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THE COST OF BASIC NETWORK ELEMENTS: THEORY, MODELING AND POLICY IMPLICATIONS

PREPARED FOR

MCI TELECOMMUNICATIONS CORPORATION

BY

HATFIELD ASSOCIATES, INC.

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EXECUTIVE SUMMARY

The Telecommunications Act of 1996 requires unbundling of monopoly local exchange networks into functional elements that can be used by local and long distance competitors. Cost-based pricing is necessary to promote local competition and to reduce the possibility of competitive harm in the long distance business when the Regional Bell Operating Companies (RBOCs) are allowed to enter. This paper presents a new model that is used to estimate the economic cost of these network elements.

The New Hatfield Model estimates the Total Service Long Run Incremental Cost ("TS-LRIC") of unbundled network elements such as switching, loops and interoffice transport. It is well understood that existing Federal Communications Commission ("FCC") access charges are priced substantially above cost. The costs analysis produced here shows that access charges must fall from the current level of approximately seven cents per minute to less than a penny.

The Local Exchange Carriers ("LECs") will criticize the model on various grounds. However, the FCC will likely discover that to the extent these criticisms have any validity, they can only be addressed by the application of data that are currently in the exclusive possession of the LECs themselves. As the recently produced Benchmark Cost Model ("BCM") shows, when the LECs have incentives to cooperate, they are able to produce useful data and information to the FCC. The FCC should accept the estimates developed here unless and until the LECs provide additional data that can be used in the Hatfield Model.

The model can also be used to quantify the gap between the bottoms up economic cost of providing unbundled network elements and the tops down revenue requirement on which existing access charges are based. This gap is large – approximately 46 billion dollars. Some portion of this gap represents the economic costs of supporting the service that are purchased by

end-users as opposed to the carrier services included in this model. Some portion of the gap is due to underdepreciation and inefficiencies in LEC networks. However, the largest portion of the gap is due to excess investment by the LECs.

Reducing current interconnection rates to cost will not necessarily harm the LECs. The 1996 Act provides these carriers with new opportunities. More significantly, a significant portion of the existing gap may be explained by investments designed to allow local telephone companies to enter new markets, such as long distance and video. These investments are not necessary for the provision of existing monopoly services.

The model presented here is based on an earlier Hatfield Associates, Inc. study. The original study, titled The Cost of Basic Universal Service, was released in July, 1994. This study incorporates many additions and refinements to the original. The current model retains the "green field" approach in which the network is assumed to be constructed with new facilities, including loop and interoffice plant, along with wire centers.

As before, the model follows TS-LRIC principles in employing "forward looking" network technology, including digital switching and use of digital loop carrier equipment along with optical fiber feeder cables. It also assumes full deployment of Signaling System 7 (SS7) among end-office and tandem switches and includes facilities – operator tandems and trunks – required to provide operator services. The network is sized to provide existing local service, including public telephones, as well as intraLATA toll, exchange access, and CLASS features.

The recurring costs of providing the unbundled network elements are estimated based on the investment figures generated by the network model. The recurring cost component of the model has three components. First, the model determines the capital carrying cost for each

component of investment associated with the network function. Second, it determines the network-related expenses associated with each component of investment. Finally, it determines non-network-related expenses, and assigns the expenses to the specific network functions.

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THE COST OF BASIC NETWORK ELEMENTS: THEORY, MODELING AND POLICY IMPLICATIONS[1]

Successful implementation of the Telecommunications Act of 1996 ("1996 Act") requires the unbundling and cost-based pricing of local monopoly network functions such as the local switching and transport components of exchange access. Prices for essential monopoly inputs must be set at cost, both to maximize the potential for local competition, and to minimize the potential for competitive problems in the long distance business. The Federal Communications Commission ("FCC") does not have a mechanism for evaluating the economic cost of these network functions.[2] Therefore, an economic costing procedure must be established.

This paper presents the results of a new model that estimates the Total Service Long Run Incremental ("TS-LRIC") costs of the basic Local Exchange Carrier ("LEC") network functions. This analysis builds on The Cost of Basic Universal Service, a July, 1994 Hatfield Associates, Inc. ("HAI") study. The 1994 study estimated network costs for a subset of the services provided by the LECs. This estimate was used to put a $4 billion price tag on the subsidy now flowing to Universal Service. The expanded model, presented in this paper, allows two additional critical questions to be addressed. First, what are the costs of unbundled network functions? Second, to the extent existing LEC revenues exceed the TS-LRIC costs of the unbundled network elements, what explains this gap?

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[1] A description of Hatfield Associates, Inc. ("HAI") is attached.

