the economic cost modeling performed here. A benchmark cost for providing unbundled network elements without excess capacity or capability must be established. As discussed above, the FCC has not engaged in this type of modeling. One limited exception has been in the area of video dialtone, which is discussed immediately below.

1. Broadband Service

The FCC did ask for economic support for the investments associated with LEC plans to enter the broadband video business through video dialtone investments. While events have overtaken those Applications, the record demonstrated that many video dialtone investments would have been profitable only if monopoly ratepayers absorbed much of the cost.[47] In the Bell Atlantic Dover Township Video Dialtone Tariff Investigation Designation Order, the FCC set out to investigate these costing issues.[48] This raises a question concerning the degree of overinvestment by LECs in areas where the FCC has devoted less (i.e., virtually no) scrutiny.

2. Official Service Networks

The RBOCs were granted the authority under the MFJ to construct interLATA official services networks. The FCC has never undertaken an investigation of the investment in official service networks, even though the RBOCs had a clear incentive to build excess capacity in those networks in contemplation of entry into the interLATA market.[49] Any expenses associated with

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[47] See, In the Matter of U S WEST Communications, Inc., Trial Services or Arrangements, Basic Video Dialtone Market Trial, Omaha, NE; NCTA Position to Reject, April 24, 1995. Also, In the Matter of SNET Video Dialtone Trial Tariff, NCTA Comments on SNET's Accounting and Cost Allocation Plan, March 29, 1995.

[48] See In the Matter of Bell Atlantic Telephone Companies Revisions to Tariff F.C.C. No. 10, CC Docket No. 95-145, released September 8, 1995.

[49] The potential cross-subsidy associated with RBOC construction of official service networks is discussed in Economics and Technology, Inc. and Hatfield Associates, Inc., The Enduring Local Bottleneck, 1994, pp. 198-200.

excess capacity and capabilities not needed by current monopoly ratepayers would reduce sharing under price caps, leading to higher access charges.

Data concerning the investment in these networks is sparse. However, in a regulatory proceeding in Florida, Joseph Gillan discovered that Southern Bell's official services network contained an enormous amount of excess capacity. He found that the idle capacity in Southern Bell's network exceeded the existing size of the entire toll market by 50 percent. He also found that Southern Bell's interlata network capacity, measure in terms of fiber pairs, is at large as AT&T's and at least twice as large as the second largest carrier.[50]

An indication of the degree to which there is excess capacity in RBOC networks is provided by a comparison of working and equipped channels. FCC data show that only 34 percent of RBOC fiber miles are "lit."[51] As a recent FCC Report notes, ". . . there is a huge amount of fiber capacity presently unused in the *interoffice* transmission plant."[52]

3. Loop Investment

The LECs also may have substantial excess capacity in loops. The model used here employs fill factors between .5 and .7, depending on density. The BCM Model uses a fill factor range of between .25 and .75. Actual fill factors in LEC networks may be lower. Some of this excess loop capacity may be explained by LECs putting capacity in place for Centrex service

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[50] See Testimonyof Joseph Gillan, In re: Comprehensive Review of the Revenue Requirements and Rate Stabilization Plan of Southern Bell Telephone and Telegrph Company, Florida Public Service Commission, Docket No. 920260-TL, November 8, 1993, pp. 20-26.

[51] See, ARMIS Report 43-08 data.

[52] See, Infrastructure of the Local Operating Companies Aggregated to the Holding Company Level, April, 1995, *supra*, note 37, p. 6 emphasis supplied.

demand that has not yet materialized.[53] There may also be significant unused capacity for multiple residential lines.

