORT & ORDER

Adopted: October 22, 1998 Released: October 28, 1998

By the Commission: Commissioner Furchtgott-Roth approving in part, dissenting in part, and issuing a statement.

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1. In the Telecommunications Act of 1996 (1996 Act),[1] Congress directed this Commission and states to take the steps necessary to establish explicit support mechanisms to ensure the delivery of affordable telecommunications service to all Americans while opening telecommunications markets to competition. In response to this directive, the Commission has taken action to put in place a universal service support system that will be sustainable in an increasingly competitive marketplace. In the *Universal Service Order*, the Commission adopted a plan for universal service support for rural, insular, and high cost areas to replace longstanding federal subsidies to incumbent local telephone companies with explicit, competitively neutral federal universal service support mechanisms.[2] The Commission adopted the recommendation of the Federal-State Joint Board on Universal Service (Joint Board) that an eligible carrier's level of universal service support should be based upon the forward-looking economic cost of constructing and operating the network facilities and functions used to provide the services supported by the federal universal service support mechanisms.[3] Full implementation of the new universal service support mechanisms is scheduled to take effect for non-rural carriers on July 1, 1999.[4]

2. Our plan to adopt a mechanism to estimate forward-looking cost is proceeding in two stages. The first stage, the model *platform*, establishes the framework for our approach by looking at the aspects of the model that are essentially fixed -- primarily the assumptions about the design of the network and network engineering and fixed characteristics such as soil and terrain. In the second stage, the Commission will select inputs for the model, such as the cost of network components such as cables and switches, in addition to various capital cost parameters. This Report and Order represents the first of these two stages. The Commission's plan is to use the model platform to estimate the cost of providing the supported services. Under the plan, the Commission would then determine the amount of federal universal service support by comparing cost with an appropriate benchmark, deciding the proportion of universal service support to be borne by the federal support mechanism,[5] and weighing in any other factors that the Commission,

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[1] Pub. L. No. 104-104, 110 Stat. 56. The 1996 Act amended the Communications Act of 1934, 47 U.S.C. §§ 151 *et. seq.* (Act). Hereinafter, all citations to the Act will be to the relevant section of the United States Code unless otherwise noted.

[2] Federal-State Joint Board on Universal Service, CC Docket No. 96-45, *Report and Order*, 12 FCC Rcd 8776 (1997) (*Universal Service Order*), as corrected by Federal-State Joint Board on Universal Service, *Errata*, CC Docket No. 96-45, FCC 97-157 (rel. June 4, 1997), appeal pending in Texas Office of Public Utility Counsel v. FCC and USA, No. 97-60421 (5th Cir. 1997).

[3] *Universal Service Order*, 12 FCC Rcd at 8888, para. 199.

[4] Federal-State Joint Board on Universal Service, *Order and Order on Reconsideration*, CC Docket No. 96-45, FCC 98-160 (rel. July 17, 1998) (*Referral Order)*. The Commission also determined that high cost support for rural carriers should continue essentially unchanged and should not be based on forward-looking costs until 2001, at the earliest. *Universal Service Order*, 12 FCC Rcd at 8889, para. 203. The Commission adopted the Joint Board's recommendation to define "rural carriers" as those carriers that meet the statutory definition of a "rural telephone company." *Universal Service Order*, 12 FCC Rcd at 8943, para. 310 *citing* 47 U.S.C. § 153(37).

[5] *See, e.g., Universal Service Order*, 12 FCC Rcd at 8925-8926, paras. 268-272 (stating that the Commission would monitor whether the 25 percent federal share of support was adequate to determine whether additional

in consultation with the Joint Board, may deem appropriate. In addition, we note that we have referred to the Federal-State Joint Board on Universal Service several questions related to how non-rural carriers' high cost support should be determined once forward-looking costs have been estimated,[6] and is committed to adopting an order on reconsideration before non-rural LECs begin receiving support based on forward-looking costs on July 1, 1999.[7] Only after we have taken those steps will we have finalized our implementation plan.

3. In this Order, we adopt neither the HAI model, which had been proposed by AT&T and MCI, nor the BCPM model, which was sponsored by U S West, BellSouth and Sprint, as submitted. Neither of these models permitted the Commission to adopt a framework or platform that would estimate the cost of building a telephone network to the subscriber's actual geographic location, taking into account the actual clustering of customers groupings such as neighborhoods and towns. Neither model, as submitted, sufficiently allows the Commission to vary engineering assumptions to account for the fact that, by statute, universal service is an "evolving concept." We also do not adopt, in its entirety, the HCPM which had been developed by Commission staff.

4. The model platform we adopt today combines the best elements from each of the three models currently in the record. The model platform we adopt today will allow the Commission to estimate the cost of building a telephone network to serve subscribers in their actual geographic locations, to the extent known. To the extent that telephone companies cannot supply the actual geographic location of the customer, the model platform assumes that those customers are located near roads. The model also allows the Commission to adjust engineering assumptions to reflect any evolution in the definition of supported services, and to assure that the model assumes a network architecture that will not impede rural Americans' ability to use the internet and other advanced telecommunications and information services. As such, we believe the federal model platform we adopt today will serve as a solid foundation for further decisions that will determine the amount of universal service support to be provided to non-rural eligible telecommunications carriers.

I. OVERVIEW

5. Since well before passage of the 1996 Act, the Commission has had in place policies to ensure the availability of telephone service in rural and high cost areas, as well as support mechanisms for low income consumers.[8] Traditionally, consumers in high cost and rural

support is necessary).

[6] *Referral Order* at para. 6.

[7] *Federal-State Joint Board on Universal Service*, CC Docket No. 96-45, Report to Congress, FCC 98-67, 13 FCC Rcd 11501, 11510, para. 19 (1998) (*Report to Congress*).

[8] *See* 47 U.S.C. § 151. The Commission's specific programs pursuant to the Act's mandate include the high cost loop fund, the dial equipment minutes (DEM) weighting program, long term support, Lifeline, and Link-Up. In addition, the Commission's interstate access charge system provided implicit subsidies for universal service

areas of the nation have received universal service support through implicit subsidies in interstate and intrastate rates. Universal service has helped ensure that consumers in all parts of the country, even the most remote and sparsely populated areas, are not forced to bear prohibitively high rates in order to obtain phone service. Universal service also has been designed to ensure that low-income consumers have access to local phone service at reasonable rates. Long distance rates and rates for certain intrastate services have been priced above cost in many instances, in order to keep local telephone rates at affordable levels throughout the country. The universal service program has benefited all telephone subscribers throughout the country by helping to ensure that all Americans are connected to the network, and therefore telephonically accessible to one another. Universal service support has increased subscribership levels by ensuring that residents in rural and high cost areas are not prevented from receiving phone service because of prohibitively high local telephone rates. As of today, approximately 94 percent of the households in the United States subscribe to telephone service, a subscribership rate that is among the best in the world.[9]

6. In the 1996 Act, Congress established a "pro-competitive, de-regulatory national policy framework designed to accelerate rapidly private sector deployment of advanced telecommunications and information technologies and services to all Americans by opening up all telecommunications markets to competition."[10] One of the principal goals of the telephony provisions of the 1996 Act is reforming universal service support so that the universal service objectives set forth in the 1996 Act continue to be met as local exchange and exchange access markets move from monopoly to competition. In the 1996 Act, Congress codified the Commission's long-standing commitment to ensuring universal service and directed that "[c]onsumers . . . in rural, insular, and high cost areas should have access to telecommunications and information services . . . that are reasonably comparable to those services provided in urban areas and that are available at rates that are reasonably comparable to [those] in urban areas."[11] The 1996 Act also directed the Commission to reform universal service support mechanisms to ensure that they are compatible with the pro-competitive goals of the 1996 Act. In requiring incumbents to open their local markets to competitive entry,[12] Congress rendered unsustainable the existing universal service support system, which is based on a complex system of implicit and explicit subsidies.[13] Rate structures that contain implicit support flows, such as artificially inflated interstate access charges and business rates, are sustainable in a monopoly environment but not in a competitive environment. Absent restructuring of the universal service system, competitors

support.

[9] *Telephone Subscribership in the United States* (Ind. Analysis Div. Jan. 1998).

[10] Joint Explanatory Statement at 113.

[11] 47 U.S.C. § 254(b)(3).

[12] *See* 47 U.S.C. §§ 251-252.

[13] In addition to the federal universal service support programs and policies, states have a variety of policies to support universal service such as business rates that are considerably higher than residential rates.

would enter markets where rates are artificially high relative to costs, and would not enter markets where rates are kept artificially low.[14] Moreover, absent rate restructuring, such systematic market entry strategies would threaten to erode altogether the system of universal service. Incumbents would continue to have to serve the high cost customers without the offsetting benefit of the high-profit revenue streams that previously subsidized serving these high cost areas.

7. In order to sustain universal service in a competitive environment, Congress found: (1) that universal service support should be explicit; (2) that all carriers (rather than only interexchange carriers) that provide telecommunications service should contribute to universal service on a competitively neutral, equitable, and non-discriminatory basis; and (3) that, as a general matter, any carrier (rather than only the incumbent LEC) should be eligible to receive, on a competitively neutral, equitable, and non-discriminatory basis, the appropriate level of support for serving a customer in a high cost area.[15]

8. In the *Universal Service Order*, the Commission adopted its plan to implement a system of universal service support for rural, insular, and high cost areas to replace the existing high cost programs and the implicit federal subsidies with explicit, competitively neutral federal universal service support mechanisms. The first steps were implemented on January 1, 1998. For instance, as of that date the new universal service rules require equitable and non-discriminatory contributions from all providers of interstate telecommunications service rather than exclusively from interstate long distance providers. Also, as of January 1, 1998, competitive eligible telecommunications carriers are also eligible to receive federal universal service support for serving customers in high cost, rural, and insular areas.[16] This order, which adopts the platform of a federal mechanism that would allow support amounts to be determined based on forward-looking cost, is the first step towards further revisions of federal support mechanisms. This estimate will be used to determine the level of support provided to eligible non-rural telecommunications carriers, beginning July 1, 1999.

9. In the *Universal Service Order*, the Commission also agreed with the Joint Board that the appropriate level of federal universal service high cost support should be based on forward-looking economic cost rather than embedded cost.[17] The Joint Board found that, for purposes of administering a federal high cost support system based on forward-looking cost, a

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[14] For example, competitors would be likely to target customers in low-cost areas, because rates in denser, lower-cost areas traditionally have subsidized rates in higher-cost, rural areas, but would not compete for residential customers in high cost areas, because new entrants could not afford to offer service at the below-cost subsidized rates that the incumbent is able to charge.

[15] *See* 47 U.S.C. § 254.

[16] 47 C.F.R. § 54.307.

[17] *Universal Service Order*, 12 FCC Rcd at 8899, paras. 224-25; *see also* Federal-State Joint Board on Universal Service, CC Docket No. 96-45, *Recommended Decision*, 12 FCC Rcd 87 at 232 (1996) (*Recommended Decision*).

forward-looking cost model would be an essential part of determining support levels in an efficient way. The Joint Board also found that determining costs with a cost model would provide other benefits, such as the ability to determine costs at smaller geographic levels than would be practical using the existing cost accounting system.[18] By using a cost model, universal service support can be targeted to support the high cost customers within a carrier's service area. Moreover, a forward-looking economic cost mechanism eliminates incentives to invest inefficiently. Also, because all eligible carriers will receive the same level of support when they win a customer and because the level of support is not based on the specific technology that the carrier used to deliver the supported service, the new universal service mechanism will be competitively and technologically neutral. Finally, the use of a forward-looking cost model allows the Commission to ensure that universal service support amounts are based on a network that will provide the supported services and not impede the provision of advanced services. In contrast, a support system based on the existing network, which is in some cases of lower quality, would not provide sufficient support for necessary upgrades. Basing support on the forward-looking cost of a network that is capable of providing the supported services will ensure that universal service support is based on a network with the capacity to ensure service quality and access to advanced services in rural areas.

10. In determining the appropriate level of high cost support, the Commission is committed to ensuring that "[q]uality services [are] available at just, reasonable, and affordable rates," and that "[c]onsumers . . . in rural, insular, and high cost areas, should have access to telecommunications and information services . . . that are reasonably comparable to those services provided in urban areas and that are available at rates that are reasonably comparable to rates charges for similar services in urban areas," as required by the statute.[19] In agreeing with the Joint Board that forward-looking economic cost will provide sufficient support for an efficient carrier to provide the supported services for a particular geographic area, the Commission specifically rejected arguments that support should be based on a carrier's embedded cost.[20] As the Joint Board recognized, providing support based on embedded cost provides the wrong signals to potential market entrants.[21] If embedded costs exceed forward-looking costs, such support would encourage inefficient entry. In contrast, providing support based on embedded costs that are below forward-looking economic costs would dissuade market entry even where such competition would be economically efficient. The Commission concurred with the Joint Board's finding that the use of forward-looking economic costs as the basis for determining support will send the correct signals for entry, investment, and innovation.[22] The Commission found that a

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[18] *Recommended Decision*, 12 FCC Rcd at 230, para. 270.

[19] 47 U.S.C. § 254(b)(1), (b)(3).

[20] *Universal Service Order*, 12 FCC Rcd at 8900-01, paras. 227-229.

[21] *Recommended Decision*, 12 FCC Rcd at 232; *see also Universal Service Order*, 12 FCC Rcd at 8901, para. 228.

[22] *Universal Service Order*, 12 FCC Rcd at 8899, para. 224; *see also Recommended Decision*, 12 FCC Rcd at 232.

forward-looking economic cost methodology creates the incentive for carriers to operate efficiently and tends not to give carriers an incentive to inflate their costs or to refrain from efficient cost-cutting.[23]

11. As noted above, our process of estimating forward-looking costs is proceeding in two stages. Consistent with the Joint Board's recommendation, the Commission in the *Universal Service Order* concluded that it would need to estimate costs based on a careful analysis of efficient network design, engineering practices, available technologies, and current technology costs. That is, to estimate forward-looking costs accurately, the Commission decided to look at all of the costs and cost-causative factors that go into building a network. The Commission decided to do this in two stages: first, it would look at the network design, engineering, and technology issues relevant to constructing a network to provide the supported services. Second, the Commission said that it would look at the costs of the components of the network, such as cabling and switch costs, and various capital cost parameters, such as debt-equity ratios and depreciation rates ("input values").

12. This Order includes our conclusions as to the platform selection, the first of the two stages. In the *Universal Service Order*, the Commission concluded that two industry-proposed cost models should continue to be considered and developed further and stated that it might also consider models or model components submitted by other parties or developed by Commission staff. Both of the industry-proposed models have improved in significant ways since the *Universal Service Order* was adopted, and Commission staff has developed a separate model. Below we adopt a synthesis of the best aspects of each of the three models before us in this proceeding. We recognize that, of necessity, models estimate the forward-looking cost of providing the supported services. Such analysis is, however, the only practicable method that presently exists for determining forward-looking costs on a widescale basis,[24] and we expect that the synthesis model will generate accurate estimates of the forward-looking of providing the supported services. The federal mechanism that we select in this Order to estimate forward-looking cost will serve as the foundation for determining the final universal service support requirements. The Commission intends to issue Orders on the input values to be used in the selected mechanism and the further recommendations of the Joint Board in time to implement the federal mechanism for non-rural carriers by July 1, 1999.[25] Because inputs are critical to determining the cost of providing the supported services, the Order we adopt today does not identify the amount of high cost support that will be provided to non-rural carriers beginning July 1, 1999. The selected platform alone is not dispositive of the cost calculations generated by the

[23] *Universal Service Order*, 12 FCC Rcd at 8900, para. 226.

[24] GTE argues that the Commission should use carrier-specific, state-approved engineering models to calculate universal service support, rather than a single federal mechanism. GTE Oct. 17 comments at 1. As discussed below, the *Universal Service Order* provided states with the option of submitting their own cost study or model to calculate the level of universal service support in that state if the state's cost study or model meets the criteria outlined in the *Universal Service Order*. The Joint Board may provide the Commission with further guidance on the use of state-specific cost studies in the near future. *See Referral Order* at para. 6.

[25] *See Referral Order* at para. 4.

mechanism. That determination also depends upon the selection of input values and the resolution of the issues recently referred back to the Joint Board, such as benchmark levels.[26] Moreover, we note that the selection of the synthesis platform is based solely on our evaluation of its performance for determining non-rural carriers' forward-looking costs for universal service purposes. We have not evaluated it for any other purpose.

13. We recognize that the task of establishing a model to estimate forward-looking costs is a dynamic process that will need to be reviewed and adjusted periodically. We must balance the needs to provide predictability and certainty with the need to account for changes that inevitably will occur over time, such as technological advances. For example, a party recently submitted data in support of basing support on the use of wireless technologies in some instances.[27] The Commission therefore intends, before the end of this year, to begin more detailed consideration of possible future modification of the model to reflect new technologies. Among other things, the Commission may consider how the model should be updated in the future to account for changes in material prices, technology, and other circumstances. We also will address issues related to the administration of high cost support, including the transition by which routine use of the model and updating of model data will be provided by the administrator of universal service support mechanisms, subject to Commission oversight. In addition, we expect that, both before we implement the model for non-rural carriers on July 1, 1999, and on an ongoing basis, we will find opportunities to make technical improvements. In such cases, we delegate to the Common Carrier Bureau the authority to make changes or direct that changes be made as necessary and appropriate to ensure that the platform of the federal mechanism operates as described in this Order.

II. PROCEDURAL HISTORY

A. *Universal Service Order*

14. Prior to the 1996 Act, three explicit universal service programs were in place to provide assistance to small incumbent local exchange carriers (LECs) and LECs that served rural and high cost areas: high cost loop support,[28] dial equipment minutes (DEM) weighting, and the

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[26] *See Referral Order*.

[27] Letter from David L. Sieradzki, Western Wireless, to Magalie Roman Salas, FCC, dated July 15, 1998. Western Wireless argues that the Commission should explicitly consider the cost of providing universal service using wireless technologies. Throughout the models development process, the Commission actively has sought input on how wireless technologies should be incorporated into the model platform. No party has yet come forward with an algorithm or sufficient data to incorporate wireless technology into the model. We expect, however, that these sorts of issues would be raised in our proceeding to consider the impact of changing technologies on the model platform.

[28] Although the existing high cost loop fund has historically been known as the "Universal Service Fund," we will avoid this terminology because of the confusion it may create with the new universal service support mechanisms that the Commission has created pursuant to section 254 of the Communications Act.

Long-Term Support program.[29] Other mechanisms also have historically contributed to maintaining affordable rates in rural areas, including subsidies implicit in intrastate rates and interstate access charges. Section 254 required the Commission to institute a Federal-State Joint Board on universal service and implement the recommendations from the Joint Board by May 8, 1997.[30] After receiving the recommendations of the Joint Board, the Commission adopted the *Universal Service Order*.

15. In the *Universal Service Order,* the Commission adopted a forward-looking economic cost methodology for non-rural carriers that will calculate support in four steps. First, a forward-looking economic cost mechanism selected by the Commission, in consultation with the Joint Board (federal mechanism), would be used to calculate non-rural carriers' forward-looking economic cost of providing the supported services in high cost areas.[31] Second, the Commission would establish a nationwide benchmark that represents the revenue that carriers receive as a result of providing service.[32] Third, the Commission would calculate the difference between the forward-looking economic cost and the benchmark.[33] Fourth, federal support would be 25 percent of that difference, corresponding to the percentage of loop costs that historically has been allocated to the interstate jurisdiction.[34] In the *Universal Service Order*, the Commission stated that, once states have taken steps to identify the subsidies implicit in intrastate rates, the Commission may reassess the amount of federal support that is necessary to achieve the Act's goals. In response to issues raised by commenters and the state Joint Board members, the Commission referred back to the Joint Board questions related to how federal support should be determined.[35] For example, the Joint Board is reviewing how best to determine the support amount, given the forward-looking cost of providing the supported services in an area, and the appropriate share to be provided by the federal mechanism.[36] Although many of the proposals

[29] The Commission's rules governing these programs are set forth at 47 C.F.R. §§ 36.601 *et. seq.* (high cost loop fund); 47 C.F.R. § 36.125(b) (DEM weighting); and 47 C.F.R. §§ 69.105, 69.502, 69.603(e), 69.612 (LTS).

[30] 47 U.S.C. § 254(a).

[31] *Universal Service Order*, 12 FCC Rcd at 8890, para. 206. Alternatively, states may elect to submit cost studies or models that will be used to compute the forward-looking cost. State cost studies or models must meet the criteria established in the *Universal Service Order*. The Joint Board may soon provide the Commission with further guidance on whether or how state cost studies should be used to determine federal support levels. *See Referral Order* at para. 6.

[32] *See Universal Service Order*, 12 FCC Rcd at 8919-8924, paras. 257-267. Although the Commission's order contemplates using a revenue benchmark, some proposals currently under consideration by the Joint Board propose to use other types of benchmarks or no benchmark at all.

[33] *Universal Service Order*, 12 FCC Rcd at 8888, para. 200.

[34] *Universal Service Order*, 12 FCC Rcd at 8888, para. 201.

[35] *See Referral Order*. *See also* Formal Request for Referral of Designated Items by the State Members of the § 254 Federal-State Joint Board on Universal Service, CC Docket No. 96-45, filed March 11, 1998.