[2] Existing access charges are based on the FCC's Price Cap Plan. Historical investment and expenses, together with the Jurisdictional Separations Process, provide the foundation for the capped rates. Consequently, access charges are significantly higher than economic cost, which continues to decline in this industry.

This paper begins in Section I by describing the relationship between local and long distance competition and unbundling, costing, and pricing issues. Section II surveys the current evidence regarding the cost of network elements for which costs must be developed. Further identification of the unbundled network elements, or "building blocks," is in Section III. The economics of network element costing is discussed in Section IV. Section V describes the HAI costing model. Section VI provides the cost modeling results. Differences between the economic cost of access measured by HAI and the existing embedded costs of the local exchange carriers ("LECs") are explained in Section VII. Section VIII discusses ways to deal with the difference between economic cost and existing inflated revenue requirements. The relationship between Universal Service and the issues discussed in this paper is briefly described in Section IX. The paper concludes in Section X with recommendations for next steps.

I. PREREQUISITES FOR RBOC INTERLATA ENTRY

The 1996 Act paves the way for Regional Bell Operating Company ("RBOC") entry into the $70 billion long distance market, the largest portion of which is regulated by the FCC. When this occurs, the RBOCs will again be in the position of providing essential monopoly inputs to their competitors. The premise of the Modification of Final Judgment in U.S. v. AT&T ("MFJ"), which the 1996 Act replaces, was that an input monopolist could leverage its market power in the supply of access to reduce competition in the downstream long distance market.[3]

Monopoly leverage can be accomplished in many ways. Access to essential facilities can be denied, the price of essential inputs can be set artificially high, or the prices of competitive

[3] U.S. v. AT&T, 552F. Supp. 131 (D.D.C. 1992).

services can be subsidized from monopoly revenues.[4] Requiring competitors to dial extra digits or failure to provide signaling information necessary to fully process long distance calls are examples of denying access to essential facilities. Overpricing essential facilities or underpricing competitive services would result in a price squeeze, which would prevent efficient competitors from earning a competitive return.

A. Long Distance Competition

The long distance market is highly competitive. This prompted the recent decision by the FCC to declare AT&T non-dominant.[5] The FCC Staff recently found that " . . . it appears that between 1992 and 1994, interstate switched [long distance] rates fell significantly more than can be attributed to the drop in interstate access rates."[6] This result is consistent with an earlier analysis of long distance pricing by Robert Hall.[7] These two analyses of long distance industry performance show that rivalry among the firms in the market is intense.

The Hall study also points to the absence of entry barriers in the long distance market.[8] This means that RBOC entry is unlikely to increase rivalry in the long distance market. Instead of additional competition, RBOC entry would likely lead to the replacement of some one or more

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[4] See Brennan, Timothy J., "Why Regulated Firms Should Be Kept Out of Unregulated Markets: Understanding the Divestiture in U.S. V. AT&T," Antitrust Bulletin, 1987.

[5] In the Matter of Revisions to Price Cap Rules for AT&T Corp., CC Docket 93-197, Report and Order, 10 FCC Rcd 3009, 1995.

[6] See Lande, Jim, Telecommunications Industry Revenue: TRS Fund Worksheet Data, February, 1996, p. 7.

[7] See, Hall, Robert E., Long Distance, Public Benefits from Increased Competition, October, 1993.

[8] *Id*, p. 20-21.

firms now in the market. Therefore, the benefits of RBOC entry into long distance may be small.

On the other hand, the costs of RBOC entry may be high. RBOC entry could distort long distance market competition by driving equally efficient, or more efficient, firms from the market. Access charge reform is necessary to reduce this possibility.

B. Necessary Safeguards

Unbundling, resale and cost-based pricing of essential network elements are necessary safeguards to limit anticompetitive activity. Network unbundling will make discrimination more difficult. Competitors will be able to purchase the same capability and pay the same price for network elements as the LEC's long distance operation. In the same vein, unbundling should also discourage the LEC from forcing a competitor dependent upon the local exchange network to buy (through unnecessary bundling) basic building blocks or network elements they do not need, or could provide more effectively or efficiently themselves.[9]

Requiring tariffing of the unbundled network elements addresses the discrimination issue by making it more difficult for LECs to price network elements in ways that favor their long distance customers. For example, if a vertically integrated LEC attempts to favor its long distance affiliate with an interconnection price that is too low, competitors could take advantage of the same low price. Successful implementation of such a policy requires that prices for all customers, including the LEC's long distance affiliate, be public – i.e., tariffed.