LECs are not penalized for spare loop capacity because the cost is allocated to services based on working loops and collected from ratepayers. Thus, even though Centrex is an unregulated, or loosely regulated, service in many states, local service ratepayers are paying for the unused capacity. As demand for second lines grows, the LECs are in a position to generate substantial revenues.[54]

D. Corporate Operations

It would not be appropriate to add the corporate operations expenses shown in Table 5 to the TS-LRIC of unbundled network elements. The Hatfield Model already includes a factor to estimate expenses included in the corporate operations categories that may vary with firm size. The model does not estimate pure economic overhead. These are expenses that do not vary with firm size.

Pure economic overhead is likely to be a small percentage of the total revenue requirement. Certainly, less than one percent of total revenue requirement for large firms such as the LECs would be required to pay for the "president's desk." To the extent the remaining corporate operations expenses are larger than this amount, they are likely paying for activities related to entering new markets, or simply represent waste and inefficiency.

LECs argue that the TS-LRIC prices of unbundled network elements should be marked up to recover overheads. However, to the extent the expenses are legitimate, it is more

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[53] See, The Enduring Local Bottleneck, *supra*, note 49, pp. 206-212.

[54] The Hatfield Model includes current second line demand and allows for increased demand to the extent that fill levels on the network are below capacity.

appropriate to recover them from retail customers. An arbitrary assignment of these expenses to rates for essential network elements purchased by competitors provides an opportunity for LECs to raise their rivals' costs. Moreover, in competitive markets, it is typical that larger customers pay rates close to incremental costs.

E. Customer Operations

The TS-LRIC figures for the unbundled network elements do not include LEC customer operations expenses of $15.3 billion. Customer operations expenses include billing and account maintenance. Therefore, these expenses are part of the economic cost of existing end-user services.

Customer Operations expenses will be minimal in the case of selling unbundled network elements. Instead of billing and managing expenses for millions of retail customer accounts, the LECs will be selling to a small group of competing local and long distance carriers. Other categories of cost included in these accounts, such as marketing and advertising, are not part of the TS-LRIC of unbundled network elements.

VIII. MOVING PRICES TO ECONOMIC COSTS

The data provided in Section VII show that the existing LEC revenue requirement is inflated. LECs argue that they are entitled by the so-called "regulatory contract" to recover this revenue requirement. There are several reasons why the alleged "regulatory contract" should not serve as a bar to reducing prices to cost. First, lower prices will stimulate demand.[55] This additional demand coupled with the opportunity to enter new markets when public interest

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[55] See, Hausman, Jerry, Timothy Tardiff and Alex Belinfante, "The Effects of the Breakup of AT&T on Telephone Penetration in the United States", 83 American Economic Review 178, 1993.

requirements are met, will help offset the revenue and profit impact on LECs of cost-based pricing for network elements.

Second, the "regulatory contract" does not guarantee that local telephone companies can recover excess costs. Local telephone companies have known for many years that local competition is coming. In fact, they have been claiming for over a decade that it is already here. They should have been taking steps to mitigate the "problem," if there is one. Instead, as described above, the LECs have taken the opportunity afforded by lax regulation of capital expenditure plans to make strategic investments in capacity designed to help them compete in the future. In any event, the 1996 Act, which the RBOCs supported, is a new regulatory contract. In exchange for meeting a checklist of obligations, which includes unbundling and cost-based pricing of network elements, the RBOCs will be allowed to enter new markets.

Third, the giveaway of cellular licenses to incumbent local telephone companies by the FCC in the 1980s erases whatever residual value the "social contract" contained for telephone companies. The recent FCC spectrum auctions prove that the LECs got the better of the "social contract," even if they are not allowed to recover the cost of overinvestment from monopoly customers.

Finally, the problem of uneconomic costs is common in competitive industries. The solution in these industries is to write off expenses against shareholders. Assume a competitive company builds a $1,000,000 factory in order to diversify into a new line of business. If demand fails to materialize, the competitive firm cannot ask its existing customers to pay for the factory. Shareholders must bear the burden of the uneconomic expenditures.

The FCC cannot rely upon the advent of local competition to drive prices to cost. The 1996 Act makes local competition possible, but legislation cannot create competition.