[36] *See Referral Order* at para. 4.

under consideration by the Joint Board and pending before the Commission on reconsideration might alter some of those four steps, the proposals would generally still require the Commission to adopt a mechanism for determining the forward-looking cost of providing the supported services.

16. In the *Universal Service Order*, the Commission concluded that two industry-proposed models, HAI and BCPM, that had been submitted for consideration in the proceeding that led up to the *Order* were not sufficiently accurate for adoption as the federal cost mechanism, but that the two models should continue to be considered and developed further.[37]

17. The Commission stated that it might consider, for the federal mechanism, alternative algorithms and approaches submitted by parties other than the model sponsors or that could be generated internally by Commission staff.[38] The Commission noted that one possible outcome of this approach would be development of a hybrid or synthesis model that combines selected components of different models with additional components and algorithms drawn from other sources.[39] The Commission presently has three models before it: (1) the Benchmark Cost Proxy Model, Version 3.0 (BCPM);[40] (2) the HAI Model, Version 5.0a (HAI);[41] and (3) the Hybrid Cost Proxy Model, Version 2.5 (HCPM).[42]

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[37] *Universal Service Order*, 12 FCC Rcd at 8909-8910, para. 245.

[38] Federal-State Joint Board on Universal Service, Forward-Looking Mechanism for High Cost Support for Non-Rural LECs, CC Docket Nos. 96-45, 97-160, *Further Notice of Proposed Rulemaking* (*Further Notice)*, 12 FCC Rcd 18514 at 18532, paras. 35-36 (1997).

[39] *Further Notice*, 12 FCC Rcd at 18532, para. 35.

[40] Submission to CC Docket Nos. 96-45 and 97-160 by BellSouth Corporation, BellSouth Telecommunications, Inc., U S WEST, Inc., and Sprint Local Telephone Company (BCPM proponents), dated Dec. 11, 1997 (BCPM Dec. 11 submission).

[41] Letter from Richard N. Clarke, AT&T, to Magalie Roman Salas, FCC, dated Dec. 11, 1997 (HAI Dec. 11 submission). HAI was submitted by AT&T and MCI (HAI proponents). Versions of HAI filed before February 3, 1998, were known as the Hatfield Model. The proponents refer to the February 3, 1998 submission as HAI. We refer to this model as HAI throughout this Report and Order.

[42] HCPM was developed by Commission staff members William Sharkey, Mark Kennet, C. Anthony Bush, Jeff Prisbrey, and Commission contractor Vaikunth Gupta of Panum Communications. Common Carrier Bureau Announces Release of HCPM Version 2.0, *Public Notice,* DA 97-2712 (rel. Dec. 29, 1997) (*Public Notice Releasing HCPM 2.0*). United States Government Memo from W. Sharkey, FCC, to Magalie Roman Salas, FCC, dated Feb. 6, 1998 (HCPM Feb. 6 submission).

B. *Further Notice* and the Model Development Process

18. In a July 18, 1997 *Further Notice of Proposed Rulemaking*, the Commission established a multi-phase plan to develop a federal mechanism that would send the correct signals

for entry, investment, and innovation.[43] The *Further Notice* divided questions related to the cost models into "platform design" issues and "input value" issues.[44] The *Further Notice* subdivided the platform issues into four topic groups, and sought comment on each group separately in order to develop a focused dialogue among interested parties. The four groups were: (1) customer location platform issues; (2) outside plant design platform issues; (3) switching and interoffice platform issues; and (4) general support facilities, expenses, and all inputs issues.[45]

19. In the *Further Notice*, we also requested that parties provide information about the platform design and input values that would allow the mechanism developed in this proceeding to estimate the forward-looking cost of non-rural carriers in Alaska and insular areas.[46] In addition, the Commission indicated in the *Further Notice* that, in selecting a federal mechanism, we might consider alternative approaches to BCPM and HAI, such as the development of a hybrid model that combines components of BCPM or HAI with each other or with algorithms drawn from other sources.[47] After reviewing the comments received in response to the *Further Notice*, the Common Carrier Bureau released two public notices as guidance to parties wishing to submit cost models for consideration as the federal mechanism.[48] The Bureau's guidance provided recommendations on the platform design of the customer location, outside plant, switching, and transport components of a cost model.[49]

[43] *Further Notice*, 12 FCC Rcd 18514.

[44] Generally, there is a platform component for each portion of the exchange network being modeled. Examples of platform design issues are the method of distributing customers within a geographic area, the establishment of switch capacity limitations, and the routing of feeder and distribution cables. Examples of input values are the price of various network components, their associated installation and placement costs, and capital cost parameters such as debt-equity ratios. *See Further Notice*, 12 FCC Rcd at 18516-18, paras. 17-18.

[45] *See Further Notice*, 12 FCC Rcd at 18514.

[46] *Further Notice*, 12 FCC Rcd at 18518-19, para. 4. In the *Universal Service Order*, the Commission rejected the suggestion of Puerto Rico Telephone Co. (PRTC) that non-rural carriers serving insular areas should be treated in the same manner as rural carriers and allowed to postpone their conversion to the forward-looking economic cost methodology. *See Universal Service Order*, 12 FCC Rcd at 8946, para. 315. The Telecommunications Regulatory Board of Puerto Rico has requested the Commission to delay conversion to a forward-looking cost mechanism in Puerto Rico for a transition period "of no less than three years." *See* Letter from Phoebe Forsythe Isales, Telecommunications Regulatory Board of Puerto Rico, to William Kennard, FCC, dated April 22, 1998 at 2. The Commission does not address this issue today but intends to review the record and make a determination at a later date.

[47] *Further Notice*, 12 FCC Rcd at 18531-32, paras. 34-38.

[48] Guidance to Proponents of Cost Models in Universal Service Proceeding: Switching, Interoffice Trunking, Signaling, and Local Tandem Investment, *Public Notice*, DA 97-1912 (rel. Sep. 3, 1997) (*Switching and Transport Public Notice*); Guidance to Proponents of Cost Models in Universal Service Proceeding: Customer Location and Outside Plant, *Public Notice*, DA 97-2372 (rel. Nov. 13, 1997) (*Customer Location & Outside Plant Public Notice*).

[49] *Switching and Transport Public Notice*; *Customer Location & Outside Plant Public Notice*.

20. During the course of the model development process, proponents of BCPM and HAI submitted a series of revisions to model components and intermediate output data. In a *Public Notice* released on November 13, 1997, the Bureau requested that model proponents by December 11, 1997 submit versions of their model platforms that incorporated the Bureau's guidance.[50] The Bureau stated its expectation that the Commission would evaluate the models submitted at that time to select the platform for the federal mechanism.[51] Updated versions of BCPM, HAI, and HCPM were filed with the Commission on December 11, 1997.[52] On August 7, 1998, HCPM released a clustering algorithm to group customers into serving areas.[53] The Bureau has continued to receive minor refinements to all three models.[54]

C. Design of a Forward-Looking Wireline Local Telephone Network

21. To understand the assumptions made in the models, it is necessary to understand the layout of the current wireline local telephone network.[55] In general, a telephone network must allow any customer to connect to any other customer. In order to accomplish this, a telephone network must connect customer premises to a switching facility, ensure that adequate capacity exists in that switching facility to process all customers' calls that are expected to be made at peak periods, and then interconnect that switching facility with other switching facilities which routes the call to its destination. A "wire center" is the location of a switching facility, and there are geographic boundaries that define the area in which all customers are connected to a given wire center. By requiring the models to use existing incumbent LEC wire center locations, the *Universal Service Order* imposed some uniformity in the models' network design.[56]

22. Within the boundaries of each wire center, the wires and other equipment that connect the central office to the customers' premises are known as *outside plant*. Outside plant can consist of either copper cable or optical fiber cable or a combination of optical fiber and

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[50] *Customer Location & Outside Plant Public Notice* at section III.

[51] *Customer Location & Outside Plant Public Notice* at section III.

[52] BCPM Dec. 11 submission; HAI Dec. 11 submission; *Public Notice Releasing HCPM 2.0*.

[53] *See* Common Carrier Bureau Seeks Comment On Model Platform Development, *Public Notice*, DA 98-1587 (rel. Aug. 7, 1998) (*Platform Public Notice*) at 4.

[54] Minor revisions have been made to the HAI and HCPM December 1998 model submissions. *See* Letter from Richard Clarke, AT&T, to Magalie Roman Salas, FCC, dated February 3, 1998 (HAI Feb. 3 Submission); HCPM Feb. 6 submission.

[55] We also note that technologies such as wireless are likely to become more important over time in providing universal service and we will review suggestions for incorporating such technologies into the forward-looking cost estimates. *See, e.g.*, Western Wireless Corp. *Platform Public Notice* comments 3-6.

[56] *Universal Service Order*, 12 FCC Rcd at 8913 para. 250. Criterion 1 requires that a model must include incumbent LECs' wire centers as the center of the loop network and the outside plant should terminate at incumbent LECs' current wire centers.

copper cable, as well as associated electronic equipment. Copper cable[57] generally carries an analog signal that is compatible with most customers' telephone equipment, but thicker, more expensive cables must be used to carry signals over greater distances. Optical fiber cable carries a digital signal that is incompatible with most customers' telephone equipment, but the quality of the signal degrades significantly less with distance compared to a signal carried on copper wire. Generally, when a neighborhood is located too far from the wire center to be served with copper cables alone, an optical fiber cable will be deployed to a point within the neighborhood, where a piece of equipment will be placed that converts the digital signal carried on optical fiber cable to an analog, electrical signal that is compatible with customers' telephones. This equipment is known as a digital loop carrier remote terminal, or DLC. Because of the cost of DLCs, the models are designed so that a single DLC is shared among a number of customers. From the DLC, copper cables of varying gauge extend to all of the customer premises in the neighborhood. Where the neighborhood is close enough to the wire center to serve entirely on copper cables, a copper trunk connects the wire center to a central point in the serving area, called the serving area interface (SAI), and copper cables will then connect the SAI to the customers in the serving area. The portion of the loop plant that connects the central office with the SAI or DLC is known as the *"feeder" plant*, and the portion that runs from the DLC or SAI throughout the neighborhood is known as the *"distribution" plant*.

23. A model's estimate of the cost of serving the customers located within a given wire center's boundaries includes the model's calculation of switch size, the lengths, gauge, and number of copper and fiber cables, and the number of DLCs required. These factors depend, in turn, on how many customers the wire center serves, where the customers are located within the wire center boundaries, and how they are distributed within neighborhoods. Particularly in rural areas, some customers may not be located in neighborhoods at all but, instead, may be scattered throughout outlying areas. In general, the models divide the area served by the wire center into smaller areas that will be served from a single DLC, known as "*serving areas*."[58] All cable within a serving area, with the exception of that which connects a DLC to a central office, is considered distribution plant.

24. The model proponents agree that forward-looking design requires that wire centers be interconnected with one another using optical fiber networks known as Synchronous

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[57] Copper cable can also be used, under other circumstances, to carry a digital signal that is incompatible with telephone equipment. For example, both BCPM and HAI use T-1 on copper technology, which involves a digital signal on copper wire.

[58] The models generally locate customers within some portion of the serving area, within which distribution plant is constructed; this is known as the "distribution area." For the sake of analysis, we also consider the cable that connects each distribution area to the DLC to be distribution cable. We adopt this definition of distribution plant for the sake of consistency. HAI considers the cable between a DLC and a distribution area to be distribution plant. HAI Dec. 11 submission, Model Description at 17. While noting that this cable "would typically be considered distribution cable," BCPM classifies it as feeder. BCPM Dec. 11 submission, Model Methodology at note 32. The difference in the model proponents' terminology does not affect our analysis of the models.

Optical Network (SONET) rings.[59] The infrastructure to interconnect the wire centers is known as the "interoffice" network, and the carriage of traffic among wire centers is known as "*transport*." In cases where a number of wire centers with relatively few people within their boundaries are located in close proximity to one another, it may be more economical to use the switching capacity of a single switch to process the calls of the customers in the boundaries of all the wire centers. In that case, a full-capacity switch (known as a "host") is placed in one of the wire centers and less expensive, more limited-capacity switches (known as "remotes") are placed in the other wire centers. The remotes are then connected to the host with interoffice facilities. Switches that are located in wire centers with enough customers within their boundaries to merit their own full-capacity switches and that do not serve as hosts to any other wire centers are called "stand-alone" switches.

25. The models under consideration in this proceeding differ in several important ways in estimating the forward-looking cost of designing a telephone network. For example, the three models in this proceeding rely on different sets of data and assumptions to ascertain the number of customers in each wire center and the geographic location of those customers.[60] The models also use different methods to calculate switch size, the size, type, and number of fiber and copper cables, and the routing of those cables.

III. CUSTOMER LOCATION AND OUTSIDE PLANT DESIGN

26. We first consider the customer location and outside plant algorithms of BCPM, HAI, and HCPM in light of the criteria identified in the *Universal Service Order*. As the Bureau pointed out in the *Outside Plant Public Notice*, the criteria suggest that the models "should be considered both from an engineering perspective, to ensure that the network provides the type and quality of service specified in the *[Universal Service] Order*, and from an economic perspective, to ensure that the network design minimizes costs and maximizes efficiency."[61] We conclude that the customer location and outside plant platform of the federal mechanism should consist of a synthesis of the best ideas presented by the model proponents, including HAI's use of geocoded customer location data, BCPM's use of the road network to estimate the locations of customers for whom no geocode data are available, HCPM's approach to identifying customer serving areas based on natural clusters of customers, and HCPM's ability to design plant to the precise customers locations within each serving area.

A. Background

[59] SONET is a set of standards for optical (fiber optic) transmission. It was developed to meet the need for transmission speeds above the T3 level (45 Mbps) and is generally considered the standard choice for transmission devices used with broadband networks. BCPM Dec. 11 submission, Model Methodology at 68. As discussed below, HCPM only contains the modules necessary to locate customers and compute the cost of outside plant.

[60] *See* Appendix A for complete description of models.

[61] *Outside Plant Public Notice* at 4.

27. Outside plant, or loop plant,[62] rather than switching and interoffice transport plant, constitutes the largest portion of total network investment, particularly in rural areas.[63] Engineering assumptions about outside plant significantly affect service quality. The design of outside plant facilities depends heavily on the location of customers relative to the wire center. Thus, the most significant portions of network costs will be determined using the model's customer location module, which locates customers, and the outside plant design module, which designs the network efficiently to serve those customers. The models' outside plant modules thus are closely associated with their customer location modules. Each model has developed an algorithm for locating customers as well as an outside plant design module. We therefore must evaluate the respective proposals and determine the most appropriate method to locate customers.

28. After the *Outside Plant Public Notice* was released, the model proponents submitted customer location and outside plant modules that use a variety of data sources, assumptions, and algorithms. The new versions of both models are significant improvements over earlier versions. A detailed description of the technical design of each model proposal is set forth in Appendix A.

B. Discussion

29. In this section, we identify the combination of data and algorithms that locate customers and design outside plant to serve those customers in a way that best meets the criteria identified in the *Universal Service Order*.[64] As an initial matter, we observe that all three models design a network that is capable of providing the supported services.[65] We also conclude, as explained below, that each of the models meets a reasonable standard for ensuring that the network designed does not impede the provision of advanced services.

30. We identify five distinct aspects of the customer location and loop design portions of a cost model that can have a significant bearing on the model's ability to estimate the least-cost, most-efficient technology for serving a particular area.[66] These include: (i) the extent to which the model uses actual customer location data to locate customers, (ii) the method of determining customer locations in the absence of actual data, (iii) the algorithms employed to group customers into serving areas, (iv) the model's ability to design plant directly to the customer locations within

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[62] A carrier's loop plant is the entire network infrastructure between the switching office and the customer's premises. *See supra* section II.C.

[63] For example, in both HAI and BCPM, loop plant represents over 70 percent of total network investment.

[64] *Universal Service Order*, 12 FCC Rcd at 8913, para. 250.

[65] HAI Dec. 11 submission, Model Description at 1-2; BCPM Dec. 11 submission, Model Methodology at 17-18; C.A. Bush et al., *Computer Modeling of the Forward-Looking Economic Cost of Local Exchange Telecommunications Networks: An Optimization Approach*, June 1, 1998 (HCPM June 1 Report) at 2.

[66] *Universal Service Order*, 12 FCC Rcd at 8913, para. 250, criterion 1.

the serving area, and (v) adherence to sound engineering and cost minimization principles in both the design of distribution plant within each serving area and the design of feeder plant to connect each serving area to the associated central office.

1. Determining Customer Location

31. Each model has a method for determining where customers are located. The issues raised are whether to use actual geocode data, to the extent they are available, and what method to use for determining surrogate customer locations where geocode data are not available.[67] We conclude that HAI's proposal to use actual geocode data, to the extent that they are available, is the preferred approach, and BCPM's proposal that we use road network information to determine customer location where actual data are not available, provides the most reasonable method for determining customer locations.

32. The starting point that all three models use in determining customer location is publicly available information from the Census Bureau, which provides the number of customers within each Census Block (CB).[68] Thus, at a minimum, each model has information about the number of customers within a specified geographic area. In urban areas, CBs tend to be relatively small, and often contain only one city block. In rural areas, however, CBs typically are much larger. It is therefore important to have a reasonable method for determining customer locations more precisely within the CB.

33. <u>Use of Geocode Data</u>. Only HAI includes a specific proposal for using actual latitude and longitude data to identify customer locations. Many commenters from across the spectrum of the industry agree that geocode data that identify the actual geographic locations of customers are preferable to algorithms intended to estimate customer locations based solely on such information as Census data.[69] We agree with Ameritech that proxy techniques for estimating customer locations are unnecessary and inappropriate for companies that can identify the actual customer dispersion of their customers with geocode data.[70] We conclude that a model is most likely to select the least-cost, most-efficient outside plant design if it uses the most accurate data

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[67] Although surrogating methods, and even customer location data provided by the Census Bureau, constitute geocode data, for purposes of clarity, we will use the term "geocode" data to refer only to actual precise latitude and longitude data, unless we specifically refer to the data as "surrogate geocode" data.

[68] A CB is the smallest geographic unit for which the Census Bureau collects information. Defined by the Census Bureau in 1990, CBs vary in shape and size, although a CB may be no smaller than 40,000 square feet or, if the CB is bounded entirely by roads, 30,000 square feet. CBs must be bounded by at least one road, and may also be bounded by railroads, bodies of water, other visible physical and cultural features, and legal boundaries. U.S. Census Bureau's Geographic Reference Manual, Chapter 11, at 11-9 - 11-11.

[69] *See* AT&T Sept. 11, 1998 comments at 3; Bell Atlantic Aug. 28, 1998 comments at 3; GTE Aug. 28, 1998 comments at 5; MCI Aug. 28, 1998 comments at 2; Aliant Sept. 2, 1997 comments at 2; Ameritech Sept. 2, 1997 comments at 6; AT&T Sept. 2, 1997 comments at 7-8; RUS Sept. 2, 1997 comments at 2; AT&T Sept. 10, 1997 reply comments at 12-13.

[70] Ameritech Sept. 2 comments at 6.

for locating customers within wire centers, and that the most accurate data for locating customers within wire centers are precise latitude and longitude coordinates for those customers' locations.

34. Recent public comment demonstrates support for the use of accurate geocode data in the federal mechanism when available.[71] At present, the only geocode data in the record of this proceeding are those prepared for the HAI model by the HAI sponsors' consultants, PNR Associates (PNR).[72] Many commenters recognize that, in addition to the current sources of geocode data, more comprehensive geocode data are likely to be available in the future.[73] Nevertheless, some commenters still question whether PNR's geocode data set should be used in the federal mechanism.[74] We note that our conclusion that the model should use geocode data to the extent that they are available is not a determination of the accuracy or reliability of any particular source of that data. We anticipate, however, that a reasonable source of verifiable geocode data can be determined at the inputs stage of this proceeding.[75] At a minimum, PNR's data is now available for review, and interested parties may comment upon and suggest improvements to the accuracy of that database. Thus, while we conclude that the federal mechanism should use geocode data to the extent available, we do not in this Order adopt a

[71] *See, e.g.,* AT&T Aug. 28, 1998 comments at 3; Bell Atlantic Aug. 28, 1998 comments at 3; BellSouth et al. Aug. 28, 1998 comments at A-2; GTE Aug. 28, 1998 comments at 5; MCI Aug. 28, 1998 comments at 2. At earlier stages of this proceeding, some commenters opposed using geocode data in the federal mechanism based on the assertion that the geocode data that presently exist for rural areas had not been made available for public review and may, therefore, be insufficient and unreliable. *See, e.g.,* GTE Sept. 2, 1997 comments at 11-12; Bell Atlantic Sept. 10, 1997 reply comments at 3-4; GTE Sept. 10, 1997 reply comments at 4-5; SBC Sept. 10, 1997 reply comments at 6-7.

[72] Pursuant to the Commission's Protective Order, PNR has recently made available the underlying geocode data for inspection by interested parties.