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[9] If price cap or incentive regulation plans allow the regulated firm to keep additional profits, the monopolist would actually have an increased incentive to use access discrimination against competitors in a regulated line of business. In effect, discrimination becomes more profitable in this circumstance. Under cost-based pricing, or under classic rate of return regulation, these profits would be limited and the benefits of discrimination correspondingly reduced.

Unbundling and tariffing are essential tools in the regulation of vertically integrated monopolists. However, unbundled network elements and resale will not prevent excessive rates for unbundled elements or access charges. Therefore, cost-based pricing is a third essential safeguard.

Excessive prices for essential monopoly inputs can damage consumers and competition in several ways.[10] Any price that exceeds cost is economically inefficient. This is a particular problem in the long distance market. Given that demand is relatively elastic, pricing access at cost would stimulate a significant number of long distance calls. Therefore, access charges in excess of costs have a large negative effect on consumer welfare through reducing allocative efficiency. Excessive charges for unbundled network elements could also lead to inefficient local entry, with consequent resource losses.

C. Cost-Based Pricing and Price Squeezes

Prices for unbundled network elements that exceed costs can also have direct negative effects on competition. Prices for essential monopoly inputs that exceed costs can squeeze the margins of competitors. In a price squeeze, the margin between the monopoly access and interconnection element and the final price of the competitive service is reduced by pricing the

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[10] FCC Chairman Hundt recently pointed out that ". . . the current system of access charges is both unfair and unsustainable. It is unfair because our current rules overcharge some people, give others a special deal they don't necessarily need, and give potential competitors distorted investment goals." Reed Hundt, Chairman, Federal Communications Commission, speaking before Deloitte & Touche Consulting Group, Telecompetition '95, Washington D.C., December 5, 1995.

former too high or the latter too low. The result is the inability of the competitor to make a profit, although it might be as efficient as, or more efficient than, the monopoly input provider.[11]

Imputation rules require the vertically integrated supplier of an essential input to charge itself, or "impute" into its own rates, the same cost of access that it charges its competitors in the downstream market. The economic cost of non-access inputs into the long distance business must also be imputed into the vertically integrated firm's final service rates. If the monopoly access supplier charges its long distance competitors three cents per minute to use the local network, then this amount, plus the economic cost of providing toll services, must serve as the price floor for LEC long distance services.

Imputation is necessary, but not sufficient, to prevent a price squeeze. If the imputed access charge is greater than the economic cost of access, then the monopoly input supplier is recovering non-economic costs, or the true economic cost of its own toll services, from its competitors. This is a problem because, even if imputation works in theory, in practice it is difficult to do. Estimates of the incremental cost of both toll and access are subject to errors.[12] Moreover, application of imputed charges to particular LEC toll services can be difficult. In

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[11] As noted above, unbundling and resale are powerful anti-discrimination tools. To the extent these safeguards work well, LECs will have an even greater incentive to create a competitive advantage for themselves in the long distance market by pricing essential network elements above cost.

[12] No cost study is perfect. Moreover, LECs always have the opportunity to design monopoly networks in ways that favor their competitive toll services. As the Council of Economic Advisors recently pointed out " . . . regulators today may be more attuned to the dangers of discrimination, but preventing through regulation all avenues of technological discrimination in network access is still likely to be difficult." See, Economic Report of the President, February, 1996, p. 173. The lower the price of access, the less damage LECs can do when they engage in this behavior.

general, if the absolute level of access charges is reduced, the potential for an error that can damage competition is also reduced.

Access charges that exceed costs will also place an artificial floor on the prices of long distance services. This will reduce static economic efficiency. Moreover, the smaller size of the market will retard entry and expansion. This is not an academic issue. Access charges are a significant component of long distance service costs. In 1993, access charges paid by AT&T amounted to 43 percent of its operating expenses.[13]

LECs have argued that strict imputation rules force them to include costs they do not incur in the provision of their own service.[14] This criticism could be valid if access charges imputed to LEC toll services recover the cost of network elements they do not use, or use less extensively than their access customers. However, access services have already been unbundled somewhat, and will be unbundled further to comply with new legislative requirements. With unbundled network elements, it will be possible to require imputation of only the basic elements the LEC uses in its service.

II. CURRENT PRICES ARE TOO HIGH

The approximate nationwide average charge for access is 3.7 cents per minute on each end, which includes a local switching charge of 1.9 cents.[15] There is no question that these LEC

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[13] FCC, Preliminary Statistics of Communications Common Carriers, July 7, 1995, Table 2.9.