Competitors must enter and begin providing customers with real choices. If a market is occupied by a monopolist, at most policymakers can allow entry and create conditions under which the entrants have a reasonable opportunity to compete for business along with the incumbent monopolist.

At least initially, the entry is likely to be piecemeal, with competitors continuing to rely on the incumbent LECs for essential facilities (i.e., the unbundled network elements) for many years to come. Moreover, competitors require the LECs to meet the other requirments of the 1996 Act, including number portability, right-of-way access, etc. An earlier analysis by Economics and Technology, Inc. and HAI demonstrated that local competition is possible, but will take many years to develop.[56]

IX. UNIVERSAL SERVICE SUBSIDIES

Universal Service subsidies need not interfere with the movement of prices to cost. The 1994 HAI study demonstrated that subsidy for local service is much lower than commonly believed. At that time, only four billion dollars was needed to maintain local rates at their current levels. The cost study described here shows that the costs of Basic Universal Service are even lower. In any event, the legislation provides a mechanism for dealing with the Universal Service issue. Universal Service costs must be separately identified. The necessary funds must then be collected and distributed through a mechanism by which all competitors contribute on a fair and equitable basis. The FCC has already begun this process.[57]

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[56] The Enduring Local Bottleneck, *supra*, note 49, pp. 206-212.

[57] See, Notice of Proposed Rulemaking and Order Establishing a Joint Board, CC Docket No. 96-45, released March 8, 1996.

X. NEXT STEPS

As part of its effort to implement the 1996 Act, the FCC must undertake to study the economic cost of LEC services. The modeling approach described here can serve as a basis for that investigation. The LECs will criticize the model on various grounds. However, the FCC will likely discover that to the extent the LEC criticisms are valid, they can only be addressed by the application of data that are currently in the exclusive possession of the LECs themselves. As the BCM Model 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 model.

Unit Cost by Network Element

Loop elements

	0-10 pop/km2	10-100 pop/km2	100-500 pop/km2	500-1,000 pop/km2	1,000-5,000 pop/km2	>5,000 pop/km2	Totals
Loop Distribution							
Annual Cost	$ 2,423,179,454	$ 6,150,810,401	$ 1,643,963,604	$ 1,275,061,157	$ 3,690,920,048	$ 770,922,988	$ 15,954,857,652
Units	8,969,439	30,420,078	27,516,643	19,807,291	56,445,945	13,066,968	156,226,363
Unit Cost/month	$ 22.51	$ 16.85	$ 4.98	$ 5.36	$ 5.45	$ 4.92	$ 8.51
Loop Concentration							
Annual Cost	$ 1,407,376,597	$ 4,358,341,762	$ 46,557,808	$ 34,169,753	$ 97,158,619	$ 24,034,105	$ 5,965,638,642
Units	8,969,439	30,420,078	27,516,643	19,807,291	56,445,945	13,066,968	156,226,363
Unit Cost/month	$ 13.06	$ 11.93	$ 0.14	$ 0.14	$ 0.14	$ 0.15	$ 3.18
Loop Feeder							
Annual Cost	$ 570,854,034	$ 1,498,576,213	$ 1,245,621,890	$ 264,379,205	$ 414,853,516	$ 35,456,856	$ 4,029,741,714
Units	8,969,439	30,420,078	27,516,643	19,807,291	56,445,945	13,066,968	156,226,363
Unit Cost/month	$ 5.30	$ 4.11	$ 3.77	$ 1.11	$ 0.61	$ 0.23	$ 2.15
Total Loop							
Annual Cost	$ 4,401,410,085	$ 12,005,728,376	$ 2,936,143,301	$ 1,573,610,115	$ 4,202,932,183	$ 830,413,948	$ 25,950,238,009
Units	8,969,439	30,420,078	27,516,643	19,807,291	56,445,945	13,066,968	156,226,363
Unit Cost/month	$ 40.89	$ 32.89	$ 8.89	$ 6.62	$ 6.20	$ 5.30	$ 13.84