[73] *See* Aliant Sep. 2 comments at 2; RUS Sep. 2 comments at 2; Letter from Orren E. Cameron III, RUS, to Office of the Secretary, FCC, dated Sep. 12, 1998 (RUS Sep. 12 *ex parte*) at 1; Letter from David N. Porter, WorldCom, to William F. Caton, FCC, dated Oct. 16, 1998 (WorldCom Oct. 16 *ex parte*) at 2-3. We have asked non-rural carriers to provide information about the extent to which they have geocode data today. *See, e.g.*, Letter from A. Richard Metzger, Jr., FCC, to Carolyn Hill, ALLTEL, dated Mar. 24, 1998. In response to this request, a few commenters such as Aliant, Bell Atlantic, and PRTC indicate that they currently maintain little or no geocode data. Others such as Ameritech, Cincinnati Bell, GTE, and SBC indicate that they geocode from 33% to 99% of their customers. The majority of commenters indicate that their geocode success rates decrease in rural areas. In a Public Notice released on May 4, 1998, the Common Carrier Bureau sought comment more generally on issues regarding the current and future availability of geocode data. Common Carrier Bureau Requests Further Comment on the Forward-Looking Economic Cost Mechanism, *Public Notice*, DA 98-848 (rel. May 4, 1998) (*Public Notice Requesting Further Comment*) at 3-4. The responses to this public notice did not include any concrete alternative sources of geocode data.

[74] *See, e.g.,* BellSouth et al. Aug. 28, 1998 comments at A-2; GTE Aug. 28, 1998 comments at 6-7.

[75] The record in this proceeding indicates that several incumbent LEC's maintain their own geocode data and that alternative methods such as use of global positioning satellite (GPS) technology and E911 data may be viable alternatives. *See, e.g.*, BCPM Joint Sponsors *Public Notice Requesting Further Comment* comments at 3-4; SBC *Public Notice Requesting Further Comment* comments at 4-5; AT&T/MCI *Public Notice Requesting Further Comment* reply comments at 5; ITC *Public Notice Requesting Further Comment* reply comments at 3.

particular source of geocode data. The final choice of what source or sources of geocode data to use in determining customer location will be decided at the inputs phase of this proceeding.[76]

35. We also conclude that the federal mechanism should not discard geocode data in favor of surrogating below some "break point" percentage in each CB.[77] The BCPM sponsors contend that actual geocode data should be used in conjunction with surrogate data only when the percentage of customer locations in a given area for whom precise geocode data are known is above 80 percent.[78] The BCPM sponsors suggest that the combined use of actual and surrogate customer locations below this threshold will lead to clusters with "unnatural distributions."[79] The BCPM sponsors have provided no concrete evidence or statistical support for their position that significant anomalies will result from mixing actual and surrogate geocode points, nor provided adequate justification for the proposed level of the break point. We find that actual geocode data, to the extent available, provide the most reliable customer location information. BCPM has not persuaded us that geocode data should be discarded simply because the available geocode data for a given area may be limited. We therefore decline to adopt BCPM's suggestion that the model use surrogate geocode data in instances where only low percentages of actual geocode data are available.[80]

36. Surrogate Location Methodology. Where actual customer location information is unavailable, the models must use other means to identify customer locations. Each model has developed a method for determining the location of customers in the absence of geocoded customer location data.

37. In the absence of geocoded customer data, HAI distributes all "surrogate" customers uniformly around the boundaries of a CB. The HAI proponents contend that this distribution results in a conservative placement of customers because it assumes they are maximally separated from one another.[81]

38. BCPM uses CB data and a grid approach that allocates customers to micrograids

[76] For example, Ameritech has geocoded a majority of its customer locations. Ameritech has used Bellcore's Loop Engineering Information System (LEIS), which identifies the addresses of where a customer's circuits terminate and the count of each circuit type, to geocode customer locations, and recommends MapInfo's MapMarker v3.0 software for the geocoding process. Ameritech Sept. 2 comments at 6-7. According to Aliant, one database provider, BLR, has stated that it can provide at a reasonable cost household and business geocodes that are 90% accurate.

[77] *See* BCPM Aug. 28, 1998 comments at A2-A3.

[78] BCPM Joint Sponsors *Platform Public Notice* comments at A-3.

[79] BCPM Joint Sponsors *Platform Public Notice* comments at A-7.

[80] *See also* AT&T *Platform Public Notice* reply comments at 2-3; MCI *Platform Public Notice* reply comments at 3.

[81] HAI Feb. 3 submission, Model Methodology at 30.

using road network data, based on the assumption that customers are located along roads. The BCPM proponents argue that many roads lie in the interior of CBs, not just along CB boundaries, and that customer location correlates with roads. Information about the correlation between "road mileage" and "housing units" presented by the BCPM proponents for the state of Kentucky suggests that customers tend to live near roads.[82] BCPM also notes that most rights of way follow roads.[83]

39. In the absence of geocode data, HCPM locates customers based on CB-level data by assuming that customers are distributed evenly across a square grid cell with the same area as the average size of a CB in the wire center.

40. Recent comments in this docket support the use of road network to place surrogate customer locations.[84] We conclude that, in the absence of precise customer location data, BCPM's rationale of associating road networks and customer locations provides the most reasonable approach in determining customer locations.[85] We find that BCPM's assumption that customers generally live along roads is reasonable. Moreover, we find that BCPM's method of associating customers with the distribution of roads is more likely to correlate to actual customer locations than uniformly distributing customers throughout the CB, as HCPM proposes, or uniformly distributing customers along the CB boundary, as HAI proposes. HCPM's surrogating method, for example, would be more likely than the other two models to locate customers in uninhabitable areas such as bodies of water or national parks. As BCPM notes, HAI's surrogating method might well associate customer locations in ditches, bodies of water, or other uninhabitable areas that may constitute CB boundaries.[86] Moreover, HAI's method of placing surrogate locations along CB boundaries may result in the identification of false customer clusters, as surrogates from adjoining CBs are placed near one another along the common CB boundary.[87] In addition, we note that BCPM has taken steps to identify and exclude certain types of roads or

[82] For example, the BCPM proponents state that approximately 37% of all roads in Kentucky are in the interior of CBs. The BCPM proponents contend that, in Kentucky, the correlation between the road mileage and the housing units in a CB is as low as 78%, in density ranges with less than five customers, and as high as 93%, in density ranges with between 20 and 200 customers. BCPM Jan. 9 *ex parte*, Review of the Hatfield Customer Location Approach at 2.

[83] Letter from Glen Brown, US West, to Magalie Roman Salas, FCC, dated March 3, 1998 (US West March 3 *ex parte*) at 2-3.

[84] *See, e.g.*, Bell Atlantic Aug. 28, 1998 comments at 3; GTE Aug. 28, 1998 comments at 5-6.

[85] *See, e.g.*, AT&T Aug. 28, 1998 comments at 3; Bell Atlantic Aug. 28, 1998 comments at 3; GTE Aug. 28, 1998 comments at 5-6.

[86] BCPM Jan. 30 *ex parte* at 7.

[87] *See* Bell Atlantic *Platform Public Notice* comments at 4; Ben Johnson Assoc. *Platform Public Notice* comments at 5. *See infra* section III.B.2. for a discussion of grouping customers into serving areas based on natural customer clustering patterns.

road segments that are unlikely to be associated with customer locations.[88] We also note that the proponents of HAI have recently proposed a road surrogate methodology premised on the rationale that customers locations correspond to roads.[89] Therefore, we adopt BCPM's proposal to use road network information as the basis for locating within a CB boundary customers whose precise locations are unknown.

41. We adopt BCPM's set of guidelines for excluding from the surrogating process the types of roads and road segments (such as interstate highways, bridges, and on- and off-ramps) that are unlikely to be associated with customer locations. Beyond these conclusions, we do not select a particular algorithm in this Order for placing surrogate points along roads. We conclude that the selection of a precise algorithm for placing road surrogates pursuant to these conclusions should be conducted in the inputs stage of this proceeding as part of the process of selecting a geocode data set for the federal mechanism.

2. Algorithms employed to group customers into serving areas

42. Once customer locations have been identified, each model must determine how to group and serve those customers in an efficient and technologically reasonable manner. A model will most fully comply with the criteria in the *Universal Service Order* if it uses customer location information to the full extent possible in determining how to serve multiple customers using a single set of electronics. Moreover, the model should strive to group customers in a manner that will allow efficient service. As discussed below, we conclude that a clustering approach, as first proposed by HAI in this proceeding, is superior to a grid-based methodology in modeling customer serving areas accurately and efficiently. In addition, we conclude that the federal high cost mechanism should use the HCPM clustering module.

43. The model proponents have identified two methods -- clustering and gridding --for grouping customers into serving areas. HAI identifies groups of customers based on their proximity to one another to create "clusters" of customers.[90] HAI defines a "serving area" as a main cluster and those outlier clusters in close proximity. BCPM determines serving areas by means of a multi-step process that begins by placing grids over a map of CBs that make up a wire center.[91] Once the grids are populated with customer location data, serving areas are determined based on technological limitations such as the number of lines that can be served from a single

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[88] BCPM Dec. 11 submission, Model Methodology at 26 n.18. For example, road data in BCPM 3.0 exclude road segments such as tunnels or underpasses, highway access ramps, and alleys for service vehicles.

[89] *See* Letter from Michael Lieberman, AT&T, to Magalie Roman Salas, FCC, dated March 2, 1998 (AT&T March 2 *ex parte*).

[90] Clusters that contain five or more lines are defined as "main clusters," and clusters with one to four lines are "outlier clusters." While the HAI documentation generally refers to the number of "customer locations" to define whether a cluster is a main or an outlier cluster, the model actually determines the type of cluster based on the number of lines. HAI Dec. 11 submission, Model Description at n.8 and 27-29.

[91] *See* Appendix A for more detail.

DLC. Although it originally proposed a gridding approach, HCPM subsequently developed a clustering algorithm.[92]

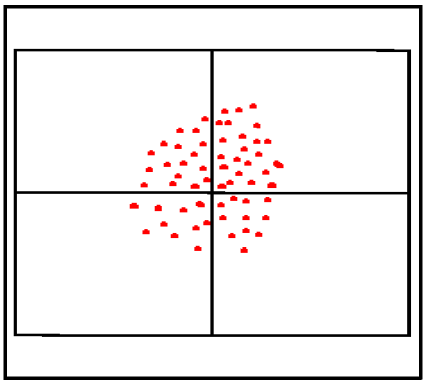
44. To meet the *Universal Service Order's* criteria, a clustering algorithm should group customer locations into serving areas in an efficient manner to minimize costs while maintaining a specified level of network performance quality.[93] This is consistent with actual, efficient network design. In other words, an efficient service provider would design its network using the most efficient method of grouping customers, in order to minimize costs.

45. The advantage of the clustering approach to creating serving areas is that it can identify natural groupings of customers. That is, because clustering does not impose arbitrary serving area boundaries, customers that are located near each other, or that it makes sense from a technological perspective to serve together, may be served by the same facilities. There are two main engineering constraints that must be accounted for in any clustering approach to grouping customers in service areas. Clustering algorithms attempt to group customers on the basis of both a distance constraint, so that no customer is farther from a DLC than is permitted by the maximum distance over which the supported services can be provided on copper wire, and on the basis of the maximum number of customers in a serving area, which depends on the maximum number of lines that can be connected to a DLC remote terminal.

46. In contrast, the chief advantage of the gridding approach is its simplicity. Placing a uniform grid over a populated area, and concluding that any customers that fall within a given grid cell will be served together, is simpler to program than an algorithm that identifies natural groupings of customers. The simplicity of the grid-based approach, however, can generate significant artificial costs. Because a simple grid cannot account for actual groupings of customers, grid boundaries may cut across natural population clusters. Serving areas based on grids may therefore require separate facilities to serve customers that are in close proximity, but that happen to fall in different grids. The worst-case scenario would involve a natural cluster of customers that, given distance and engineering constraints, could be served as a single serving area but that happened to be centered over the intersection of a set of grid lines, as shown below.

[92] C.A. Bush, et al., *The Hybrid Cost Proxy Model Customer Location and Loop Design Modules*, July 1, 1998 (HCPM July 1 Report) at 5.

[93] *Universal Service Order*, 12 FCC Rcd at 8913-15, para. 250 (model must assume least-cost, most-efficient, and reasonable technology for providing the supported services; model's loop design should not impede the provision of advanced services).



This would result in the division of the natural population cluster into four serving areas instead of one. As a result, a gridding approach cannot reflect the most cost-effective method of distributing customers into serving areas. In order best to meet the *Universal Service Order's* criteria, we conclude that the federal mechanism should use a clustering methodology, rather than a grid-based methodology, to determine serving areas.

47. Having determined that a clustering approach should be used, we must determine which clustering approach to adopt for use in the federal mechanism. Two types of clustering algorithms have been proposed in this proceeding, agglomerative and divisive.[94] The HAI clustering algorithm is a "nearest neighbor" algorithm, a type of agglomerative approach, which forms clusters by joining customer locations to the nearest adjacent location in a sequential fashion. The HCPM sponsors have developed a divisive algorithm that they describe as tending " to create the smallest number of clusters and is also by far the most efficient algorithm in terms of computer run-time."[95]

48. The agglomerative approaches to clustering, including the HAI nearest neighbor algorithm, work as follows. Initially, each location constitutes its own individual cluster. This initial state is modified by merging the two closest clusters together, reducing the total number of clusters by one. This modification is repeated until merging is no longer feasible from an engineering standpoint. In the HAI nearest-neighbor algorithm, distance is measured from the two customer locations that are closest together. The HAI nearest-neighbor method contains an additional constraint that no customer locations are joined if the distance between them is more than two miles.

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[94] Statisticians have studied a wide variety of clustering methods. *See generally* Brian S. Everitt, *Cluster Analysis* (Arnold: London, 3rd ed. 1993).

[95] HCPM July 1 Report at 6.

49. In the divisive approach advocated by HCPM, all customer locations initially are grouped in a single cluster. If one or more engineering constraints are violated, the original cluster is divided into a new "parent" cluster and a "child" cluster. Customer locations are added to the child cluster until it is full, i.e., until no more locations can be added without violating the line count and maximum distance constraints. This process continues until the original cluster has been subdivided into a set of clusters that conform to the line count and maximum distance constraints.

50. The clustering module developed by the HCPM sponsors includes several optimization routines that seek to lower the cost of constructing distribution areas by reassigning certain customer locations to different clusters. One routine, called "simple reassignment," reassigns a customer location to a different cluster if the location is closer to that cluster's center. The routine operates sequentially, taking account of both the maximum distance and line count constraints. After the reassignment, cluster centers are re-computed and the routine is repeated. The process continues until no more reassignments can be made. The second routine, called "full optimization," considers customer locations one by one. It measures the effect each customer location has on the location of cluster centers, and moves a location from one cluster to another if the total distance from all customer locations to their cluster centers is reduced. The routine moves the customer location that gives the most distance reduction at each step. It continues until no more distance reduction is possible.

51. While some commenters express concern that the HCPM clustering algorithm has not undergone extensive review, most agree that the HCPM clustering algorithm introduces innovations and improvements over previous models.[96] For example, Bell Atlantic notes that HCPM's ability to limit redistribution of customers from their geocoded locations by assigning them to small microgrids is a substantial improvement over the approaches of HAI and BCPM.[97] GTE contends that the HCPM clustering algorithm is a significant improvement over the HAI clustering approach.[98]

52. While we are cognizant of the concern expressed by commenters that the HCPM clustering algorithm has been available for review for a more limited time than the HAI clustering algorithm, we note that the HCPM clustering algorithm and test data have been made available for public comment.[99] Commission staff have met with and discussed issues relating to HCPM with the model sponsors and interested parties.[100] The BCPM sponsors have performed an initial

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[96] *See* AT&T *Platform Public Notice* comments at 5; Bell Atlantic *Platform Public Notice* comments at 2; GTE *Platform Public Notice* comments at 17.

[97] Bell Atlantic *Platform Public Notice* comments at 2.

[98] GTE *Platform Public Notice* comments at 17.

[99] *See* HCPM July 1 Report.

[100] *See, e.g.,* Ameritech Sept. 18, 1998 *ex parte* meeting; BCPM sponsors Sept. 3, 1998 *ex parte* meeting; GTE Sept. 17, 1998 *ex parte* meeting; HAI sponsors Sept. 16, 1998 *ex parte* meeting.

analysis of the HCPM clustering algorithm and while they suggest certain improvements to the HCPM clustering algorithm, no major flaw has been identified.[101] Moreover, we observe that clustering algorithms, including in particular the divisive algorithm that HCPM employs, are a generally accepted and thoroughly tested part of statistical theory.[102]

53. We find that the HCPM clustering algorithm provides the least-cost, most-efficient method of grouping customers into serving areas. The HCPM clustering algorithm tends to create the smallest number of clusters and is more efficient in terms of computer run-time.[103] The divisive algorithm has greater ability to minimize costs while conforming to technological constraints and network quality standards. By considering at all times the most efficient assignment of a customer to a particular cluster, HCPM's divisive clustering algorithm ensures that customers will be served at the least cost possible. In establishing the least-cost, most-efficient method of grouping customers into serving areas, we note that fixed costs (i.e., those that do not vary with the number of lines) associated with DLC terminal devices in serving areas militate in favor of selecting an algorithm that generates a small number of large clusters rather than a larger number of small clusters. On the other hand, with a small number of clusters, the average distance of a customer from a central point of a cluster, and consequently the variable costs associated with cable and structures, tends to be greater than it would be if there were more clusters. In low-density rural areas, it is likely that fixed costs will be the most significant cost driver. Consequently, a clustering algorithm such as HCPM's that generates the smallest number of clusters should provide the least-cost, most-efficient method of determining customer serving areas in rural areas. In addition, a practical advantage of the divisive algorithm is that it runs in a small fraction of the time required for the agglomerative approaches. Hence it is more compatible with the criterion that the model platform be available for review.[104] Therefore, we conclude that HCPM's clustering algorithm is superior to alternative algorithms designed to group customers into serving areas and adopt it for use in the federal mechanism.

3. Outside plant design

54. In designing outside plant, a model will most fully comply with the *Universal Service Order's* criteria if it designs a network that reflects as accurately as possible the available data on customer locations, adheres to sound engineering and forward-looking, cost-minimizing principles, and does not impede the provision of advanced services. We conclude that HCPM's outside plant design algorithms best meet the criteria developed in the *Universal Service Order*, including the requirement that the technology assumed in the model is the "least-cost, most-

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[101] Letter from Whit Jordan, BellSouth, to Magalie Roman Salas, FCC, dated September 2, 1998.

[102] *See generally* Brian S. Everitt, *Cluster Analysis* (Arnold: London, 3d ed. 1993). *See also* J.C. and G.J.S. Ross, "Minimum Spanning Trees and Single Linkage Cluster Analysis," 18 Applied Statistics 54-64 (1969) (observing the close connection between clustering theory and traditional operations research problems involving shortest path problems).

[103] HCPM July 1 Report.

[104] *Universal Service Order*, 12 FCC Rcd at 8915.

efficient, and reasonable technology for providing the supported services."[105] We therefore conclude that the federal mechanism should incorporate HCPM's outside plant design algorithm.

a. Designing plant to customer locations

55. We first consider the manner in which each of the models designs outside plant once customer location and serving areas have been identified. After selecting a model that determines customer locations as accurately as possible and identifies efficient serving areas, it is important that the model design a network that takes the greatest advantage of that information. Thus, the model's method of designing outside plant should provide the best estimation of the design of outside plant to customer locations.

56. The HCPM loop design modules build loop plant directly to individual microgrids in which customers are located. The microgrids that HCPM is able to design closely reflect the underlying customer locations.[106] If an accurate source of geocoded customer locations is used, the model is capable of building plant directly to every customer location with an error of no more than a few hundred feet for any individual customer.[107]

57. By contrast, HAI and BCPM design outside plant by modifying the distribution areas so that they have square or rectangular dimensions and relocating customers so that they are distributed uniformly within the distribution area. In doing so, HAI and BCPM discard or distort customer location data. For example, although BCPM initially locates customers based on road network information, these customers are subsequently relocated into a square distribution area that is smaller than the quadrant in which the road network containing these customers is located.[108] HAI's approach of designing plant to simplified customer locations within rectangularized serving areas, instead of to actual customer locations, could result in a systematic underestimation of outside plant costs. Sprint has observed that HAI's simplification of actual clusters to rectangles can result in an underestimation of plant costs. Sprint has shown that, under certain circumstances, HAI's conversion of actual clusters into rectangular distribution areas results in a shorter maximum cable length -- and thus a lower cost of service -- within the

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[105] *Universal Service Order*, 12 FCC Rcd at 8913, para. 250.

[106] In the version of HCPM released most recently, the default for the microgrids was set at 360 square feet, but the size of the microgrids is user-adjustable. *See* C.A. Bush et al., *The Hybrid Cost Proxy Model Customer Location and Loop Design Modules*, July 1, 1998 at 3. *See also* HCPM June 1 Report at 3.

[107] HCPM June 1 Report at 3.