[14] See, Kahn, Alfred E. and William E. Taylor, "The Pricing of Inputs Sold to Competitors: A Comment," 11 Yale Journal on Regulation 225, 1994.

[15] These figures are derived from LEC TRP data.

interconnection rates are substantially higher than cost. As the Council of Economic Advisors recently affirmed, "access fees charged by local network operators to long distance companies far exceed marginal costs."[16] This Section surveys some of the evidence.

A. State Interconnection Rates

Regulators in Illinois and Maryland have established rates for local interconnection that are much lower than LEC switching charges, although the functions performed are virtually the same. Maryland has set the rate for interconnecting competitive local exchange carriers ("CLECs") at end-office switches at 0.3 cents per minute.[17] The Illinois Commission Staff found that Ameritech should charge 0.5 cents per minute for end-office connection.[18]

B. LEC Cost Studies

Pacific Telesis recently reported that the " . . . 24 hour average LRIC for Feature Group B termination is approximately $0.0062 [0.62 cents] per minute . . . ."[19] A publicly available New England Telephone incremental cost study estimated a cost for switched access of 0.24 cents per

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[16] See, Economic Report of the President, *supra,* note 12, p. 176.

[17] Maryland Public Service Commission, In the Matter of Investigation by the Commission on Its Own Motion into Policies Regarding Competitive Local Exchange Telephone Service, Case No. 8584, Phase II, Order, December 28, 1995, p. 32. The price for connection at the tandem, which includes some transport, was set at 0.5 cents per minute.

[18] Illinois Commerce Commission, Illinois Bell Telephone Company Proposed Introductions of a Trial of Ameritech's Customer First Plan in Illinois, Case No. 94-0096, Order, April 7, 1995, p. 85. Tandem connections were priced at 0.75 cents.

[19] Statement of Professor Jerry A. Hausman, submitted with Comments by Pacific Bell, Pacific Bell Mobile Services, and Nevada Bell, in Interconnection Between Local Exchange Carriers and Commercial Mobile Radio Service Providers, CC Docket No. 95-185, March 4, 1996, p. 14.

minute for the day period.[20] A study undertaken for USTA by Strategic Policy Research ("SPR") estimated the incremental cost of access, including both switching and transport functions, at 1.3 cents per minute. SPR deliberately used a "high end" estimate to be conservative for the purposes of their study.[21]

Table 1 summarizes this survey of access charge elements. Most of these estimates are well below a penny per minute, and substantially lower than existing interstate switching charges, which average 3.7 cents per minute.

Table 1
Per Minute Costs

	Element	Rate
Maryland Public Service Commission	End-office Switching	0.3
Illinois Commerce Commission	End-office Switching	0.5
Pacific Telesis	Terminating FGB	0.62
NET	Switched Access	0.24
Marcus-Spavins	Switched Access	1.0
USTA	Switched Access	1.3

[20] See New England Telephone Company, 1993 New Hampshire Incremental Cost Study, p. 377.

[21] See, USTA, "Potential Impact of Competition on Residential and Rural Telephone Service," July 21, 1993, and Monson, Calvin S. and Jeffrey H. Rohlfs, "The $20 Billion Impact of Local Competition in Telecommunications," July 16, 1993, Appendix, pp. 2-3. SPR cites a study by two FCC staff members, who estimated an incremental cost of access and toll at 1.0 cents per minute. See, Marcus, Michael J. and Thomas C. Spavins, "The Impact of Technical Change on the Structure of the Local Exchange and the Pricing of Exchange Access: An Interim Assessment," unpublished draft.

C. Interstate Carrier Common Line Charges

Interstate access charges contain a substantial Carrier Common Line Charge ("CCLC"). The CCLC is currently 0.73 cents per minute on the originating end and 0.93 cents per minute on the terminating end. This charge is based on the assignment of 25 percent of non-traffic sensitive costs to the interstate jurisdiction. The portion of the NTS revenue requirement that is not collected directly from end-users through subscriber line charges ("SLCs") is collected from interexchange carriers (and, of course, ultimately their customers) through the CCLC.

The CCLC is not related to the economic cost of interexchange access. It collects part of the cost that end-users cause when they make the decision to subscribe to the local telephone network. The function of the CCLC is sometimes represented as a means to encourage subscription to the local telephone network by keeping local rates low. Even on this basis, the CCLC is too large. First, from an economic point of view, subsidies should be narrowly targeted to those consumers who would not subscribe to the network if they had to pay for the full cost. The subsidy required to meet this objective is likely quite small.[22]

Second, even assuming that as a matter of public policy, regulators decide that all local ratepayers are entitled to service at or near existing prices, the CCLC is still too large. Prices for local service (including the SLC) are already at or above economic cost for most subscribers to the network. As the earlier HAI study shows, subsidies are only necessary in low density areas,

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[22] See, Hatfield Associates, Inc., The Cost of Basic Universal Service, July, 1994.

where the cost of local service is substantially higher than the national average.[23] Such subsidies should be collected from all carriers. This issue is discussed further in Section IX.