[108] BCPM determines the amount of road network in each microgrid based on topographically integrated geographic encoding and referencing files (TIGER) from the U.S. Census Bureau. BCPM then allocates customers to microgrids based on the relative proportions or roads in the microgrids. BCPM divides the serving area grids into four quadrants. Each serving area grid, and each quadrant in a serving area grid, is made up of microgrids. The point where the quadrants meet is the microgrid corner that is closest to the road centroid of the grid. BCPM uses the microgrids' road network data to create distribution areas within each quadrant that contains roads. BCPM uses the microgrids' customer data to identify the number of customers in the quadrant that should be placed in the quadrant's distribution area.

rectangularized cluster than in the actual, underlying cluster.[109] Commission staff analysis has also revealed that HAI's approach to distributing customers evenly within its rectangularized serving areas can also result in a systematic underestimation in less dense areas when compared to the cost of constructing plant to serve the underlying customer locations within the clusters.[110] BCPM's approach of designing plant to square customer serving areas that are significantly smaller than the areas over which the customers are actually distributed is likely to have similar infirmities.

58. The HAI model also sacrifices accuracy by assuming that customers are dispersed uniformly within its distribution areas. As a result, the boundaries of HAI's distribution areas are unlikely to correlate exactly with the boundaries of the clusters, so some customers located inside a cluster may be shifted beyond the boundaries of that cluster.[111] Commenters have criticized this "squaring up" of cluster areas to create distribution areas,[112] as well as the assumption that customers are uniformly distributed throughout the distribution area. We agree that inaccuracies may be introduced by modifying the geographical boundaries of distribution areas and the location of customers within those areas for purposes of constructing outside plant.

59. The models also have other elements that help ensure that an adequate amount of plant is constructed. For example, all three models categorize the terrain where plant is being built based on factors that affect the difficulty of building plant, such as soil type, depth to bedrock, and slope. HAI uses multipliers to reflect increased costs in areas with difficult terrain. BCPM uses separate structure cost tables for each of three terrain categories to reflect higher cost in more difficult areas. HCPM incorporates BCPM's approach. We find that the federal model should account for terrain factors in determining structure costs. For the reasons stated elsewhere in this Order, we conclude that the federal platform should employ HCPM's outside plant algorithms, which take terrain factors into account in determining the cost of outside plant.

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[109] Letter from Pete Sywenki, Sprint, to Magalie Roman Salas, FCC, dated April 17, 1997 (Sprint April 17 ex parte). After this problem was identified, HAI proposed modifications to their algorithms that they contended would resolve this problem. *See* Letter from Chris Frentrup, MCI, to Magalie Roman Salas, FCC, dated April 23, 1998 (MCI April 23 *ex parte*); Letter from Richard Clarke, AT&T, to Magalie Roman Salas, FCC, dated May 5, 1998 (AT&T May 5 *ex parte*) at 2.

[110] *See* Memorandum from Jeffrey Prisbrey, FCC, to Magalie Roman Salas, FCC, CC Docket Nos. 96-45 and 97-160 (filed May 13, 1998).

[111] HAI retains the geocode data to build distribution plant to, and within, outlier clusters, however. In an outlier cluster, HAI generally assumes that customers' lots fall in a straight line along a "road." The two customers located farthest from one another are linked by cable (or "primary subscriber road cable"). Customers within one drop length of the primary cable are served by drop wire off of the primary cable. Customers further than one drop length from the primary cable are served by secondary subscriber road cable that connects to the primary cable. Road cable from the nearest main cluster runs to the middle of the primary cable. HAI Feb. 13 *ex parte* at att. 2. HAI will therefore build the cable within an outlier cluster and the cable that runs between clusters more accurately if customer locations are identified more accurately with geocode data.

[112] HAI actually creates rectangular distribution areas, while BCPM creates square distribution areas.

60. Thus, both BCPM and HAI, by relocating customers so as to distribute them uniformly in square or rectangular distribution areas, create an apparent systematic downward bias in the required amount of distribution plant that is constructed in less dense areas. In contrast, HCPM's outside plant design algorithm is capable of designing plant directly to, or very nearly to, precise customer locations and thus should generate estimates of distribution plant that are sufficient to reach actual customer locations. HCPM therefore has a significant advantage in estimating sufficient outside plant over HAI and BCPM in its ability to avoid the distortions associated with adjusting customer locations to establish square or rectangular distribution areas. This is particularly important for ensuring that the federal mechanism estimates the cost of a sufficient amount of plant. By designing plant to serve actual customer locations instead of simplified representations of customer locations, HCPM is substantially more likely to estimate the correct amount of plant necessary for providing the supported services. As a result, HCPM's outside plant cost estimates are likely to reflect more accurately the forward-looking cost of providing the supported services and thus comport more fully with the *Universal Service Order*'s criteria.[113]

b. Cost minimization principles

61. We conclude that the outside plant module should be able to perform optimization routines through the use of sound network engineering design to use the most cost-effective forward-looking technology under a variety of circumstances, such as varying terrain and density.[114] Each of the three model proponents has made some effort to consider alternative plant designs and select the most economical approach, or to place limits on investment in certain circumstances in order to control costs. The ability of a model to perform optimization routines is a significant factor in its ability to estimate the least-cost, most-efficient technology under a variety of conditions, as the first criterion in the *Universal Service Order* requires.[115] For example, assuming that the price of fiber cable or DLC electronics continues to drop, an optimizing model might shift the mix of fiber and analog copper towards fiber and away from copper.

62. HAI and BCPM have made efforts to incorporate cost minimization principles into their respective approaches. Both models permit main feeder routes to be angled towards areas of population concentration in order to reduce feeder costs. BCPM also economizes the cost of DLC equipment in the central office by connecting multiple DLC remote terminals with a single central office terminal where possible, and limits distribution investment by limiting total distribution plant within a distribution area to the total road distance in the area. In HAI, for feeder plant that is less than 9,000 feet in length, the model chooses between fiber or copper cable

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[113] *See Universal Service Order*, 12 FCC Rcd at 8913, para. 250, criterion 1 (a model's average loop length should reflect those of the incumbent carrier).

[114] HCPM user documentation at 2. *See Universal Service Order,* 12 FCC Rcd at 8913, para. 250.

[115] To the extent that a model does not explore different loop architectures and select the least-cost alternative, the Bureau recommended that model proponents explain and justify the model's assumptions and engineering rules of thumb. *See Customer Location and Outside Plant Public Notice* at section II.A.

technologies based on life-cycle cost minimization. In determining plant mix, HAI also can choose between aerial and buried plant based in part on the alternative with the lower life-cycle cost.[116] We have concerns, however, that the effectiveness of these cost minimization principles are tempered by their practicality in actual use. For example, the angling of feeder routes toward population centers without regard to considerations such as rights of way may lead to significantly lower cost estimates than are practicable in reality. More importantly, however, neither HAI nor BCPM would recompute the type of technology deployed in response to a change in relative input prices, a key feature of ensuring that costs are minimized, subject to technological and service quality constraints.

63. In contrast, HCPM selects the optimal type, number, and placement of DLCs, which are sized based on the number of lines served. For example, in a distribution area with 400 lines, HCPM would determine, based on input values for equipment prices, whether it is more economical to place one DLC with a maximum capacity of 500 lines or two DLCs each with a maximum capacity of 250 lines. HCPM also considers the relative costs of placing various feeder technologies (fiber or T-1 on copper) and selects the most economical technology. HCPM further selects the lowest relative cost of different feeder routings.

64. HCPM uses an algorithm developed for network planning purposes in both its feeder and distribution segments. This algorithm selects a feeder or distribution routing network by weighing the relative benefits of minimizing total route distance (and therefore structure costs) and minimizing total cable distance (and therefore cable investment and maintenance costs.) HCPM also selects technologies (e.g., fiber vs. copper, aerial vs. buried) on the basis of annual cost factors that account for both operating expenses and capital expenses over the expected life of the technology.[117]

65. In reviewing the current models, we conclude that HCPM's explicit optimization routines are superior to those in BCPM and HAI. In addition, because the platform that we adopt for the federal mechanism may be in place for a significant time period during which relative costs may change, the impact of optimization may increase in importance over time.

66. We do not agree, as some parties have argued, that the models' outside plant design parameters should be verified by comparing the design of the model networks in specific locations to the design of incumbent LECs' existing plant in those locations in all cases.[118] While

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[116] The benefit of the optimization of plant mix may be constrained by particular zoning requirements, however. We contemplate future modifications of the outside plant module and will consider this issue at that time.

[117] While the optimization routines in previous versions of HCPM considered only first-installed costs, HCPM 2.5 allows optimization based on lifecycle costs. The user must provide lifecycle costs for HCPM to perform the relevant optimization routines, however, because HCPM does not contain an expense module that would calculate maintenance costs. HCPM Feb. 6 submission; *see also infra* App. A.

[118] *See, e.g.,* Ameritech outside plant comments at 2-4; GTE outside plant comments at 2-3; Bell Atlantic outside plant comments at 6.

we recognize that certain factors such as terrain, road networks, and customer locations are fixed, the design of the existing networks under these conditions may not represent the least-cost, most-efficient design in some cases. The Commission, in the *Universal Service Order*, adopted the Joint Board's recommendation that universal service support should be based on forward-looking economic costs. Existing incumbent LEC plant is not likely to reflect forward-looking technology or design choices.[119] Instead, incumbent LECs' existing plant will tend to reflect choices made at a time when different technology options existed or when the relative cost of equipment to labor may have been different than it is today. Incumbent LECs' existing plant also was designed and built in a monopoly environment, and therefore may not reflect the economic choices faced by an efficient provider in a competitive market.[120] Although we do not believe that a forward-looking platform can meaningfully be verified by comparing its network to an embedded network, we note that the platform is only one of many considerations used to set actual levels of support.

c. Service Quality

67. The *Universal Service Order*'s first criterion specifies that a model should not "impede the provision of advanced services."[121] In the *Universal Service Order*, the Commission disallowed a model's use of loading coils because their use may impede high-speed data transmission.[122] During the model development process, the Bureau recommended that model proponents "demonstrate how their models permit standard customer premises equipment (CPE) available to consumers today, such as 28.8 Kbps or 56 Kbps modems, to perform at speeds at least as fast as the same CPE can perform on the typical existing network of a non-rural carrier."[123] The BCPM proponents propose that testing a model network's capability to support data transmission over a 28.8 Kbps modem is a "conservative approach" to identifying whether a model may impede advanced services because network access at 28.8 Kbps is "widely available today in urban areas" and "modem speeds of 33.6 Kbps and even 56 Kbps are becoming more and more common."[124] We agree that a reasonable standard for ensuring that a model's network does not impede the provision of advanced services would ensure the reasonable performance of 28.8 Kbps modems. We find that proponents of the BCPM, HAI, and HCPM have demonstrated that their models allow 28.8 modems to work at reasonable rates, which will permit all customers to have access to high-speed data transmission.

4. Maximum Copper Loop Length

[119] *See* AT&T outside plant comments at 5.

[120] *See Universal Service Order*, 12 FCC Rcd at 8899, para. 224.

[121] *Universal Service Order*, 12 FCC Rcd at 8913, para. 250, criterion one.

[122] *Id.*

[123] *Outside Plant Public Notice* at section II.B.

[124] BCPM Dec. 11 submission, BCPM3 Designs the Most Efficient Proxy Network at 2.

68. We now turn to the issue of the maximum loop length that the federal mechanism should permit. We note that, in making this determination, we must examine whether the models use the least-cost, most efficient, and reasonable technology while not impeding the provision of advanced services.[125] HAI and BCPM proponents disagree on the maximum loop length over which a copper loop will carry a signal of appropriate quality, without the use of expensive electronics. The HCPM sponsors state that an 18,000 foot copper loop is capable of meeting current Bellcore standards, but they otherwise take no position on the appropriate length of copper loops.[126] The maximum copper loop length will affect the model's cost estimates because a longer loop length will permit more customers to be served from a single DLC. As noted above, reducing the number of DLCs tends to reduce the overall cost. In the models, the "fiber-copper cross-over point" determines when carriers will use fiber cable instead of copper cable.[127] BCPM asserts that Bell Labs standards call for loops not to exceed 12,000 feet.[128] The proponents of BCPM further assert that copper loops longer than 13,600 feet will require the use of an expensive extended-range line card in the DLC to provide advanced services, the additional cost of which will outweigh the cost savings from using longer loops. Taking into consideration loading and resistance, the BCPM default provides that loop lengths that exceed 12,000 feet will be fiber cables.[129] HAI contends that copper lengths may extend to 18,000 feet using only a slightly more expensive line card in the DLC.

69. The Commission sought comment on this issue in the *Further Notice* and a *Public Notice Requesting Further Comment*.[130] A few commenters contend that use of the HAI standard would impede access to advanced services and violate Carrier Serving Area (CSA) design standards.[131] The HAI proponents disagree, and contend that there is no support for the claim that a 18,000 foot cooper loop is too long to support advanced services such as ISDN and

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[125] *See Universal Service Order*, 12 FCC Rcd at 8913, para. 250.

[126] *See* HCPM documentation at 3. HCPM also allows the user to adjust the maximum copper loop length.

[127] For example, a copper/fiber crossover of 12,000 feet requires placing copper in the feeder if the maximum loop length from the wire center to all customers within the serving area is less than 12,000 feet. If the loop length for any customer exceeds 12,000 feet, fiber is placed in the feeder to serve all customers.

[128] BCPM 3.1 April 30 Model Methodology at 18, *citing Outside Plant Systems: Outside Plant Engineering Handbook*, Lucent Technologies, Bell Labs Innovations (doc. 900-200-318, Lucent 1996) at 13-1.

[129] BCPM Dec. 11 submission, Model Methodology at 40. BCPM allows the user to adjust the copper/fiber break point between 6,000 feet and 18,000 feet, given 3,000 foot increments. *See also* BCPM 3.1 submission dated April 30, 1998, Model Methodology at 18.

[130] *Further Notice*, 12 FCC Rcd at 18,548-18,552 paras. 84-89. *See also Public Notice Requesting Further Comment* at 4.

[131] *See, e.g.*, GTE *Public Notice Requesting Further Comment* reply comment at 11-13; ITC *Public Notice Requesting Further Comment* reply comment at 3-4; USTA *Public Notice Requesting Further Comment* comment at 2.

Asymmetric Digital Subscriber Line (ADSL).[132] The HAI proponents note that there are two ADSL standards, ADSL1 and ADSL2. The HAI proponents contend that no commenter alleges that the facilities modeled by HAI are unable to support ADSL1.[133] Although the HAI proponents admit that their plant design cannot support ADSL2 using a loop length of 18,000 feet, they argue that the higher speed of ADSL2 is not a component of basic service supported by universal service.

70. We conclude that the federal mechanism should assume a maximum copper loop length of 18,000 feet. The record supports the finding that a platform that uses 18,000 foot loop-lengths will support at appropriate quality levels the services eligible for universal service support.[134] Although BCPM has presented evidence that the provision of some, high-bandwidth advanced services may be impaired over 18,000-foot loops, we conclude that the BCPM sponsors have not presented credible evidence that the 18,000 foot limit will not provide service at an appropriate level, absent the use of expensive DLC line cards. We also disagree with BCPM's interpretation of the Bell Labs standards manual. The publication states, in pertinent part, that "[d]emands for sophisticated services are requiring the outside plant network to support services ranging from low-bit rate transmission to high-bit rates. To meet this demand, a digital subscriber carrier is being placed into the network starting at 12,000 feet from the serving [wire center]."[135] The document is referring to the design of digital loop carrier systems and related outside plant that will "accommodate a wide range of transmission applications including voice, data, video, sensor control, and many others."[136] This design standard seems to exceed the service quality standards for universal service. We find that the public interest would not be served by burdening the federal universal service support mechanism with the additional cost necessary to support a network that is capable of delivering very advanced services, to which only a small portion of customers currently subscribe.[137] Accordingly, we conclude that the federal mechanism should assume a maximum copper loop length of 18,000 feet.

IV. SWITCHING AND INTEROFFICE FACILITIES

A. Background

[132] ADSL is a modem technology that transforms ordinary phone lines into high-speed digital lines for Internet access.

[133] AT&T/MCI *Public Notice Requesting Further Comment* reply comments at 9.

[134] *See, e.g.,* AT&T/MCI Jan. 23, 1998 *ex parte* at 6; AT&T/MCI Jan. 5, 1998 *ex parte* at 8 (*citing Bellcore Notes on the Network*, SR-2275, December 1997 at 7-71); AT&T/MCI Dec. 23, 1997 *ex parte*; WorldCom Oct. 16, 1997 *ex parte*.

[135] *Outside Plant Systems: Outside Plant Engineering Handbook,* Lucent Technologies, Bell Labs Innovations (doc. 900-200-318, Lucent 1996) at 13-1.

[136] *Id.*

[137] *See* 47 U.S.C. § 254(c)(1)(B).

71. We now examine the switching and interoffice transport algorithms of HAI and BCPM in light of the relevant criteria identified in the *Universal Service Order*.[138]

72. In the *Universal Service Order*, the Commission found that estimating the cost of switching presented significant unresolved problems in terms of the cost models' ability to provide an associated cost for each network function.[139] In the *Further Notice*, the Commission sought comment on the issues that affect the algorithms for switching, including: whether the type of switch chosen affects cost, switch capacity constraints, and switch costs.[140] The *Switching and Transport Public Notice* established several guidelines relating to switching, the design of the interoffice network, and interoffice cost attributable to providing supported services.[141] The Bureau guidelines established that: (1) the models should permit individual switches to be identified as host, remote, or stand-alone; (2) switching investment costs should be separately estimated for host, remote, and stand-alone switches; (3) models should include switch capacity constraints; and (4) models should accommodate an interoffice network that is capable of connecting switches designated as hosts and remotes in a way that is compatible with the capabilities of equipment and technology that are available today and are consistent with current engineering practices.[142] We find that the new versions of both industry sponsored models are significant improvements over earlier versions.[143]

73. In its default mode, BCPM 3.0 generates its inputs for switch cost based on a regression of switch investment costs using Switching Cost Information System (SCIS)[144] and Switching Cost Model (SCM)[145] data. Switch costs are assumed to vary with lines, trunks,

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[138] HCPM did not contain an algorithm to estimate switching and interoffice transport prior to February 1998. The HCPM switching module that was subsequently developed was never subject to public comment and we do not consider it here.

[139] *Universal Service Order*, 12 FCC Rcd at 8909 para. 244.

[140] *Further Notice*, 12 FCC Rcd at 18,560-18,568 paras. 121-138.

[141] *Switching and Transport Public Notice* at 2-6.

[142] *Switching and Transport Public Notice* at 4-6. Switches can be designated as either host, remote, or stand-alone switches. Both a host switch and a stand-alone switch can provide a full complement of switching services without relying on another switch. A remote switch relies on a host switch to supply a complete array of switching functions and for interconnection with other switches.

[143] Detailed descriptions of the switching and interoffice transport algorithms of HAI and BCPM are provided in Appendix A.

[144] SCIS is a computerized switching cost model developed by Bellcore to establish the costs and prices of certain switch-related services in state proceedings and before the Commission.

[145] SCM is a cost model developed by US West for determining switching costs.

minutes of use and calls (BHCCS and BHCA).[146] BCPM also uses outputs from SCIS and SCM to allocate switch costs to functional categories, including the categories attributable to universal service.[147] It is also possible to supply inputs to be used in place of the SCIS- and SCM-generated input values, both for generating switch cost estimates and for allocating costs to functional categories. BCPM identifies host and remote switches by incorporating existing host-remote relationships as revealed in Bellcore's Local Exchange Routing Guide (LERG) database. BCPM also permits the substitution of a user-supplied cost curve that would not specifically identify switches as host, remote, or stand-alone.

74. The HAI switching and interoffice module computes investment for end office switching, tandem switching, signaling, and interoffice transmission facilities. HAI divides the cost of the switch into fixed costs and usage costs, and allocates all fixed costs, and a portion of usage costs, to the cost of universal service. In its default mode, HAI assumes a blended configuration of switch technologies to develop switching cost curves.[148] HAI also allows the user the option of designating, in an input table, specific wire center locations that house host, remote, and stand-alone switches. When the host-remote option is selected, switching curves that correspond to host, remote, and stand-alone switches are used to determine the appropriate switching investment. The LERG could be used to provide these inputs.

B. Discussion

75. We conclude that the federal universal service mechanism should incorporate, with certain modifications, the HAI 5.0 switching and interoffice facilities module.[149] We find that HAI's module satisfies the relevant criteria set forth in the *Universal Service Order*[150] and would be simpler to implement than BCPM's module. In our evaluation of the switching modules in this proceeding, we note that, for universal service purposes, where cost differences caused by differing loop lengths are the most significant cost factor, switching costs are less significant than they would be in, for example, a cost model to determine unbundled network element switching

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[146] For example, if the coefficient for lines is $300 and for trunks is $100 and the switch serves 1,000 lines and 100 trunks, then the switch investment for these two categories would be $300 times 1,000 lines plus $100 times 100 trunks which equals $310,000. "BHCCS" is the acronym for busy-hour hundreds of call seconds. "BHCA" is the acronym for busy-hour call attempts.

[147] BCPM identifies six "functional categories": Processor related cost; Line termination (MDF and protector); Line port cost; Line CCS usage; Trunk CCS usage; and, SS7. *See* BCPM Dec. 11 submission, Model Methodology at 57.

[148] HAI Feb. 3 submission, Model Description at 58.

[149] We note that Commission staff has developed interface software that will integrate HCPM's outside plant design module with the remainder of the HAI module, including HAI's outside plant design module. This interface has been made available to the public for review and comment. *See Platform Public Notice*. No commenters found fault with the interface. Accordingly, we conclude that this interface software should be used in the platform of the federal mechanism.

[150] *Universal Service Order*, 12 FCC Rcd at 8913-8915 para. 250.

and transport costs.

76. We find that both models meet the *Universal Service Order*'s requirement that a model assume the least-cost, most-efficient and reasonable technology to provide the supported services. Both models assume the use of modern, high-capacity digital switches, and interconnect switching facilities with state-of-the-art SONET rings. The *Further Notice* recommended that the federal mechanism should be capable of separately identifying host, remote, and stand-alone switches and of distributing the savings associated with lower-cost remote switches among all lines in a given host-remote relationship.[151] In the *Further Notice*, we requested "engineering and cost data to demonstrate the most cost-effective deployment of switches in general and host-remote switching arrangements in particular," and sought comment on "how to design an algorithm to predict this deployment pattern." No party has developed an algorithm that will determine whether a wire center should house a stand-alone, host, or remote switch. As noted above, however, both models can incorporate either a single blended cost curve that assumes a mix of host, remote, and stand-along switches, or use the LERG to assume the existing deployment of switches and host-remote relationships. In the inputs stage of this proceeding we will weigh the benefits and costs of using the LERG database to determine switch type and will consider alternative approaches by which the selected model can incorporate the efficiencies gained through the deployment of host-remote configurations.

77. Both models also permit a significant amount of flexibility to ensure the allocation of a reasonable portion of the joint and common costs of the switching and interoffice functions to the cost of providing the supported services. As discussed below, however, BCPM's allocation methodology would introduce an additional degree of complexity to the inputs stage of this proceeding that we conclude is not administratively justified in light of the potential marginal gains in accuracy. We find that HAI's switching and interoffice modules satisfy the *Universal Service Order*'s requirements to associate and allocate the costs of the network elements and functionalities necessary to provide the supported services, and do so in a less complex manner than BCPM's module, while still providing a degree of detail that is sufficient for the accurate computation of costs for federal universal service purposes.

78. We also find that HAI's switching module more fully satisfies the requirement that data, computations, and assumptions be available for review and comment. HAI's modules use a spreadsheet program that reveals all computations and formulas, allows the user to vary input costs, and provides a simple, user-adjustable allocation factor. BCPM also uses a spreadsheet program that reveals its computations and formulas, but its default costs and allocation factors are based on results from the proprietary SCIS and SCM models, and the defaults used to generate the results that BCPM uses in its modules have not been placed on the record in this

[151] *Further Notice*, 12 FCC Rcd at 18560-18561, para. 122. As noted in the *Further Notice*, incumbent LECs' depreciation filings suggest that frequent deployment of remote switches is evidence that they are often the most economical choice. *Id.*

proceeding.[152] To minimize concerns regarding BCPM's use of proprietary data, the Commission could, in the inputs stage of the proceeding, substitute other inputs in place of the SCIS and SCM results for the cost amounts and allocation factors. Because the SCIS and SCM generate such detailed results, however, the process of trying to determine input values to replace the SCIS and SCM results would inject a significant degree of complexity into the inputs phase of this proceeding. We conclude that this additional complexity in the inputs phase is not justified by potential gains in accuracy. As noted above, we find that HAI's modules compute and allocate switching and interoffice costs with a degree of accuracy that is sufficient for the computation of federal universal service costs and in a manner that more readily provides for public review.

79. We find that both models generally satisfy the requirement that each network function and element necessary to provide switching and interoffice transport is associated with a particular cost, though HAI satisfies the criterion more thoroughly than BCPM. AT&T contends that the BCPM 3.0 signaling network calculations indicate no explicit modeling of signaling costs.[153] In BCPM, signaling costs used to develop per-line investments are provided through a user input table that its proponents assert reflects the cost of building a modern SS7 network.[154] The signaling cost for a wire center is based on a weighted average of residence and business lines associated with that wire center.[155] Users have the option of using the provided default values or entering their own values.[156] In contrast to HAI, which explicitly models the cost of signaling, BCPM 3.0 simply adds on a signaling cost to the cost of switching based upon an input table of costs.[157] Although this technically satisfies the criterion that any network function or element necessary to produce supported services must have an associated cost, we find that it is not likely to produce results that are as accurate as an estimate obtained through the explicit cost estimation used in HAI. The HAI 5.0 Switching and Interoffice Module computes signaling link investment to end office or tandem links between segments connecting different networks. HAI always equips at least two signaling links per switch and computes the required SS7 message traffic according to call type and traffic assumptions.[158] We therefore conclude that HAI employs a more reliable method of assigning an associated cost to the network functions or elements, such as switching and signaling, that are necessary to produce supported services.

[152] On September 21, 1998, the BCPM sponsors offered to make the SCIS and SCM models available for inspection by interested parties pursuant to protective order. Sprint Sept. 21, 1998, *ex parte*. The BCPM sponsors did not, however, propose to make available the company-specific inputs that they used to generate the input values used in BCPM.

[153] AT&T Jan. 6 *ex parte* at 22.

[154] BCPM Dec. 11 submission, Model Methodology at 76.

[155] BCPM Dec. 11 submission, Model Methodology at 76.

[156] BCPM Dec. 11 submission, Model Methodology at 76.

[157] BCPM Dec. 11 submission, Model Methodology at 76.

[158] HAI Dec. 11 submission, Model Description at 57.

80. Thus, although we conclude that either model's switching and interoffice modules could be used to adequately model universal service costs for these functionalities, we conclude that the federal mechanism should incorporate the HAI modules. Moreover, parties recently have identified certain aspects of HAI's interoffice module with respect to which the progress of state proceedings has shown a need for minor changes in the model's coding. These changes were identified too late in the proceeding to be included in this Order. Because general agreement exists among the parties as to the need to make them, however, we delegate to the Common Carrier Bureau the authority to make these changes.[159]

V. EXPENSES AND GENERAL SUPPORT FACILITIES

81. We now consider the algorithms of HAI and BCPM for calculating expenses and general support facilities (GSF) costs in light of the criteria identified in the *Universal Service Order*. The most relevant of the criteria to expense and GSF issues is the ninth, which requires that the models make a reasonable allocation of joint and common costs. With this criterion, the Commission intended to "ensure that the forward-looking economic cost [calculated by the federal mechanism] does not include an unreasonable share of the joint and common costs for non-supported services."[160] Therefore, the platform of the federal mechanism must permit the reasonable allocation of joint and common costs for such non-network related costs as GSF, corporate overhead, and customer operations. In addition, the criterion requires that "[t]he cost study or model must include the capability to examine and modify the critical assumptions and engineering principles."[161] Therefore, it is important that the platform's method of calculating expenses and GSF costs must be sufficiently flexible. It is also important that we select model components that are compatible with one another to compute cost estimates in a reasonable time. In light of these considerations, we conclude that the platform for the federal mechanism should consist of HAI's algorithm for calculating expenses and GSF costs, as modified to provide some additional flexibility in calculating expenses offered by BCPM.

A. Background

82. Both HAI and BCPM include modules that compute the costs of expenses and GSF. GSF costs include the investment and expenses related to vehicles, land, buildings, and general purpose computers. Other expenses (that are not associated with GSF) include: plant specific expenses, such as maintenance of facilities and equipment expenses; plant non-specific expenses, such as engineering, network operations, and power expenses; customer services expenses, such as marketing, billing, and directory listing expenses; and corporate operations expenses, such as administration, human resources, legal, and accounting expenses.

[159] *See also supra* para. 13.

[160] *Universal Service Order*, 12 FCC Rcd at 8915 para. 250, criterion 7. This criterion requires that "[a] reasonable allocation of joint and common costs must be assigned to the cost of supported services." *Id*.

[161] *Universal Service Order*, 12 FCC Rcd at 8915, para. 250.

83. In the *Further Notice*, the Commission sought comment on the appropriate assumptions that should be used in the platform design to compute the forward-looking GSF investment and expenses attributable to the cost of providing the supported services.[162] The Commission also sought comment on how to remove costs for nonregulated activities from costs for regulated activities in order to incorporate the appropriate amount of GSF investment and expenses in an estimate of the costs of providing the supported services.[163] The Commission tentatively concluded that GSF expenses should vary by state with respect to land values because a large share of GSF expenses is attributable to the cost of land.

84. In the *Further Notice*, the Commission also sought comment on how to establish forward-looking expenses in the selected federal mechanism.[164] The Commission specifically sought comment on which expenses should be calculated on a per-line basis and which should be calculated as a percentage of investment. The Commission also sought comment on whether there are measures other than lines and investment to which specific expenses should be tied.[165] With respect to plant specific expenses, the Commission sought comment on whether maintenance expense estimates should depend upon plant mix and, in particular, whether an increase in the use of aerial cable also increases maintenance expenses, and whether plant specific expenses should vary with such characteristics as climate or soil type.[166] In addition, the Commission asked commenters to identify the complete set of forward-looking expenses for which universal service support should be available.[167]

85. The prior version of BCPM (BCPM 1.1) estimated expenses on a per-line basis and the prior version of HAI (HAI 3.1) calculated expenses as a percentage of investment. In the *Further Notice*, the Commission tentatively concluded that the selected mechanism should provide the user with the ability to calculate each category of expense based either on line count

[162] *Further Notice*, 12 FCC Rcd at 18569, para. 148.

[163] *Further Notice*, 12 FCC Rcd at 18569, para. 148. We found in our *Access Charge Reform Order* that the previous allocation of GSF costs enables incumbent LECs to recover through interstate access charges costs associated with the incumbent LECs' nonregulated billing and collection functions and tentatively concluded that such costs should not be recovered through regulated access charges. *Access Charge Reform Order* at para. 411. We subsequently adopted changes to out Part 69 cost allocation rules for price cap LECs to require reductions in those carriers' price cap indices to ensure that regulated access rates do not recover GSF costs related to nonregulated billing and collection services. Access Charge Reform, Transport Rate Structure and Pricing, CC Docket No. 96-262, 91-213, *Third Report and Order* (rel. Nov. 26, 1997). In the *Further Notice,* we similarly noted that universal service support should only provide for the regulated costs of local exchange service. *Further Notice* at para. 145.

[164] *Further Notice*, 12 FCC Rcd at 18572 -18573, para. 157.

[165] *Further Notice*, 12 FCC Rcd at 18572, 18574-18577, paras. 157, 162, 165, 168, 171.

[166] *Further Notice*, 12 FCC Rcd at 18574, para. 162.

[167] *Further Notice*, 12 FCC Rcd at 18574-18577, paras. 162, 165, 168, 171.

or on other investment, at the user's election.[168] The Commission also tentatively concluded that users should be able to use different expense estimates for small, medium, and large companies, as BCPM allows.[169]

86. The new versions of both models are more flexible than earlier versions because they provide alternative means of calculating expenses.[170] BCPM's Operating Expenses Module permits users to estimate operating expenses as either a per-line amount or as a percentage of investment. HAI allows users to assign some categories of expenses (general support, network operations, and variable overheads) on a per-line basis.[171] HAI also has added a worksheet that breaks out investments and expenses by Part 32 accounts for comparison purposes. Unlike BCPM, however, HAI does not allow users to calculate expenses for each Part 32 account category. Marketing expenses, for example, are excluded in calculating customer operations expenses.

B. Discussion

87. Although we sought comment on alternative measures for estimating forward-looking GSF investment and other expenses, most commenters only address which expenses should be calculated on a per-line basis and which expenses should be calculated as a percentage of investment.[172] We agree that the majority of expenses can be estimated accurately on the basis of either lines or investment. Other commenters argue, however, that GSF investment and other expenses should be based on ARMIS data for individual companies to ensure accuracy.[173] GTE argues that, without empirical evidence, neither calculating expenses on a per-line nor a per-investment basis is entirely satisfactory.[174] GTE proposes a time-series forecasting model, which

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[168] *Further Notice*, 12 FCC Rcd at 18572-18573, para. 157.

[169] *Further Notice*, 12 FCC Rcd at 18572-18573, para. 157.

[170] Detailed descriptions of the customer location and outside plant modules of HAI, BCPM, and HCPM are provided in Appendix A.

[171] HAI 5.0a still calculates estimated expenses in these categories, however, according to the assumptions in the model, but the user can vary the proportion of total expenses that are assigned to loop network elements (i.e., network interface device, distribution, concentration, and feeder) based either on relative number of lines or on the relative amount of investment. At the request of Commission staff, HAI proponents subsequently modified their model so that expenses could be calculated on either a per-line amount or as a percentage of investment. *See* Letter from Chris Frentrup, MCI\WorldCom, to Magalie Roman Salas, FCC, dated September 15, 1998.

[172] *See, e.g.,* AT&T/MCI comments at 24-31; Florida PSC comments at 3-7.

[173] GTE comments at 37-38; Puerto Rico Telephone Company comments at 4-5.

[174] GTE comments at 41-46. Bell Atlantic argues that any proxy model that applies existing ratios to a new, hypothetical network will tend to produce inaccurate results simply because no one has attempted to budget the personnel and facilities needed to support such a network. Bell Atlantic comments, attachment at 5-6.

it attaches to its comments.[175] While we find that most expenses can be estimated accurately based on either number of lines or investment, we agree that neither investment ratios nor per-line calculations may be entirely satisfactory for estimating the forward-looking costs of certain expenses. Further, we observe that many of the input questions regarding how best to calculate expenses will be resolved in the input selection stage of this proceeding, and find that the platform of the federal mechanism must be sufficiently flexible to allow for the correct resolution of these issues.[176] In this way, we can best ensure that the model will correctly allocate joint and common costs[177] and includes sufficient flexibility to allow the modification and examination of critical assumptions.[178]

88. The Florida Public Service Commission agrees with our tentative conclusion that the cost of land, which comprises a large portion of GSF, should vary by state in order to reflect differing land values.[179] In addition, the Florida Commission argues that, because of varying labor costs, state-specific expense-to-investment percentages should be used to estimate plant-specific operating expenses and state-specific per-line values should be used to estimate plant non-specific expenses.[180] We note that there may be other variables, in addition to land values and labor costs, that may vary by state, and find that the model should allow GSF and expense calculations to vary by state. Both models allow the user to make different assumptions by state, thus both models provide the same degree of flexibility in this regard.

89. Because BCPM permits users to estimate all operating expenses (including GSF expenses) either as a per-line amount or as a percentage of investment and to adjust these amounts easily, it is somewhat more flexible than HAI in this regard. Because the federal mechanism must be sufficiently flexible to accommodate the decisions we will be making in the input selection phase of this proceeding, the HAI developers have made minor changes in their model so that expenses can be calculated on a per-line or percentage-of-investment basis.[181] As noted above, many of the issues regarding the appropriate method of calculating forward-looking expenses will be resolved when we determine the input values that should be used in the federal

[175] GTE comments, attachment 1.

[176] In addition, no commenter suggests how we should separate costs for nonregulated activities from costs for regulated activities to determine the appropriate proportion of costs that should be supported by the federal mechanism and there is no conclusive evidence in the record on how joint and common costs should be allocated. As these questions are more appropriately answered during the input stage of this proceeding, we expect further review of this issue at that time.

[177] *Universal Service Order*, 12 FCC Rcd at 8915, para 250, criterion 7.

[178] *Universal Service Order*, 12 FCC Rcd at 8915, para 250, criterion 9.

[179] Florida PSC comments at 2.

[180] Florida PSC comments at 4-5.

[181] *See* Letter from Chris Frentrup, MCI/WorldCom, to Magalie Roman Salas, FCC, dated September 15, 1998.

mechanism.

90. We adopt our tentative conclusions in the *Further Notice* with respect to GSF investment and other expenses and conclude that the federal mechanism should: (1) be capable of calculating GSF investment and expenses by state; (2) provide the user with the capability to calculate each category of expense based either on line count or investment ratios; and (3) permit users to use different ratios or per-line amounts to calculate expenses for different size companies. We also conclude that the combination of model components that the Commission selects in this Order should be capable of generating cost estimates for the supported services within a reasonable time. The model will not be used to make final support calculations until next year, but it is important that the Commission and the Universal Service Joint Board can use the selected platform in the near term in connection with the issues that the Joint Board is considering in light of the *Referral Order*.

91. We find that the HAI and BCPM modules for computing expenses and GSF are roughly comparable, and conclude that the federal mechanism should incorporate the HAI module. Although, as noted above, the BCPM module may be somewhat more flexible, and therefore create the possibility for somewhat more fine-tuning at the inputs stage, we have thoroughly tested HAI's module and conclude that it generates accurate results. We also observe that expenses and GSF represent a small percentage of the total cost of providing the supported services.[182] We therefore conclude that the practical benefits of using the HAI module outweigh those of using the BCPM module and that, in the interest of administrative efficiency, the federal mechanism should incorporate HAI's expense and GSF module.[183]

VI. CONCLUSION

92. In this Order, we select a platform for the federal mechanism to estimate non-rural carriers' forward-looking cost to provide the supported services. To generate the most accurate estimates possible, we have selected the best components from the three models on the record. The model components selected are all generally available to the parties, and a software interface to merge the selected components is also available on the Commission's World Wide Web site.[184] Thus, the federal platform is available for use by states, other interested policymakers, and the public. Pursuant to the plan established in the *Further Notice of Proposed Rulemaking*, we will continue to evaluate model input values with the intention of selecting inputs for the federal platform at a later date. Once input values have been selected, the federal platform will be used to generate cost estimates.

VII. PROCEDURAL MATTERS AND ORDERING CLAUSES

[182] As noted above, outside plant represents over 70 percent of total network investment.

[183] We note that the HAI expense and GSF module is more easily integrated with the remainder of the model.

[184] *See* http://www.fcc.gov/Bureaus/Common_Carrier/Other/hcpm.

A. Final Regulatory Flexibility Act Certification

93. The Regulatory Flexibility Act (RFA)[185] requires a Final Regulatory Flexibility Analysis (FRFA) in rulemaking proceedings, unless we certify that "the rule will not, if promulgated, have a significant economic impact on a substantial number of small entities."[186] It further requires that the FRFA describe the impact of the rule on small entities. The RFA generally defines "small entity" as having the same meaning as the term "small business concern" under the Small Business Act, 15 U.S.C. § 632.[187] The Small Business Administration (SBA) defines a "small business concern" as one that "(1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) meets any additional criteria established by the SBA.[188] Section 121.201 of the SBA regulations defines a small telecommunications entity in SIC code 4813 (Telephone Companies Except Radio Telephone) as any entity with 1,500 or fewer employees at the holding company level.[189] In the *Further Notice of Proposed Rulemaking* (*Further Notice*) released July 18, 1997, the Commission considered regulatory flexibility issues relating to the selection of a mechanism to determine the forward-looking economic costs of non-rural LECs for providing supported services, but certified that there was no significant economic impact on a substantial number of small entities.[190] The Commission found that non-rural LECs do not meet the criteria established by the SBA to be designated as a "small business concern."[191] Non-rural LECs are not small business concerns pursuant to the SBA guidelines because they are generally large corporations, affiliates of such corporations, or dominate in their field of operation. No comments were filed in response to the certification.

94. We therefore certify, pursuant to section 605(b) of the RFA, that this Report and Order will not have a significant economic impact on a substantial number of small entities.[192]

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[185] *See* 5 U.S.C. § 601 *et seq.* The RFA was amended by the "Small Business Regulatory Enforcement Fairness Act of 1996" (SBREFA), Title II of the Contract with America Advancement Act of 1996, Pub. L. 104-121, 110 Stat. 847 (1996) (CWAAA).

[186] 5 U.S.C. § 605(b).

[187] 5 U.S.C. § 601(3) (incorporating by reference the definition of "small business concern" in 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of small business applies "unless an agency after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definitions in the Federal Register."

[188] 15 U.S.C. § 632.

[189] 13 C.F.R. § 121.201.

[190] Federal-State Joint Board on Universal Service, Forward-Looking Mechanism for High Cost Support for Non-Rural LECs, CC Docket Nos. 96-45, 97-160, *Further Notice of Proposed Rulemaking* (*Further Notice)*, 12 FCC Rcd at 18582-18583, paras. 183-185.

[191] *Further Notice*, 12 FCC Rcd at 18582-18583, para. 183.

[192] 47 U.S.C. § 605(b).

The Office of Public Affairs, Reference Operations Division, will send a copy of this Certification, along with this Report and Order, in a report to Congress pursuant to the Small Business Regulatory Enforcement Fairness Act of 1996, 5 U.S.C. § 801(a)(1)(A), and to the Chief Counsel for Advocacy of the Small Business Administration, 5 U.S.C. § 605(b). A copy of this final certification will also be published in the Federal Register.

B. Ordering Clauses

95. Accordingly, IT IS ORDERED, pursuant to sections 1, 4(i) and (j), and 254 of the Communications Act as amended, 47 U.S.C. §§ 151, 154(i), 154(j), and 254, that the FIFTH REPORT & ORDER in CC Docket Nos. 96-45 and 97-160, FCC 98-279, IS ADOPTED, effective 30 days after publication of a summary in the Federal Register.