The CCLC can be reduced in one or more of several ways. The interstate NTS revenue requirement could be reallocated to the intrastate jurisdiction through changes in the Separations Rules. Alternatively, SLCs could be increased. However, before either of these options are considered, the FCC and state regulators should investigate telephone company costs. If the NTS revenue requirement is reduced to economic cost, the amount of jurisdictional cost shifting or SLC increases would likely be small. It is even possible that SLCs could be reduced.

The FCC's recent unbundling and repricing of transport rates provide further evidence that interstate access charges are too high. LECs had claimed that special access rates were cost-based. However, when the FCC ordered that switched transport rates be priced at special access equivalents, the LECs revealed several sources of cross-subsidy and inflated costs in the rates.[24]

D. Unbundled Loop Charges

Unbundled loop charges have also been set by a few state Commissions. The Michigan Commission has set a price of $11.00 for residential loops and $8.00 for business loops.[25] Ameritech filed loop rates ranging from $4.59 to $12.14 for residential loops and $7.28 to $14.65 for business loops. Finally, Frontier in Rochester prices residential loops at $14.45 and business

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[23] The CCLC is not an efficient means of collecting such a subsidy. *Id.*

[24] The FCC allowed the LECs to recover these costs through a residual interconnection charge ("RIC"). The RIC currently averages 0.7 cents per minute.

[25] Michigan Public Service Commission, Case No. U-1064, Order, February 23, 1995.

loops at $8.29. These loop rates are well below the average embedded inter plus intrastate NTS revenue requirement of approximately $24 per line per month.[26]

A group of carriers, including MCI, U S West, Sprint and NYNEX have produced a Benchmark Cost Model ("BCM") that can be used to estimate loop costs.[27] An average nationwide cost per loop of between $10.93 and $15.07 monthly can be derived from the BCM. The larger number includes embedded expenses while the smaller number recognizes that forward looking technology will reduce operating expenses for an efficient firm without excess capacity. Both numbers are biased upwards because they include expenses that should not be included in the TS-LRIC of an unbundled network element.

III. NETWORK BUILDING BLOCKS

The 1996 Act requires unbundling of the local network into its functional elements. These network piece parts can be thought of as the "building blocks" of the monopoly local exchange network. Under the building blocks approach to costing and pricing, the unit of analysis for costing purposes begins with basic functional elements of the network, rather than with final services. Once the functional elements are identified and costed, then service costs can be "built-up" from the individual elements. Each service that uses the same element in the same way has the same cost attributed to it. Competitors will use these building blocks to provide either competing local services or to provide vertically related services such as toll.

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[26] Calculated from ARMIS Report 43-01.

[27] See MCI Communications, Inc., NYNEX Corporation, Sprint/United Management Co., and U S WEST, Inc., Benchmark Cost Model: A Joint Submission, CC Docket No. 80-286, December 1, 1995.

Implementation of network unbundling requires the identification of individual network elements (the building blocks). This step requires a technical assessment and functionalization of the local exchange network. Basic categories of building blocks include loops, local switching, and common, direct and tandem transport. Other possible candidates are interoffice signaling and operator functions.

Table 2 displays the unbundled network elements for which costs were developed here.[28] This list is not meant to be exhaustive. The loop can, for example, be further disaggregated into distribution and feeder components, and can be multiplexed or not multiplexed. The local switching function has both traffic sensitive and non-traffic sensitive components. The cost of these components are identified as local switching and ports. As noted above, competitors will purchase these unbundled elements for use as inputs into their own services. Therefore, there must be a price associated with each building block.

Table 2
Network Elements

Element	Costing Basis
Loop	number of lines
Local Switch	minutes of use number of connections (ports)
Transport Dedicated Common Tandem Switch	 number of lines minutes of use per leg minutes of use
Signaling	minutes of use
Operator Functions	minutes of use

[28] Unit costs are shown in Appendix 1.