96. IT IS FURTHER ORDERED that the Commission's Office of Public Affairs, Reference Operations Division, SHALL SEND a copy of this Report and Order, including the Final Regulatory Flexibility Certifications, to the Chief Counsel for Advocacy of the Small Business Administration.

FEDERAL COMMUNICATIONS COMMISSION

Magalie Roman Salas
Secretary

APPENDIX A

1. This appendix explains how the BCPM, HAI, and HCPM models collect information and then transform that information into forward-looking investment and cost estimates. The explanation is divided into five sections: data collection and preprocessing; customer location; outside plant design; switching, signaling, and transport; and expense calculation. The BCPM and HAI models estimate costs for all categories, while HCPM does not provide switching, signaling, transport, and expense calculations.

2. Section III of the Order compares how the three models group customers into geographic areas that will be served by common facilities. The number of customers in each geographic area depends on the distance between customers and the technical constraints of the facilities used to provide service. Section III also compares the outside plant design used by the three models to connect the customer to the wire center. This design specifies how feeder plant is built, how distribution areas are constructed, and what types of electronic equipment is used in conjunction with copper and fiber cables. Section IV compares how BCPM and HAI determine switch, transport, and signaling investment. Switch investment depends on the number of customers served, local usage, and whether the switch is a stand alone, host or remote switch. The wire centers are connected by a transport system. Both BCPM and HAI use SONET ring technology to connect the wire centers, and SS7 to provide signaling service. Summing the outside plant, switching, signaling, and transport investment generates an estimate of total network investment. Section V compares how BCPM and HAI calculate support investments such as general purpose computers to the network investment and then calculate capital costs and operating expenses.

I. Data Sources and Model Preprocessing

3. The customer location modules of the BCPM, HAI, and HCPM models each rely on external data sources to determine certain model input data. Each model uses input data on the number of households and business lines reported by Census block,[1] the number of residential lines per household, the location of the switching office in each wire center and the boundaries of each wire center. In addition, each model is capable of using as input data the exact geocoded locations of individual customers, although only the HAI model proposes a source of this information. In response to the Bureau's recommendation that a model be capable of accepting wire center boundary data in standard Geographic Information System format, the proponents of each model state that their customer location algorithms can accept alternative wire center boundary data.[2]

1 In some cases business line counts are reported at the Census block group or higher level and an allocation to Census blocks must be made.

2 BCPM Dec. 11 submission, Model Methodology at 3 (stating that BCPM can accept "any appropriately geocoded wire center boundary data"); HAI Dec. 11 submission, Model Description at 3 (stating that "[a]lternative data can be easily substituted" for the BLR data currently used by HAI); HCPM Release Notes at 1 (stating that "[w]ire center boundary data are currently preprocessed by a standard commercial GIS software package" and that "other packages can be substituted if they are deemed to contain more accurate data"). On February 6, 1998 the

A. BCPM

4. The complete set of preprocessing steps used by the BCPM is described in Appendix B of the BCPM 3.0 Model Documentation.[3] The preprocessing makes use of the mapping software MapInfo, data and software from PNR and Associates, Inc. (PNR) and Stopwatch Maps, and data from Business Locations Research (BLR). The end result is a set of comma-separated-value ascii text files which contain grid-level information on the grid location, area, population, line counts, terrain characteristics, and location of the serving switch. Some additional files contain information on wire centers and CBG to grid cross reference data.

5. BCPM begins with 1990 Census data on the number of occupied and unoccupied dwellings in each census block, updated with 1995 Census statistics regarding household growth.[4] BCPM uses the statewide average number of additional (i.e., non-primary) residential lines to estimate the number of additional lines in each census block. PNR provides BCPM with business line counts for each census block. BCPM uses data from BLR to determine wire center boundaries. The BCPM proponents state that, if a census block crosses a wire center boundary, housing and business data are apportioned to a wire center based on the proportion of land area, if a census block is less than 1/4 of a square mile, or on the proportion of roads, for larger census blocks.[5]

B. HAI

6. The input data and preprocessing steps used in the HAI model are described in detail in section 5 of the model documentation for Release 5.0. The preprocessing steps, which include subsequent customer location algorithms, make use of data and software from PNR. HAI estimates of residential line counts are based on demographic probabilities developed by Claritas and PNR.[6] Business line counts are developed from a national Dun & Bradstreet (D&B) database that generates business locations and business lines based on such information as counts of employees and business type.[7] HAI uses area code and telephone number prefix information (NPA-NXX) for "backup and data scrubbing purposes when anomalies arise in the BLR

HCPM released model outputs based on a set of publicly available wire center switch and boundary data.

[3] These steps describe both the use of input data and the assignment of customer locations to grids, as described in the next section.

[4] BCPM therefore identifies the cost of outside plant that serves both occupied and unoccupied dwellings. For a discussion of whether universal service requires that a model calculate the cost of serving both occupied and unoccupied dwellings, *see infra*.

[5] BCPM Dec. 11 submission, Model Methodology at 24.

[6] HAI Dec. 11 submission, Model Description at 22.

[7] HAI Dec. 11 submission, Model Description at 22-23.

geographical assignment process."[8]

7. HAI uses data, also purchased from PNR, to generate a database of geographic customer locations identifying, as precisely as possible, the actual latitude and longitude coordinates of each customer. PNR used, as its starting points, a large database of residential street addresses, based on information provided by a commercial bulk mailing firm, Metromail, and, for business locations, Dun & Bradstreet's database of business addresses.[9]

C. HCPM

8. HCPM is capable of utilizing geocoded data from any source, including either Census block data or individual geocoded points, that has been formatted according to Section 6 of the HCPM model documentation. The current default data source for customer locations is the HAI geocoded customer dataset, where actual geocodes are available, augmented with surrogates placed uniformly along roads following the BCPM approach. HCPM's wire center boundaries can also be derived from any source.

II. Customer Location

A. BCPM

9. BCPM's customer location algorithm is a multi-step process in which BCPM imposes a grid structure over the entire wire center boundary. BCPM divides the map of census blocks into rectangular "macrogrids" that are 1/25th of a degree latitude and longitude.[10] Each macrogrid is divided into sixty-four microgrids that are 1/200th of a degree latitude and longitude.[11] Next, BCPM uses census block information to decide how to assign customers in each census block to microgrids. For census blocks that lie wholly within one microgrid, all of the

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[8] For example, HAI suggests that anomalies can occur if one wire center falls completely within another wire center's boundaries. HAI Dec. 11 submission, Model Description at 23.

[9] The Metromail National Consumer Database (Metromail) has national household information such as deliverable postal addresses and phone numbers. It is compiled from telephone White Pages and such sources of information as new mover records, voter registration data, motor vehicle registration, mail-order respondent records, realty data, and home sales and mortgage transaction information. HAI documentation states that Metromail contains over 100 million households, or over 90% of the households reported by the Census Bureau for 1995. MCI Sep. 30 *ex parte* at 13; HAI Dec. 11 submission, Model Description at 21-24; AT&T Dec. 24 *ex parte* at 3. The Dun & Bradstreet database includes information on more than 11 million business establishments gathered from sources like business principals, public records, industry trade tapes, associations, directories, government records, etc.

[10] BCPM proponents state that each macrogrid is approximately 12,000 feet by 14,000 feet. Because the distance between degrees latitude increases as one moves from the North Pole to the equator due to the curvature of the earth, the sizes of BCPM's grids will vary. For example, grids will be smaller in Alaska than in Puerto Rico. BCPM Dec. 11 submission, Model Methodology at 27-28 and note 16.

[11] BCPM proponents state that each microgrid is approximately 1,500 feet by 1,700 feet. BCPM Dec. 11 submission, Model Methodology at 25-26.

customers in that census block are assigned to that microgrid. Many census blocks, however, extend into more than one microgrid. If a census block is small,[12] but nevertheless overlaps more than one microgrid, then BCPM apportions customers in the census block to the microgrids based on the percentage of the census block's area that lies in each microgrid.[13] If a census block is large, and overlays multiple microgrids, then BCPM apportions its customers to each microgrid according to the fraction of road network within each microgrid relative to the total amount of road network contained in all of the microgrids in which the census block is located.[14]

10. BCPM next identifies "ultimate" grids, which contain from one to sixty-four microgrids. Ultimate grids are BCPM's equivalent of carrier serving areas.[15] The determination of ultimate grids is based on the population within the microgrids and assumptions about the technological limitations on the number of lines that can be served from a single serving area interface.[16] Ultimate grids can be as small as a microgrid in highly populated areas, or as large as a macrogrid in sparsely populated areas.[17]

11. Once the ultimate grid is determined, BCPM identifies the "road centroid" of the ultimate grid and divides the grid into four quadrants that intersect at that point.[18] BCPM then determines the size and placement of a square "distribution area" within each ultimate grid quadrant, and assumes that the customers within that quadrant are evenly distributed on square

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[12] BCPM defines "small" census blocks as those with an area of less than 1/4 square mile. BCPM Dec. 11 submission, Model Methodology at 26.

[13] For example, if 20 percent of the total census block area falls into one microgrid and the remaining portion falls in a second microgrid, BCPM assumes that 20 percent of the total lines are located in the first microgrid, and 80 percent are located in the second microgrid. Census block data is allocated to microgrids based on relative land area only if the census block is less than 1/4 of a square mile, or less than 2,640 feet by 2,640 feet. BCPM Dec. 11 submission, Model Methodology at 26.

[14] Census block data is allocated to microgrids based on relative road lengths only if the census block is greater than 1/4 of a square mile, or greater than 2,640 feet by 2,640 feet. Road lengths are determined using actual road data from TIGER/Line files [Togographically Integrated Geographic Encoding and Referencing] from the U.S. Census Bureau. BCPM Dec. 11 submission, Model Methodology at 26.

[15] See Bell Notes to the Network.

[16] Macrogrids with fewer than 1000 lines become ultimate grids. For other macrogrids, BCPM evaluates the number of lines in each microgrid and the neighboring microgrids. In general, microgrids are combined into final grids that serve at least 400 lines. There will be instances, however, in which the aggregation process will result in final grids that serve as few as 100 lines. No ultimate grid can be smaller than a microgrid, however. BCPM Dec. 11 submission, Model Methodology at 109.

[17] Ultimate grids can therefore be as small as approximately 1,500 feet by 1,700 feet (one microgrid) and as large as approximately 12,000 feet by 14,000 feet (one macrogrid), although an ultimate grid may occasionally be larger if isolated grids are combined with a macrogrid. BCPM Dec. 11 submission, Model Methodology at 27-29 and note 20.

[18] The road centroid, in essence, marks the place within the ultimate grid with the greatest concentration of roads. BCPM Dec. 11 submission, Model Methodology at note 22.

lots within that square area. To determine the size of the distribution areas, BCPM first considers the total length of roads within the quadrant, and assumes that customers are located within 500 feet on either side roads. Therefore, BCPM multiplies the total number of feet of road network within each quadrant by 1000 feet (i.e., 500 feet on either side of the road) to calculate the size of the square distribution area within the quadrant.[19] BCPM then assumes that the square distribution area is centered at the road centroid of the quadrant.

12. The BCPM proponents assert that, consistent with the Bureau's guidance, BCPM can incorporate geocode data with a minimum of preprocessing adjustments and with no changes to the model itself.[20] Customers would be assigned to microgrids based on their exact geocoded location rather than on an algorithm that allocates Census blocks to microgrids based on area and information about the road network. After customers are assigned to microgrids in this way, the creation of ultimate grids would proceed as described above. In the case of partial geocoded customer location information, the BCPM sponsors indicate that the model would assign geocoded locations to "residual" customers (whose actual location is unknown) in every Census block by placing them uniformly on the road network in each Census block.[21]

B. HAI

13. The HAI model employs a clustering algorithm to aggregate customer locations into serving areas. Address data for residential locations are provided by Metromail, Inc. and for business locations by Dun & Bradstreet.[22] Addresses are converted into geocoded customer locations by PNR using a software product by Qualitative Marketing Software called Centrus Desktop.[23] The geocoding process is accomplished by standardizing addresses to specifications defined by the United States Postal Service, and then determining geocodes corresponding to addresses by extrapolating from known geocoded locations, which typically occur at road intersections. Since not all customers have addresses, and not all addresses can be successfully geocoded by the above processes, the HAI model assigns "surrogate" geocode locations to residual (unlocated) customers within every Census block. The surrogate geocode locations are determined by uniformly distributing the residual customers in each Census block around the boundary of the block.

14. The clustering algorithm used by PNR is a "nearest neighbor" agglomerative algorithm combined with a set of stopping rules. Conceptually the algorithm begins with a single

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[19] At this stage, customers have already been distributed among the micrograms that make up the ultimate grids based on land area or the distribution of road network. Only quadrants that contain both roads and populated microgrids will have distribution areas. BCPM Dec. 11 submission, Model Methodology at note 22.

[20] BCPM Dec. 11 submission, Model Methodology at 3; Sprint *ex parte*, Jan. 28, 1998.

[21] *See* Appendix to Sprint *ex parte*, January 28, 1998.

[22] HAI Dec. 11 submission, Model Description at 23.

[23] HAI Dec. 11 submission, Model Description at 24.

location and repeatedly adds additional locations to form clusters as long as one of the following rules is not violated: (1) No point in a cluster may be more than 18,000 feet (based on right angle distance) from the centroid of the cluster. (2) No cluster may exceed 1800 lines in size. (3) No point in a cluster may be farther than two miles from its nearest neighbor in the cluster.[24] The first two rules are engineering constraints similar to those used by BCPM and HCPM in defining grids. The third rule is not based on engineering considerations. According the HAI proponents, it "is used to ensure that customer locations that are separated by the given distance are not required to be clustered together."[25]

15. The following specific steps are used to build clusters. First, the set of actual and surrogate geocode locations are "rasterized" into 150 foot square cells that overlay the geographic rectangle covering the wire center boundary.[26] That is, all customer locations that fall within a given 150 foot cell are aggregated and their location is assumed to be at the center of the cell for purposes of clustering. The nearest neighbor algorithm starts with a cluster defined by an arbitrarily chosen initial raster cell. It then inspects each of the four neighboring cells. If a neighboring cell is populated, the algorithm checks to see if any of the rules are violated, and if none are, the cell is added to the cluster. This process continues by examining in turn each newly added raster cell to see if additional neighbors can be added to the cluster.

16. When no additional points can be added to a given cluster by examining neighbors within a 150 foot radius, the algorithm moves to the next populated cell that is unclustered and repeats the above process. Whenever new locations cannot be added to clusters by looking for nearest neighbors at a given distance, the entire process is repeated by examining nearest neighbors located at a greater distance (in multiples of the raster cell size of 150 feet). The algorithm terminates when no additional points can be added to any cluster.

C. HCPM

17. Although it originally proposed a gridding approach for aggregating customers into serving areas, HCPM subsequently developed a clustering algorithm.[27] HCPM's customer location algorithm operates in one of two ways depending on the customer location data source. If the data source contains individual geocoded customer locations, the HCPM clustering module (called CLUSTER) performs either an agglomerative or divisive cluster algorithm (depending on the user’s choice) to determine serving areas. If the source contains Census block data, HCPM preprocesses the data to distribute customers uniformly throughout a square equal in area to the Census block, with the center of the square set at the internal point of the Census block as identified in the Census data. After performing this preprocessing step, the cluster routine

[24] HAI Dec. 11 submission, Model Description at 26.

[25] HAI Dec. 11 submission, Model Description at 27.

[26] HAI Dec. 11 submission, Model Description at 27.

[27] C.A. Bush, et al., *The Hybrid Cost Proxy Model Customer Location and Loop Design Modules*, July 1, 1998 (HCPM July 1 Report) at 5.

proceeds as noted above.

18. After performing the cluster analysis, the HCPM cluster module allows the user the option to "optimize" the clusters it creates using two separate procedures. In simple reassignment, a customer location is reassigned from its original cluster to a new one if the location is closer to the new cluster's centroid. This process is repeated until no more reassignments can be made. In full optimization, customer locations are considered one by one. The effect each customer location has on centroid locations is measured, and customer locations are moved from one cluster to another if the total distance from customer locations to centroid locations is reduced. This process is repeated until no more distance reduction is possible.

19. The cluster module takes the maximum copper loop length and maximum number of lines as well as the type of clustering desired and the type and amount of optimization desired into account as user-adjustable inputs.

20. After the customer location data have been clustered, a separate module (called CLUSINTF) places a fine (square) grid over each cluster. The size of the grid (or "microgrid") is determined by the user; the current default is 360 feet by 360 feet. The interface module determines the terrain adjustment of each cluster by looking up its value in a table, and also calculates the line density of each cluster and of the wire center as a whole.[28]

III. Outside Plant Design

A. BCPM

21. As discussed above, BCPM considers each ultimate grid established by its customer location module to be a serving area. BCPM assumes that the DLC will be placed at the road centroid of the ultimate grid.[29] The model then calculates the design of the feeder plant from the central office to the DLC in each serving area. BCPM begins this process by assuming that each of four main feeder routes extends 10,000 feet due north, south, east, and west, respectively, from the central office, into each quadrant of the wire center.[30] Once the feeder routes extend beyond 10,000 feet from the central office, the model considers two possible feeder systems in every quadrant. If the line count in the center third of the quadrant is greater than 30 percent of the lines in the quadrant as a whole, a single main feeder route is used and the model user can select whether or not the main feeder cables angle toward the population centroid of the

[28] Additionally, if the input data contain fractional lines as input, the interface (which reports out only integer-valued lines) performs a "true-up" to place fractional lines as appropriate within populated microgrids.

[29] BCPM Dec. 11 submission, Model Methodology at 38. Where the total length of feeder cable and all distribution cables in a serving area does not exceed the maximum practical distance for which copper cable may be used, BCPM would assume copper (rather than fiber) feeder cable. In that case, the feeder-distribution interface would be a simple connection of the copper cables, rather than a DLC device. It would, however, be located in the same place.

[30] BCPM Dec. 11 submission, Model Methodology at 35.

quadrant. If the line count in the center third of the quadrant does not exceed 30 percent of the quadrant's total, then the model constructs dual main feeder routes that extend toward the area of greatest population concentration in the outer thirds of the quadrant. The model computes total feeder distance for the quadrant under both scenarios and selects the option that minimizes total feeder distance for the quadrant.

22. The main feeder routes are connected to the DLCs in each serving area by subfeeder cables extending from the main feeder cable. Within 10,000 feet from the central office, subfeeders can run from the main feeder on any grid boundary, even if the ultimate grids have been sized at the smallest microgrid size possible (1/200th of a degree latitude or longitude).[31] Beyond 10,000 feet from the central office, subfeeders are run on grid boundaries no more frequently than every 1/25th of a degree latitude or longitude. The size of the feeder cable is determined by the number of customer locations that the model has determined to exist in the quadrant multiplied by a user-adjustable "fill factor."[32] BCPM economizes on DLC costs by ensuring that the portion of the DLC equipment that is placed in the central office is connected to as many DLC remote terminals as its capacity will allow.

23. BCPM divides its square distribution areas into lots and runs backbone (north-south) and branch (east-west) distribution cable to each lot.[33] The size of the lots is determined by dividing the number of customers by the area of the distribution area. The final piece of the distribution network is the drop, which connects the branch cable to the network interface device at the customer premises. BCPM assumes that the length of the drop is one half of the diagonal width of the lot, capped at 500 feet.[34] As a final check on the reasonableness of the length of the distribution cable that BCPM has calculated, the model constrains the length of distribution cable within a quadrant to the total length of the roads in that quadrant.[35] Consistent with the direction provided in the *Customer Location & Outside Plant Public Notice*, BCPM also permits the model user to select an overall cap on per-loop investment.[36]

24. BCPM estimates plant mix based on the terrain and line density of the grid.[37] BCPM also adjusts the costs of cable placement based on the level of bedrock and the water table

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[31] BCPM Dec. 11 submission, Model Methodology at 37.

[32] Telephone engineers typically use fill factors to determine the number of "extra" lines that should be placed in a given cable. Extra lines are included to allow for future growth in lines, redundancy in the cable, and other situations in which extra capacity in the cable might be needed.

[33] BCPM Dec. 11 submission, Model Methodology at 44.

[34] BCPM Dec. 11 submission, Model Methodology at 44. The diagonal width of the lot is the distance from one corner of the square lot to the opposite corner.

[35] BCPM Dec. 11 submission, Model Methodology at 45.

[36] BCPM Dec. 11 submission, Model Methodology at 47.

[37] BCPM Dec. 11 submission, Model Methodology at 46.

and the hardness of bedrock in the CBG in which the grid falls.[38]

B. HAI

25. HAI uses a simplified algorithm for laying out distribution plant to customer locations. Clusters with five or more customers are called "main" clusters, while clusters with fewer than five customers are called "outliers." For main clusters and outlier clusters with more than one customer, HAI creates a rectangular "distribution area" centered on the geographic center of the cluster, with the same area and aspect ratio of the cluster.[39] Customers in a cluster are assumed to be distributed in a uniform manner throughout the rectangle.[40] The number of lots is determined by dividing the area of the rectangle by the number of customers in a cluster, and rounding up as necessary to ensure that lot depth is twice as great as lot frontage. Backbone cables terminate one lot-depth inside the north and south boundaries of the rectangle. Similarly, branch cables run to within one lot-width of the east and west sides of the rectangle.[41]

26. In the case of outlier clusters (fewer than five customers), HAI determines the distribution area and lot size as above, but the model assumes that customers in outlier clusters are distributed evenly along a "road" that is assumed to run through the geographic center of the outlier cluster. Outlier clusters[42] are grouped in the same serving area as the nearest main cluster, and the centroid of the outlier cluster is connected to the centroid of the nearest main cluster by analog or T1 connections depending on the distance of the furthest customer in an outlier to the centroid of the main cluster. Outliers may be connected directly to the main cluster or indirectly through another outlier cluster.

27. Near each customer's premises in both main and outlier clusters, a terminal connects a drop cable from the distribution cable to the network interface device located on the customer's premises. The model user may choose whether the model assumes that drop cables are buried or aerial.[43] Main clusters with total areas of less than 0.03 square miles and with line

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[38] BCPM Dec. 11 submission, Model Methodology at 48.

[39] The area of a cluster is actually the area of a "convex hull" of the cluster. A convex hull is determined by connecting all of the outer points in a cluster. The aspect ratio is the ratio of the North-South length to the East-West length, using the outermost points of a cluster. If a cluster has an aspect ratio of 2:1, HAI will therefore create a rectangle that has the same area as the cluster's convex hull and that has North-South sides that are twice as long as its East-West sides. *See* HAI Dec. 11 submission, Model Description at 27-28 and note 31. All clusters are assumed to have a minimum width so that an area can be identified for a cluster that is formed by points laid out in a straight line. HAI Jan. 29 *ex parte*

[40] Thus, although HAI begins with geocodes for the precise locations of many customers, it does not actually construct outside plant to those precise locations.

[41] HAI Dec. 11 submission, Model Description at 36.

[42] For a definition of outlier clusters in HAI, *see supra* section III.B.

[43] HAI Dec. 11 submission, Model Description at 39.

densities of more than 30,000 lines per square mile are assumed to be high rise residential buildings. The model assumes that distribution cable is riser cable inside each high-rise building and that the feeder-distribution interface is located in the basement of each building.[44]

28. HAI assumes that feeder cable begins at the wire center and ends at the feeder-distribution interface in each serving area.[45] The model divides the wire center area into four quadrants and deploys feeder cable to every populated quadrant. Default directions for feeder emanating from the wire center are north, east, south and west (0, 90, 180, and 270 degrees.) At the model user's discretion, HAI can "steer" feeder routes towards the preponderance of main clusters within each quadrant. When this method is used, the resulting feeder length is increased by a user-specified multiplier to account for instances where rights-of-way are unavailable along the straight-line feeder route designed by the model. Sub-feeder cables branch at right angles off of the main feeder route toward main clusters.[46]

29. Fiber feeder technology is used if any one of the following five conditions is met: (1) total feeder and subfeeder distance from the wire center to the main cluster centroid exceeds the user-adjustable threshold; (2) the life-cycle cost of fiber is more economical than copper; (3) the length of the longest distribution cable run from the wire center to the farthest corner of a main cluster is greater than a user-adjustable threshold; (4) there is at least one outlier cluster connected to the main cluster; or (5) the wireless investment cap is invoked, in which case fiber connects the radio sites to the wire center.[47] Otherwise analog copper feeder cables are used.

30. The HAI model permits the user to invoke a wireless investment cap which compares the cost of a wireline network to the cost of both a point-to-point wireless system and a broadcast wireless network. A user input, set by default at $7,500, determines point-to-point costs for a single user. A broadcast wireless system is assumed to have user specified fixed and per-user costs, which are set by default at $112,500 and $500 respectively. When the wireless cap option is invoked, the cost of a serving area is set equal to the minimum of the wireline cost, the point-to-point wireless cost, and the broadcast wireless cost.

C. HCPM

31. As described above, HCPM locates customers within clusters. Each cluster is then divided into microgrids (up to 2500). In addition, every cluster contains at least one terminal

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[44] HAI estimates the number of floors in a high-rise by first estimating the size of the building's footprint by subtracting space for streets and sidewalks. HAI then determines how many floors of this size are needed to accommodate the number of households and businesses located in the building, assuming that each household uses 1500 square feet and, for businesses, each employee uses 200 square feet. HAI Dec. 11 submission, Model Description at 37.

[45] A serving area is one main cluster and the outlier clusters associated with it.

[46] HAI Dec. 11 submission, Model Description at 40.

[47] HAI Dec. 11 submission, Model Description at 39-40. The wireless cap is discussed *infra*.

location, or serving area interface (SAI), which defines the boundary between feeder and distribution plant. Distribution plant consists of the set of analog copper cables, structures, and other facilities such as network interface devices that are required to connect every customer location to the closest SAI. Feeder plant consists of the set of fiber, digital copper (T1 or xDSL), or analog copper cables and structures that connect every SAI to the central office.

32. HCPM locates an SAI within a cluster at the centroid of that cluster. Additional SAIs may also be located within the cluster to determine if annualized cost would be minimized through the addition of terminal nodes within a cluster; the current default method, however, is to locate no more than one SAI per cluster. If more than one SAI is specified and located within a cluster, one of the SAIs is designated "primary" and interconnects with the feeder network; the remaining SAIs are interconnected with the primary SAI using xDSL on copper technology. From the SAIs, HCPM builds distribution plant to each populated microgrid within the cluster.

33. The distribution plant is first designed using a simple rule-of-thumb that is a variant of the "pinetree" topology. In this approach, vertical and horizontal distribution backbones are placed along alternate lattice lines in the grid structure of the cluster, gathering lines from each populated microgrid. A user option is to compare the cost of this rule-of-thumb calculation with an alternative calculation, which uses a cost-minimizing variant of the Prim[48] "minimum spanning tree" algorithm to connect each drop terminal with the SAI.[49]

34. The feeder network, which connects every primary SAI to the central office, is also designed using a variant of the minimum-cost spanning tree algorithm. Beginning at the central office, the algorithm builds a feeder network sequentially by examining both the cable and structure costs involved in attaching new nodes to the network. Lowest cost nodes are attached first. When each new node is attached, the connection is chosen that minimizes the cost of cable and structures that are required to connect that node to the central office using the currently existing network.[50] Distance computation can be done using either rectilinear distance or airline distance according to user option. In addition, "junction nodes" are placed at points due north, south, east, and west of the central office along what would be the main feeder routes in a traditional "pinetree" feeder design.[51]

35. As part of the feeder design algorithm, HCPM calculates the feeder technology for

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[48] Prim, R.C. (1957), "Shortest Connection Networks and some Generalizations." *Bell Technical Journal* 38, pp. 1389-1401.

[49] Since this alternative calculation requires additional computing time, the user can also determine a maximum line density above which the computation will not be performed.

[50] The algorithm does not achieve a "global" cost minimum because it is not able to take account of the impact that choosing a particular link will have on the cost of attaching future nodes as the algorithm proceeds.

[51] Junction nodes are nodes that can be used as connection points but which have no line demand associated with them. Their use allows greater opportunities for sharing of structure costs than would be possible in a network without junction points. See HCPM documentation, pp. 14-15.

each SAI that minimizes annualized cost subject to engineering constraints defined by the user inputs.[52] The model also selects loop electronics by examining every feasible combination of large and small terminals and selecting the cost minimizing outcome. HCPM 2.5 modified its technology selecting algorithms to consider lifecycle costs instead of first-installed cost and made other significant enhancements to its algorithms for selecting the lowest-cost technology in a given situation.

IV. Switching, Signaling, and Transport

36. In the *Further Notice*, the Commission sought comment on issues that affect the algorithms for switching, interoffice trunking, signaling, and local tandem investment.[53] In a *Public Notice* released on September 3, 1997, the Common Carrier Bureau set forth its recommendations to the model proponents to ensure that their modules for calculating switching, interoffice trunking, signaling, and local tandem investment comply with all the criteria set forth in the *Universal Service Order*.[54] The *Switching and Transport Public Notice* established several guidelines relating to switching, the design of the interoffice network, and interoffice cost attributable to providing supported services.[55] The Bureau guidelines determined that: the models permit individual switches to be identified as host, remote, or stand-alone; switching investment costs should be separately estimated for host, remote, and stand-alone switches; that models include switch capacity constraints, and that the models should accommodate an interoffice network that is capable of connecting switches designated as hosts and remotes in a way that is compatible with the capabilities of equipment and technology that are "available today and current engineering practices."[56] The Bureau also found that all of the line-side port costs and a percentage of usage costs should be assigned to the cost of providing supported services.[57]

A. BCPM

37. BCPM 3.0 estimates separate switch investment costs for host, remote, and stand-

[52] HCPM Dec. 23 additional information at 6; HCPM Feb. 6 submission. HCPM 2.5 considers lifecycle costs, including maintenance costs, in determining the least-cost alternative. Prior to February 6, 1998, HCPM's optimization routines considered first-installed, rather than lifecycle, costs.

[53] *Further Notice*, 12 FCC Rcd at 18,560-18,567 paras. 121-141.

[54] Guidance To Proponents of Cost Models in Universal Service Proceeding: Switching, Interoffice Trunking, Signaling, and Local Tandem Investment, *Public Notice*, CC Docket Nos. 96-45, 97-160, DA 97-1912, (rel. Sept. 3, 1997) at 2-6 (*Switching and Transport Public Notice*).

[55] *Switching and Transport Public Notice* at 2-6.

[56] *Switching and Transport Public Notice* at 4-6. Switches can be designated as either host, remote, or stand-alone switches. Both a host switch and a stand-alone switch can provide a full complement of switching services without relying on another switch. A remote switch relies on a host switch to supply a complete array of switching functions and for interconnection with other switches.

[57] *Switching and Transport Public Notice* at 4-6.

alone switches. BCPM 3.0 determines whether each switch is a host, remote, or stand-alone by consulting data on current host, remote, and stand-alone switch deployment contained in the Local Exchange Routing Guide (LERG), a database maintained by Bellcore.[58] BCPM 3.0 deploys more than one switch if single switch capacity constraints are exceeded.[59]

38. BCPM 3.0 permits the model user to select from among four methods of determining investment per switch: (1) a BCPM default; (2) the audited LEC switching model (ALSM); (3) a state-specific LEC model, if the user provides it; and (4) a user-defined model.[60] The BCPM default is based on a regression of switch investment costs using SCIS and SCM data. Switch costs are assumed to vary with lines, trunks, minutes of use and calls (BHCCS and BHCA).[61]

39. Once total switching investment per wire center is determined, BCPM 3.0 divides total investment into functional categories based on cost drivers which include line ports, call duration and call setup.[62] For the default switch investment, this division is based on regression results of the SCIS and SCM models. The final step is to determine the investment per line for all switch categories. Line port investment is allocated completely to the provision of supported services. For the other categories, the switch investment per unit of usage is translated into per-line cost by multiplying usage investments by an estimate of usage per line.[63] Where there are host-remote systems, trunk and SS7 usage investment is shared among all users of the system.

40. In the Transport Cost Proxy Model module, BCPM 3.0 estimates the transport cost per line based on SONET ring technologies. Inputs to this module include (1) LERG data that identify and locate the existing switching network; (2) a set of user specified thresholds on ring size;[64] and (3) the number of access lines served by the switch as determined by the loop module. The model constructs a SONET ring for each host-remote configuration. It then connects each host or stand alone office to the tandem office. After the rings are designed,

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58 BCPM Dec. 11 submission at 50.

59 BCPM Dec. 11 submission, Model Methodology at 56.

60 BCPM Dec. 11 submission, Model Methodology at 58-61.

61 For example, if the coefficient for lines is $300 and for trunks is $100 and the switch serves 1,000 lines and 100 trunks, then the switch investment for these two categories would be $300 times 1,000 lines plus $100 times 100 trunks which equals $310,000.

62 BCPM Dec. 11 submission, Model Methodology at 57. Call duration is expressed in hundreds of call seconds (CCS).

63 BCPM Dec. 11 submission, Model Methodology at 64.

64 For example, these inputs include among others: the maximum number of nodes per ring; airline miles to route miles factor; line to trunk factor. BCPM Dec. 11 submission, Model Methodology at 69.

BCPM determines the appropriate bandwidth for each of the rings.[65]

41. The following algorithm is used for connecting nodes to a common source for both host-remote and host-stand-alone tandem rings. First, a three node ring is created by interconnecting the source and the two nodes closest to the source. Next, the remaining nodes are placed in order in terms of increasing distance to the source. A new node is added to the ring by computing the increase in cost that would result if any given segment of the original ring were replaced by two new segments which connect the end points of that segment with the new node. A new ring is then formed by dropping the segment that minimizes the cost of adding the new node to the ring. The process continues until all nodes have been attached or the user specified maximum ring size is reached.

42. User inputs determine both the number of rings constructed and the total investment required for each ring. The model next converts total investment into a cost per DS1, selects the appropriate mileage element, and computes the cost per common transport minute.[66] The transport investment results are provided for public switched network common transport on an individual ring basis, recognizing the use of existing LEC wire centers, mileage characteristic, and each ring's specific utilization. The common transport results are utilized in the development of the universal service fund monthly transport cost per line by exchange.[67]

43. Signaling costs for use in developing per line investment for BCPM 3.0 are provided through a user input table that its proponents assert reflects the cost of building a modern SS7 network.[68] The input table provides investments for residence and business lines for small, medium, and large companies. The signaling cost for a wire center is based on a weighted average of residence and business lines associated with that wire center.

B. HAI

44. To determine the number of switches needed in each wire center, HAI 5.0 compares a number of factors that will affect the demands placed on a switch with capacity constraints. Switch capacity requirements depend upon the call volume that the switch must process during the busiest hour of the day (the "busy hour"). The number of call attempts that the switch must connect during the busy hour is generally expressed in busy hour call attempts (BHCAs), and the duration of those calls is expressed in busy hour hundred call seconds (BHCCS). Specifically, HAI compares the number of lines, BHCAs, and BHCCS to capacity

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[65] BCPM determines the appropriate bandwidth of the rings by analyzing the number of switched access lines served by the ring. After determining special access circuit needs, it builds the proper number of DS1 and DS0s to accommodate the ring's traffic. A Ring Size Table then finds the capacity of the ring. BCPM Dec. 11 submission, Model Methodology at 72.

[66] BCPM Dec. 11 submission, Model Methodology at 73.

[67] BCPM Dec. 11 submission, Model Methodology at 74-75.

[68] BCPM Dec. 11 submission, Model Methodology at 76.

constraints.[69] If any of the capacity constraints are exceeded, HAI 5.0 adds additional switches.[70] Once the number of switches is determined, switch investment is estimated using a single switch curve.[71] This estimate is adjusted to reflect the effects of digital line carrier equipment -- reduced trunking requirements and port savings.[72] The monthly cost per line for switching is assumed to be the same for all lines in a study area. HAI assigns a percentage of total switch investment to the port and the remainder to usage. It separates usage costs associated with local traffic from those associated with other traffic on the basis of switched minutes of use. It then allocates the port and local traffic costs to universal service.[73]

45. HAI 5.0 is capable of estimating the cost of switching systems comprised of combinations of host, remote, and stand-alone switches.[74] The model allows the user to decide whether each wire center houses a host, remote, or stand-alone switch.[75] End office switching investment calculations obtain common equipment and per-line investments for all three switch types from a user-adjustable investment table, which contains end office investment entries for both large and small LECs.[76] HAI allocates the cost of host-remote systems equally across all lines in the system. If the user does not specify whether each switch is a remote, host or stand-alone, HAI will generate investments estimate based on its default switch curve.

46. In calculating transport investments, HAI 5.0 determines the overall breakdown of traffic per subscriber according to the given traffic assumptions and computes the number of trunks required to carry this traffic. These calculations are based on the fractions of total traffic assumed for interoffice, local direct routing, local tandem routing, intraLATA direct and tandem routing, and access dedicated and tandem routing.[77] These traffic fractions are applied to the total traffic generated in each wire center according to a mix of business and residential lines and

[69] HAI Dec. 11 submission, Model Description at 50-51. HAI compares the BHCA produced by a mix of lines served by each switch with a user-adjustable processor capacity (default set at a maximum of 600,000 BHCA, depending on the size of the switch). HAI compares the offered traffic, expressed as BHCCS with a user-adjustable traffic capacity limit (default set at a maximum of 1,800,000 BHCCS).

[70] If multiple switches are required in a wire center, they are sized equally to allow for maximum growth on each switch. For example, if a wire center serves 90,000 ports, HAI will compute the investment required for two 45,000-port switches. HAI Dec. 11 submission, Model Description at 50.

[71] HAI Dec. 11 submission, Model Description at 52.

[72] HAI Dec. 11 submission, Model Description at 53.

[73] HAI Aug. 8 comments at 13.

[74] HAI Dec. 11 submission, Model Description at 51.

[75] HAI Dec. 11 submission, Model Description at 18.

[76] HAI Dec. 11 submission, Model Description at 52. Switch investment is the sum of the common equipment costs plus the product of the per line costs and the model estimated line counts.

[77] HAI Dec. 11 submission, Model Description at 54.

appropriate per-line offered load assumptions. HAI 5.0 computes the total offered load per wire center for various classes of trunks, e.g., local direct-routed trunks. If the offered load exceeds the threshold, the computed number of trunks is the quotient of the total offered load divided by the user-specified maximum trunk occupancy. If the traffic load is less than the threshold, HAI 5.0 obtains the correct number of trunks using Erlang B assumptions and 1% blocking from a look-up table.[78]

47. HAI 5.0 assumes that, with some exceptions, all interoffice facilities take the form of a set of interconnected SONET fiber rings. The HAI interoffice network of rings consist of two ring classes: host-remote and tandem-host-standalone.[79] If the user invokes the feature that allows hosts and remotes to be specified, host/remote rings are used to interconnect remote switches to their serving host. Tandem-host-stand-alone rings interconnect hosts and stand-alone wire centers to their serving tandem.

48. To compute the set of interoffice rings for both host-remote and host-stand alone-tandem configurations, HAI 5.0 begins with a "star" network in which all wire centers are directly connected to their serving tandem via redundant paths. Each wire center is then examined to determine whether it is more advantageous to leave the wire center directly connected to the tandem or incorporate it into a ring. The algorithm used to construct the ring is similar to the algorithm used by the BCPM, except that HAI model adds a node to a ring only if the increase in cost to the ring (which includes both increased distance to attach the new node and increased multiplexing to handle additional traffic on the entire ring) is less than the cost of directly connecting the node to the tandem. Once HAI determines the total interoffice distances, it calculates the costs of installed cable and structure based upon user-defined inputs, the mix of different structure types, and the amount of structure sharing between interoffice and feeder plant.[80]

49. HAI computes signaling links for Signal Transfer Points (STP) to end office tandem "A links" and "C links" between STPs in a mated pair, and "D link" segments connecting the STPs of different networks. All links are assumed to be carried on the interoffice rings.[81] HAI equips at least two signaling links per switch. It also computes required SS7 message traffic according to call type and traffic assumptions. User inputs define the number and length of ISDN

[78] HAI Dec. 11 submission, Model Description at 54. The traffic engineering threshold value is determined from the user-specified maximum occupancy value through another table that determines the number of trunks that will carry the specified maximum occupancy at 1% blocking. The threshold value is the product of the input maximum occupancy and the corresponding number of trunks.

[79] HAI Dec. 11 submission, Model Description at 54.

[80] HAI Dec. 11 submission, Model Description at 56. To account for the structure sharing, HAI determines the smaller of the investment in feeder and the investment in interoffice facilities, and applies the user-specified sharing percentage to the smaller value to calculate the amount of shared structure investment. HAI then subtracts this amount of investment from both the interoffice and feeder investment, and reassigns it back to feeder and interoffice investments according to the relative amounts of investment in feeder versus interoffice.

[81] HAI Dec. 11 submission, Model Description at 57.

User Part messages required to set up interoffice calls.[82] Other inputs define the number and length of Transaction Capabilities Application Part (TCAP) messages required for database lookups, along with the percentage of calls requiring TCAP message generation. STP capacity is expressed as the total number of signaling links each STP in a mated pair can terminate (default value is 720 with an 80% fill factor).[83] Signal Control Point (SCP) investment is expressed in terms of dollars of investment per transaction per second. The translation calculation is based on the fraction of calls requiring TCAP message generation. The total TCAP message rate in each LATA is then used to determine the total SCP investment.[84]

V. Expenses

50. In the *Further Notice*, the Commission sought comment on the appropriate assumptions that should be used in the platform design to compute the forward-looking general support facilities (GSF) investment and expenses attributable to the cost of providing the supported services.[85] The Commission also sought comment on how to establish forward-looking expenses in the selected federal mechanism and specifically sought comment on which expenses should be calculated on a per-line basis and which should be calculated as a percentage of investment.[86]

51. Both HAI and BCPM estimate operating expenses and investment in GSF after the models calculate the cost of investment in outside plant, switching and transport. Both models calculate GSF investment as a function of total investment in plant. HAI assumes that certain operating expenses are closely linked to the number of lines, that other expenses are related more closely to the levels of their related investments, and calculates expenses accordingly, either as a function of related investment or as a function of demand, *i.e.*, either as a percentage of investment or as a per-line amount. BCPM permits the user to estimate operating expenses as either a per-line amount or as a percentage of investment. BCPM default values are based upon per-line amounts derived from`a survey of local exchange carriers.