IV. MEASURING ECONOMIC COST – THEORY

As discussed in Section I, prices should be based on economic cost if the goals of maximizing economic efficiency, encouraging local competition, and preserving long distance competition are to be met. This Section discusses the measurement of economic costs. The conclusion is that the prices of essential monopoly inputs should be set at TS-LRIC.[29]

A. What Is Economic Cost?

Economic cost is the forward looking, least cost of providing a good or a service using the best available technology. Economic cost can be contrasted with historical, or embedded cost, which may reflect inefficiencies, excess investment, or the use of technology that is no longer state of the art. Alternate measures of economic cost are discussed below.

Rates should be set at economic cost because they are efficient. From a societal point of view, rates equal to economic cost will bring the optimal amount of resources into the market. Moreover, as discussed above, if rates for unbundled network access are above their economic cost, competition in both local and long distance markets will be distorted.

B. Alternate Measures of Economic Cost

Economic costs can be measured in the short run or the long run. There is increasing agreement among economists and state regulators that TS-LRIC should be used to measure economic cost. TS-LRIC measures the total cost of providing an entire network building block. In other words, the increment to be measured is between providing and not providing the network element. In this way, all of the costs associated with providing a service are recovered

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[29] TS-LRIC studies can be used to measure the costs of the network elements from which services are constructed. The "service" in TS-LRIC is a term of art.

from the customers who buy the service. As discussed below, TS-LRIC is superior to other potential measures of economic cost for purposes of establishing the cost of unbundled network components.

In the past, LECs have proposed to measure incremental cost based on discrete changes in demand and cost. In other words, an increment of demand will be selected and the costs of adding capacity to serve the increment are computed. Incremental cost then is measured by the change in cost divided by the change in demand. This is a simple long run incremental cost ("LRIC") approach. Total demand multiplied by incremental cost computed in this way may not generate revenues sufficient to recover the total costs of the service. Therefore, a simple incremental cost standard can result in consumers paying excessive rates for monopoly services because they are likely to be charged for the shortfall. At the same time, prices below TS-LRIC in competitive markets will discourage entry and expansion by firms who can offer the service at a price below the TS-LRIC of the LEC, but above the simple incremental cost. In other words, unless a TS-LRIC cost standard is used, a vertically integrated monopolist can cross-subsidize competitive services.

V. MEASURING ECONOMIC COST – PRACTICE

The FCC has never performed a detailed analysis of the economic cost of providing the telephone services it regulates. As long as local telephone companies retained *de jure* or *de facto* monopolies, and as long as the structural safeguards contained in the MFJ were in place, the issue of economic cost of service could be avoided. That choice is no longer available to the FCC. The 1996 Act opens local markets to competition, and allows the RBOCs to enter the long distance market, if they comply with certain prerequisites.

As discussed above, the FCC should identify network building blocks and estimate the economic costs for each using a TS-LRIC methodology. HAI has performed a TS-LRIC study that can be used to estimate the cost of various network elements. This Section describes the various elements of the Hatfield Model.

The Hatfield Model is a "green field" approach in that it is not constrained by the existing network topography. LECs have criticized the Hatfield Model for failing to reflect the "real world" network they have deployed. However, economic cost is based on providing the service in ways that the best available technology allows. In competitive markets, prices are based on the investment and expenses that an efficient new entrant using modern technology would incur. The existing infrastructure of any particular competitor is irrelevant. By attempting to measure costs using existing network configurations, the telephone companies are evidently trying to find ways to recover at least some of their embedded costs.

In any event, the BCM Model discussed in Section II, which is not based on the green field assumption, estimates loop costs that are below those generated by the Hatfield Model. While there are many other differences between the two models, this suggests that the green field assumption does not have a dramatic effect on loop cost estimates. The BCM is discussed further below.

A. Description of the Network Model

The network investment model used in the study incorporates many additions and refinements to the original Hatfield Universal Service study produced in July 1994.[30] As

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[30] The Cost of Basic Universal Service, *supra*, note 22.

discussed above, the current model retains the green field approach in which the network is assumed to be constructed with new facilities, including loop and interoffice plant, along with wire centers. As before, the model follows TS-LRIC principles in employing "forward looking" network technology, including digital switching and use of digital loop carrier equipment along with optical fiber feeder cables for longer loops.

The model also assumes full deployment of Signaling System 7 (SS7) among end-office and tandem switches and includes facilities – operator tandems and trunks – required to provide operator services. The network is sized to provide existing local service, including public telephones, as well as intraLATA toll, exchange access, and CLASS features.[31] Model fill factors are always substantially less than one, allowing for future growth. The remainder of this Section outlines the assumptions and general methodology followed by the model. Figures 1 through 3 give an overall view of the basic network structure in increasing level of detail. Figure 4 shows the network element cost model components and their inputs.

1. Population Densities

The model computes the network facilities required to serve the U. S. population as divided into six population density ranges. The ranges, and the estimated total population in each, are shown in Table 3.

[31] CLASS is a trademark of Bell Communications Research.

Table 3
Population Density Ranges

Range (population per square kilometer)	Population
0 - 10	14,893,004
10 - 100	50,509,999
100 - 500	45,689,087
500 - 1000	32,888,352
1000 - 5000	93,723,779
greater than 5000	21,696,610

Population in each range is based on the total population reported in the 1990 U. S. Census. We used a weighted average increase in population of 4.3 percent to estimate the population in the study year, 1994.[32] Lacking more detailed information, we applied the 4.3 percent growth factor uniformly across all six density ranges.

The FCC's Preliminary Statistics of Communications Common Carriers for 1994 was used as the source of total switched and special access lines and overall residential penetration (assumed at 94 percent across all density ranges).[33] We also used the FCC's figures for breakdowns of total switched access lines among residential, business single line and multiline service.[34]

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[32] We calculated the population increase from state-by-state population growth estimates contained in Rand-McNally's 1995 Commercial Atlas and Marketing Guide.

[33] FCC, Monitoring Report, May, 1995, CC Docket No. 87-339, Table 1, "Household Telephone Subscribership in the United States."

[34] "Multiline" business lines are high usage facilities such as PBX trunks.