A. BCPM

52. After BCPM calculates the loop, switching, and interoffice plant investment needed for each grid, BCPM's Support Plant Module and Operating Expenses Module calculate GSF investment and operating expenses. In addition, the Capital Cost Module develops annual

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[82] HAI Dec. 11 submission, Model Description at 57 (Default values are six messages per interoffice call attempts to set up, with 25 octets per message).

[83] HAI Dec. 11 submission, Model Description at 57.

[84] HAI Dec. 11 submission, Model Description at 58. The default SCP investment is $20,000 per transaction per second.

[85] *Further Notice*, 12 FCC Rcd at 18,569 para. 148.

[86] *Further Notice*, 12 FCC Rcd at 18,572-18,573 para. 157.

capital cost factors that are applied to the investment categories developed in the other modules.

53. BCPM's Support Plant Module calculates investment in network support (motor vehicles, special purpose vehicles, garage work equipment, other work equipment) and general support (furniture, office equipment, general purpose computers) by multiplying total investment (excluding support, land, and buildings) by user-adjustable investment ratios. The default values are based on the historical expense-to-investment ratios for each of the seven investment categories. BCPM permits users to specify different support factors for small, medium, and large companies. BCPM's Switch Module calculates land and building investment using the historical ratio of average land or building investment to central office investment.[87]

54. BCPM's Operating Expenses Module permits users to estimate operating expenses as either a per-line amount or as a percentage of investment. If a per-line expense factor is specified, total operating cost for the relevant Part 32 account is a function of the number of access lines. If a percent-of-investment factor is specified, total operating expense is a function of investment, usually of investment in the relevant account. BCPM permits the user to vary operating expense estimates for small, medium, and large companies and to differentiate between operating expenses related to residential customers and those related to business customers. BCPM also subdivides expense accounts for cable and wire facilities to differentiate among aerial, underground and buried, copper, and fiber cable.

55. BCPM's Report Module estimates universal service support levels by combining investment costs, capital costs and operating expenses to generate monthly costs. BCPM then uses monthly costs to calculate, for a given benchmark, universal service support levels at the grid, wire center, company, or state level.

B. HAI

56. HAI's Expense Module,[88] after receiving from the other HAI modules all the network investments, by type of network component necessary to provide unbundled network elements (UNEs), basic universal service, and network interconnection and carrier access in each study area, estimates the capital carrying costs associated with the investments and the costs of operating this network. Network related operating expenses include maintenance and network operations. Non-network related operating expenses include customer operations expenses, general support expenses, other taxes, uncollectibles and variable overhead expenses.

57. Plant-specific network-related operations expenses are primarily maintenance expenses, and HAI calculates these as functions of their associated capital investments. HAI uses

[87] Total Network Support is the sum of the following Part 32 accounts: 2112, 2214, 2115, 2116, and 2111 (Land). Total General Support is the sum of the following Part 32 accounts: 2122, 2123, 2124, and 2121 (Buildings).

[88] *See* HAI Feb. 2 submission, Model Description at 64-74. HAI 5.0a contains four Expense Modules in order to allow the user to display results by line density range, by wire center, by CBG, or by cluster.

historic expense ratios calculated from balance sheet and expense account information reported in each carrier's ARMIS report. These expense ratios are applied to the investments developed by the Distribution, Feeder, and Switching and Interoffice Modules to derive associated operating expenses. Non-plant specific expenses, such as network operations, on the other hand, are calculated in proportion to the number of access lines supported. HAI estimates direct network-related expenses (*i.e.*, network support, central office switching, central office transmission, cable and wire, network operations) for all UNEs and these operating expenses are added to the annual capital carrying cost to determine total expenses associated with each UNE. HAI then uses specific forward-looking expense factors to calculate the forward-looking cost of these expenses. HAI derives the forward-looking expense factor for digital switching and for central office transmission equipment from a New England Telephone cost study.[89] HAI computes a forward-looking network operations value based on the corresponding ARMIS value. HAI computes total network operations expense as a per-line additive value based on the ARMIS-reported total network operations expense divided by the number of access lines and deducts a user-adjustable 50 percent of the resulting quotient to produce a forward-looking estimate.

58. HAI assigns non-network related expenses to each density range, CBG, or wire center (depending on the unit of analysis chosen) based on the proportion of direct expenses (network expenses and capital carrying costs) for that unit of analysis to total expenses in each category. To calculate corporate overhead, HAI applies a user-adjustable 10.4 percent variable support factor to the total costs (*i.e.*, capital costs, network-related operations expenses and non-network related operating expenses) estimated for unbundled network elements, as well as basic local service. To calculate investment for furniture, office equipment, general purpose computers, buildings, motor vehicles, garage work equipment, and other work equipment, HAI uses actual 1996 company investments to determine the ratio of investments in these categories of investment to total investment. The ratio is then multiplied by the network investment estimated by the model to produce the investment in general support equipment. The recurring costs -- capital costs and operating expenses -- of these items are then calculated in the same way as the recurring costs of other network components. A portion of general support costs is assigned to customer operations and corporate operations according to the proportion of operating expenses in these categories to total operating expenses reported in ARMIS data. The remainder of costs is then assigned directly to UNEs. To calculate uncollectible revenues, HAI uses the ratio of uncollectible expenses to adjusted net revenue and applies a retail uncollectible factor to basic local telephone monthly service costs and uses a wholesale uncollectibles factor in the calculation of UNEs.

59. HAI bases the costs for basic local service on the cost of the UNEs constituting this service, *i.e.*, the loop, switch line port, local minutes portions of end office and tandem

[89] HAI Feb. 2 submission, Model Description at 70 n. 69 (*citing* New England Telephone, *1993 New Hampshire Incremental Cost Study,* Provided in Compliance with New Hampshire Public Utility Commission Order Number 20, 082, Docket 89-010/85-185, March 11, 1991.

switching, transport facilities for local traffic, and the local portions of signaling costs.[90] In addition, HAI includes costs associated with retail uncollectibles, variable overheads, and certain other services required for basic local service, such as billing and bill inquiry, directory listings, and number portability costs, which are estimated on a per-line basis. The model user can select the portions of non-traffic sensitive UNEs to include in the supported basic local service. Specifically, the user can vary the proportion of total expenses that are assigned to loop network elements (i.e., network interface device, distribution, concentration, and feeder) based either on relative number of lines or on the relative amount of investment. HAI includes a worksheet that breaks out investments and expenses by Part 32 accounts for comparison purposes

60. To calculate universal service support amounts, HAI compares the monthly cost per line in each density range, wire center, CBG or cluster to user-adjustable benchmark monthly costs for local service. If the cost exceeds the benchmark, HAI calculates the total required annual support according to the number of primary residential lines, secondary residence lines, single line business lines, or public lines by density range, wire center, CBG or cluster.

[90] On an optional basis, the usage sensitive cost of switched access use can be included as well. *See* HAI Feb. 2 submission at 73 n.70.

STATEMENT OF COMMISSIONER HAROLD FURCHTGOTT-ROTH DISSENTING IN PART

Re: Forward-Looking Mechanism for High Cost Support for Non-Rural LECs; (CC Docket Nos. 96-45, 97-160).

I want to express my appreciation to the staff who have worked so diligently to produce this internal model. I agree that this model has many benefits over either of the two industry submitted models, and I congratulate those involved for creatively incorporating the best aspects of both proposals.

Today, the Commission takes the next step in its plan to determine, from here in Washington, D.C., the total cost of providing service to every high cost resident in the country and then use that estimate to determine the total amount of high cost universal service support that should be needed to ensure service to everyone. I question whether the Commission can use such a hypothetical model to determine the cost -- whether actual or forward-looking -- of providing service to every individual, including those located in the remotest regions of our country. Moreover, I object to using a model to determine the total federal universal subsidy that is now needed or to distribute that subsidy among the states. Using a model for either of these purposes, as the Commission seems intent on doing, conflicts with the Telecommunication Act's mandate that we "preserve and advance" universal service and contradicts the Commission's promise to Congress last spring to the hold the States harmless -- i.e. guarantee that the adoption of a new federal universal service subsidy scheme would not result in any state receiving "less total interstate universal service support than is currently provided through aggregate implicit and explicit federal subsidies."[1] For these reasons, I dissent in part from today's Order.

I question, however, not that the model adopted today is superior to either model originally proposed, but the Commission's purpose in adopting a model at all. Indeed, as one fellow economist explained to me the other day, "but the model is good at evaluating relative costs" -- i.e. whether it costs more to provide service to residents of rural Montana than to residents of Minneapolis or even downtown Missoula -- "even if the model is not as good at determining absolute costs" -- i.e. how much it actually costs to provide service to a resident in either rural Montana or downtown Missoula. The problem is that it is the latter purpose -- determining an absolute cost of providing service to these areas and basing federal support on some percentage of that amount -- for which this agency seems intent on using the models.

I am also concerned about adopting this model before the Joint Board has made its final recommendation. The issues related to the use of explicit federal universal service support to reduce implicit federal support was raised in a request by the state Joint Board members and has been referred back to the Joint Board for further consideration. That issue seems necessarily to

[1] *Federal State Joint Board on Universal Service*, CC Docket 96-45, April 10, 1998 Report to Congress, FCC 98-67, at para. 197.

implicate the adoption of any model.

I fear that we are being requested to focus on the minute details of one possible solution without stepping back to consider the simple outlines of a broad range of possible solutions. In particular, I fear that we are now focusing narrowly on how to apply a specific model to determine the total high-cost support needed for non-rural telcos and how to allocate that amount between carriers or States when we have not even addressed the simple question of whether any model at all is necessary, or indeed even advantageous. Moreover, we seem to be focusing on how to improve the existing allocation of funds by giving more to some firms in some States and less to others thereby creating "winners" and "losers" when we could be making practically all consumers a "winner" by changing the way by which we raise funds. My reflections on these issues lead me to some tentative conclusions:

1. We do not need a federal model either to size or to allocate a fund for non-rural high-cost carriers, nor is one advantageous;

2. We should place the federal model in the public domain to allow the States to incorporate State-specific data and to use it as they see fit; and

3. We may be better able to improve consumer welfare by focusing on how we collect high-cost support than on how to reallocate support among existing users.

I. The Commission does not need to adopt a federal model.

A. The Commission should not adopt a model to distribute the current universal service support dedicated to non-rural carriers in high-cost areas. Current federal universal service support for non-rural carriers in high-cost areas is relatively small by national standards. For the Fourth Quarter of 1998, these funds are projected to be $253 million on an annualized basis, of which $140 million are for Puerto Rico. Twenty-two States plus the District of Columbia, Guam, and the Virgin Islands receive no support. Of the twenty-eight States that receive support, only two -- Alabama and North Carolina -- receive more than $10 million, and average support is much less than $5 million annually. Too much time and resources have been spent on the development of an extremely complicated model if the intent is only to use it to distribute this current amount of high-cost support.

Moreover, if the size of the federal non-rural high-cost support fund is to remain the same or shrink, a model can only divide an ever-dwindling pie. Any gain from any possible economic efficiency from reallocation -- and I am skeptical that there are any such gains to be made -- would likely be substantially outweighed by the political costs associated with a fight between new "winners" -- States and carriers that would receive more money than before -- and new "losers" -- States and carriers that would receive less money than before.

B. Unless the Commission breaks its promise to hold the states harmless at their current levels of "aggregate implicit and explicit support," the adoption of a model would

only create a larger total amount of federal support. There is ample reason to believe that the overall size of the federal non-rural high-cost support fund cannot easily shrink. Last April, the Commission indicated to Congress that, under new universal programs, we would hold carriers harmless. Specifically, the Commission indicated:

> [W]e note that the pre-may 1997 regulatory scheme created a de facto allocation of responsibility between the Commission and state commissions with respect t support for service to rural and high cost areas. The allocation of responsibility was defined by the separations rules, which placed 25 percent of booked loop costs in the interstate jurisdiction for most of the loop plant used by the non-rural LECs. . . . [W]e conclude that a strict, across the board rule that provides 25% of unseparated high cost support to the larger LECs might provide some states with less total interstate universal service support than is currently provided through aggregate implicit and explicit federal subsidies. The Commission will work to ensure that states do not receive less funding as we implement the high cost mechanisms under the 1996 Act. We find that no state should receive less federal high cost assistance than it currently receives.[2]

The plain language of this promise indicates that the Commission would ensure that States did not receive less in federal support than they do currently through explicit universal service funding and implicit support embedded in access charges. Thus, additionally allocating support using the model would allow States to choose the greater of what they would get under the model, or what they previously received through federal explicit and implicit support.

Some here at the Commission argue that all that was promised last spring was to hold the States harmless as to the current *explicit* fund. The language quoted above, however, indicates that the Commission's commitment to hold the States harmless goes farther. Apparently, whether this hold-harmless promise extends just to current explicit federal non-rural, high-cost universal support but not to all implicit federal subsidies will be the subject of semantic games. My impression is that many carriers and States -- and indeed many Members of Congress -- believe that universal service programs promulgated by the Commission will hold both carriers and States harmless. Indeed, the statute itself speaks of the "preservation" of universal service, not its reallocation.

Stated slightly differently, in the minds of many, high-cost support can only grow but not shrink. A related result is that if the relative allocation of high-cost support changes as the result of a cost model, total support can only grow because of the hold-harmless provisions.

If high-cost support is to increase, I am skeptical that a model that applies only to non-rural carriers is practical. If universal service support is to increase, why should it increase only for non-rural, high-cost carriers? Why not rural telcos as well? Or why not low-income households?

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[2] *Federal State Joint Board on Universal Service*, CC Docket 96-45, April 10, 1998 Report to Congress, FCC 98-67, at para. 197.

In the end, other than the current allocation, I can see no viable allocation of non-rural, high-cost support that does not raise more troubling questions than answers. Thus, I see no reason to use any cost model if the current allocation will ultimately be used. I fear, however, that the Commission may try to limit its hold harmless commitment to the current explicit universal service support, thereby reducing the total amount of federal universal support -- at least to some states. I cannot support such an attempt to reduce support when the statute mandates that the Commission "preserve and advance" universal service.[3]

C. Neither is this cost model the right tool for access charge reform. Some observers have suggested that a cost model may be useful for access charge reform. I fear that the same logical traps that apply to altering the allocation of non-rural high-cost funds apply here as well. There will likely be substantial political consequences if carriers and States are not held harmless relative to current receipts and current expectations of reductions in those receipts -- based on expectations of future productivity factors. Thus, reallocation of access charges based on a cost model would only result in an expansion of those funds relative to current levels. Again, any proposed expansion of high-cost support begs the question of why not expand other segments of universal service instead, such as low-income households. In sum, the only viable allocation in the near term will be the current allocation.

II. What should the Commission do with these cost models?

As I have explained above, I don't believe that the cost models should be used to either size the universal service fund or to distribute money from the fund among the States. Fundamentally, what this Commission must decide is whether it believes that the current level of federal support (both explicit and implicit -- including access charges) is sufficient to support universal service. Even if the models can play a helpful role in determining relative costs between high cost and low cost areas, I am concerned that it is an inappropriate tool for determining the absolute cost of service to any particular area. Consequently, I question whether the models can determine the ultimate universal service subsidy needed. At present, I am not convinced that the total federal outlay is in excess of what is necessary; rather, I believe the Commission should hold the States harmless as to the amount that carriers currently receive. Thus, I do not support using the models to determine the size of universal service support.

I do believe, however, that the models can play a valuable role in the debate on universal service. The models are a valuable tool that could be use at the State level to distribute universal service support to carriers within a State. I would support the Commission releasing this model to the public, explicitly acknowledging the possible benefits of this model over both of the other proposals. States would then be free to use the federal model platform, modified as they see fit and with as many State-specific inputs as any State feels is appropriate, to distribute universal service funds within a State.

Along those lines, I also object to this agencies continued efforts to perfect and maintain

[3] 47 USCA section 254

control of this model at the federal level. As I have described, I am unclear as to what purpose we in the federal jurisdiction can put this tool. While we may have provided a valuable service to states in developing this for their use, we cannot afford to continue to expend the time and resources necessary to further develop and maintain this tool. Especially since its most useful purpose is at the state level with state specific inputs. We should expeditiously seek to provide the model to the States and allow them to perform whatever additional work is necessary to use it as they see fit.

III. It is more important for the Commission to act to improve consumer welfare by ensuring that the universal service burden is not imposed through usage-sensitive fees.

Up until now, most of the Commission's efforts seem to be focused on either sizing or reallocating universal service support. I believe that the first step in universal service reform should focus on the collection of the universal service subsidy. Some consumers will win and some will lose if we develop new mechanisms to reallocate universal service, but practically all consumers may benefit if we move to a more rational form of collecting universal service fees.

A recent study by Jerry Hausman[4] illustrates the enormous penalty that consumers pay when universal service is supported by taxes and fees on a usage-sensitive basis. For example, for every dollar collected on fees assessed on long-distance service, such as access charges, consumers lose more than two dollars in welfare.

The solution is not to broaden the tax base because a broadened tax base, no matter how defined, will still impose usage-sensitive fees. Instead, consumer would be much better off with a fixed assessment, such as a per-line charge. This assessment could distinguish between business and residential customers.

There is ample legal precedent for a federal per-line charge. The current SLC and PICC are assessed per line. There are several other reasons to use a per-line charge, which I outline below.

A. Fees must be in exchange for service. The FCC has the authority to levee fees, not taxes. For a payment to be a fee, there should be something tangible received in exchange. We should therefore define precisely those services and conditions that telecommunications carriers (as the direct contributors to universal service) and consumers (as the indirect contributors to universal service) receive from the federal government and the FCC in particular.

I believe that carriers and consumers do receive something from the FCC. In particular, the FCC administers or is responsible for:

a. Numbering system or addressability of telecommunications;

[4] Jerry Hausman, *Taxation by Telecommunications Regulation: The Economics of the E-Rate*, (Washington, D.C. AEI Press, 1998).

b. Ensuring access to an interstate telecommunications network;
c. Ensuring access to an interstate telecommunications network with nodes that have been expanded as the result of universal service (to high-cost areas and low-income households); and
d. For carriers, a centralized system for the determination of payments.

There may be other services that the FCC performs, but any service that the FCC provides, I believe, is fixed in cost and is not usage sensitive. That is, the service that the FCC provides a carrier or a customer is the same whether a customer is making a one-minute or a one-hour interstate call. Consequently, any fee structure that the FCC might consider for universal service should be fixed for the sake of consistency with the fixity of the service provided. Moreover, any usage-sensitive charge from the FCC, to the extent services provided are not usage sensitive, runs the risk of being a tax.

B. Federal fees should be consistent with the law. The federal government and the FCC cannot tax intrastate services. Moreover, the FCC has little or no authority to place universal service fees on entities that do not provide telecommunications services. Primary responsibility rests with telecommunications carriers, the same population that may become eligible carriers.

C. Fees should be consistent with technology. A rational universal service fee must not only avoid being a tax, but it should also avoid being inconsistent with technology and market developments. Telecommunications markets are evolving rapidly with multiple services available to consumers. Some of these services are provided by telecommunications carriers subject to universal service fees; some services are available from other services. Consumers have opportunities to avoid usage-sensitive fees by selecting service providers that are not technically telecommunications carriers. To the extent a universal service fee structure is inefficient, it will artificially accelerate the migration of traffic away from telecommunications carriers.

Future technologies are even more incongruent with usage- sensitive access fees. Telecommunications networks may well develop into predominantly packet-switched networks in which line access is not a particularly relevant concept. Within these packet-switched networks, determining what is interstate and what is not, and determining the identity and purpose of traffic, are impossible tasks.

D. A federal per line fee would ease the universal service burden over time and allow for an easier transition. The number of lines has been growing rapidly in recent years. Thus, a flat per line universal service fee would produce increasing revenues every year. If we held the amount of federal universal service subsidy fixed at current levels, the burden that each subscriber carries would decrease each year. In addition, the Commission could consider phasing in the flat fee to take advantage of the growth in the number of lines. Moreover, a flat fee should reduce usage rates, thereby expanding demand for usage-sensitive services, increasing carrier revenues, and ultimately reducing requirements for universal service support.

IV. Conclusion

The need to adopt a federal model necessarily means that the Commission is heading down one of three paths, none of which I could support.

First, the Commission might not use the model to size or to distribute universal service funding. This is the path I would recommend, and to which I would ask then why do we need to officially adopt a model today and maintain it in the future. This exercise would be an unfortunate use of the Commissions time and resources.

Second, the Commission could use the model to size and distribute the universal service funds but also fulfill its commitment to hold the states harmless. Such actions, however, would thereby create a larger total federal universal service subsidy. Then I would ask why the rural carriers have not also had the opportunity to gain a larger share of support.

Third, and most likely, the Commission will limit its hold-harmless promise to the current explicit universal service fund, using the model to size and distribute the new high cost fund and to justify a net reduction in the current federal subsidy flow. In light of this agency's statutory mandate to preserve existing universal service and its own promise to Congress that it would hold the states harmless, I would object to such an attempt.

Ultimately, today's Commission action only begs the greater question of the allocation of universal service support between the federal and state jurisdictions, raising more questions about the Commission's direction than it provides answers.