Figure 1
Local Exchange Network Structure

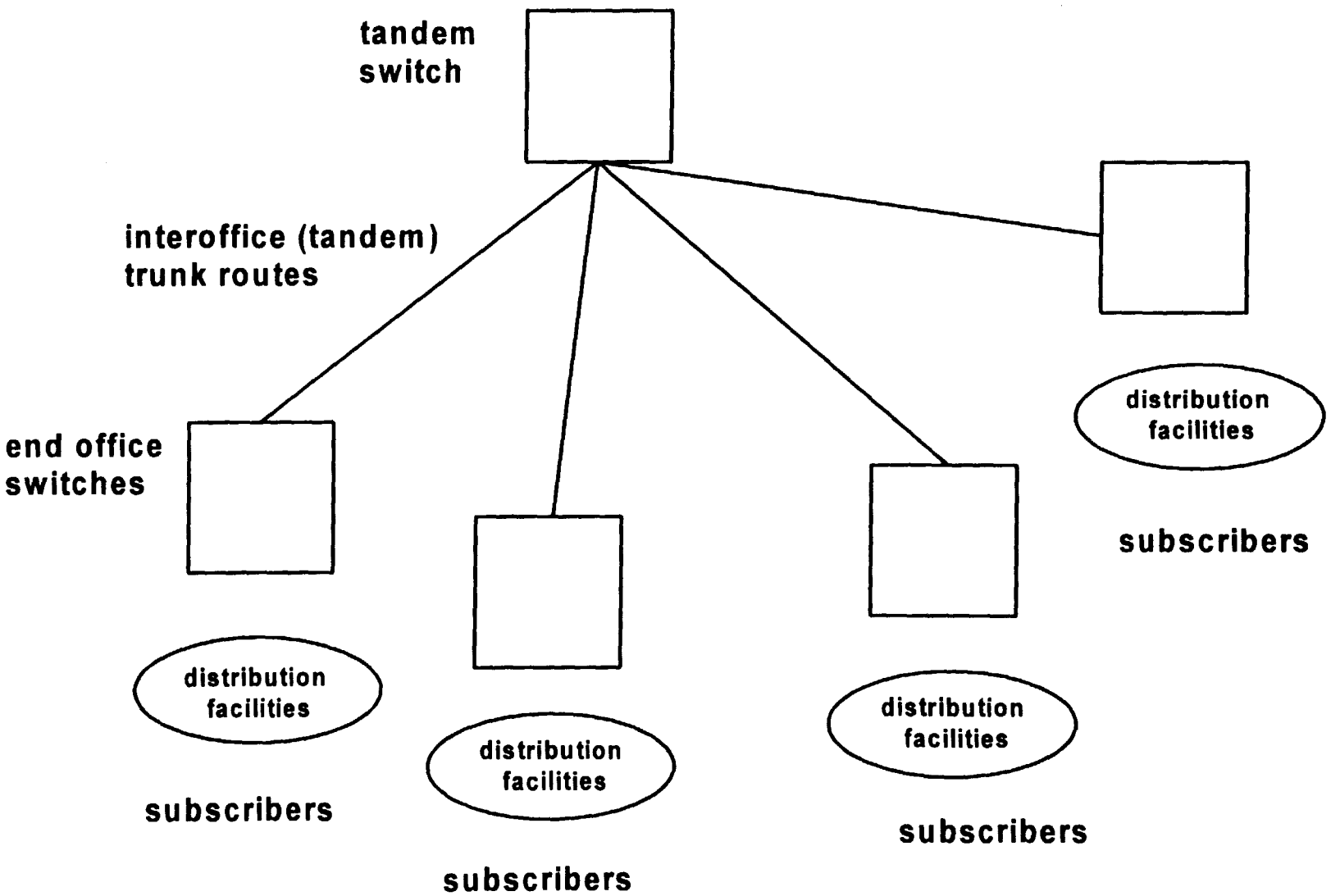
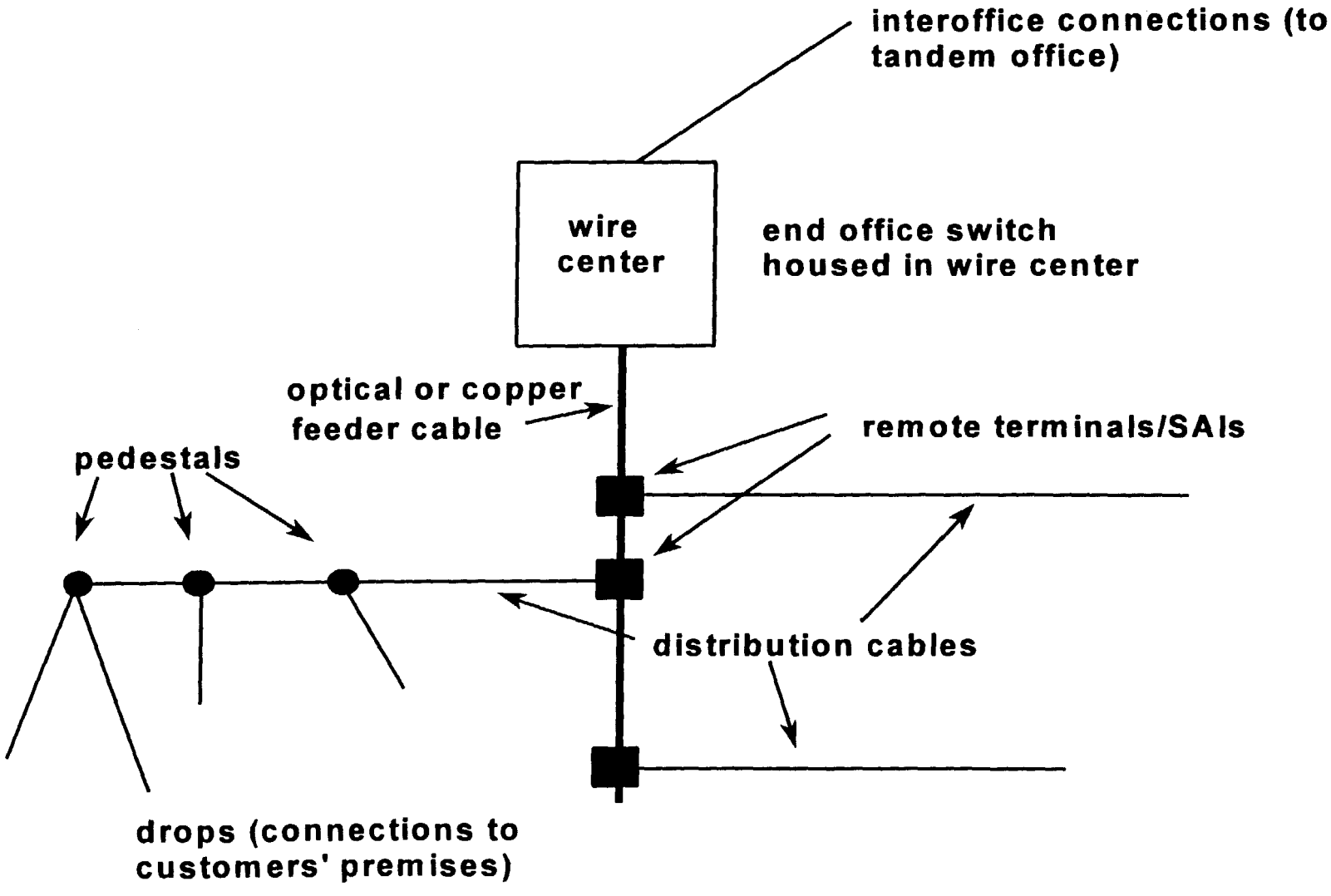
Figure 2
Distribution Network Structure