	Annual Cost	Units		Unit Cost		
End office switching	$ 5,751,872,548					
1. Port	$ 1,725,561,764	141,126,511	switched lines	$	1.02	per line/month
2. Usage	$ 4,026,310,783	2,264,200,000,000	minutes	$	0.0018	per minute
Signaling network elements	253857787.7	n/a				
Transport network elements						
1. Dedicated	$ 1,150,882,311	18,227,755	trunks	$	5.26	per DS-0 equivalent/month
				$	126.28	per DS-1 equivalen/month
				$	3,535.78	per DS-3 equivalent/month
2. Common	$ 664,454,045	1,464,070,959,357	minutes	$	0.0002	per minute per leg (orig or term)
3. Tandem switch	$ 1,112,005,760	1,464,070,959,357	minutes	$	0.0008	per minute
Operator systems	$ 116,117,445	n/a				
Public Telephones	$ 1,098,242,547	n/a				
Total	$ 36,097,470,452					

Attachment

HATFIELD ASSOCIATES, INC.
International Telecommunications Consultants
737 29th Street, Suite 200
Boulder, Colorado 80303
(303) 442-5395

Statement of Qualifications

General Qualifications

Hatfield Associates, Inc. (HAI) is an interdisciplinary consulting and research firm serving a wide range of telecommunications industry clients. The firm was founded in February, 1982. In the more than one decade of its existence, the firm has provided consulting and educational services in nearly all aspects of the present and future telecommunications infrastructure, including local exchange networks, cable television systems, competitive access networks, land mobile and personal communications, long haul terrestrial and satellite communications, data communications, and customer premises equipment. Principals of the firm include consultants with graduate degrees and decades of senior level experience in engineering, economics, business, and policy/regulation.

Examples of recent consulting assignments include:

- Estimating the investments and costs associated with the provision of local exchange and exchange access services;

- Analyzing the potential for competitive entry into the local exchange telecommunications business, presented in a paper entitled "The Enduring Local Bottleneck: Monopoly Power and the Local Exchange Carriers";

- Testifying in state proceedings on various aspects of competitive entry into local exchange and exchange access services, and on state mechanisms to fund Universal Service;

- Assessing the technological and economic merits of various telephone companies' plans for offering video dialtone services;

- Preparing a report entitled "Cross-Subsidy Concerns Raised by Local Exchange Company Provision of Video Dialtone Services" that was attached to a petition filed with the Federal Communications Commission (FCC) by the National Cable Television Association and the Consumer Federation of America;

- Developing a vision statement dealing with the future of cable television networks in providing telecommunications and enhanced video services;

4

Documentation of the:

HATFIELD MODEL

Version 2.2
Release 1

Prepared for:

AT&T CORP.

and

MCI TELECOMMUNICATIONS CORPORATION

by

Hatfield Associates, Inc.
International Telecommunications Consultants
737 29th Street, Suite 200
Boulder, Colorado 80303

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Appendix 1: PRINCIPLES TO GUIDE STUDIES OF LOCAL EXCHANGE TOTAL SERVICE LONG-RUN INCREMENTAL COST (TSLRIC)

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I. OVERVIEW

This document describes the "Hatfield Model Version 2.2, Release 1", a flexible tool for estimating the economic costs of providing telephone service to business and residence users throughout the United States. Hatfield Associates, Inc. ("Hatfield Associates" or "HAI") developed this model at the request of AT&T Corp. ("AT&T") and MCI Telecommunications Corporation ("MCI"). This Hatfield Model (called, variously, "the Hatfield Model," "the Model" or "HM") builds upon modeling work that Hatfield Associates performed previously for AT&T and MCI.[1] It uses certain outputs from the Benchmark Cost Model ("BCM") developed by Sprint, NYNEX, MCI and US West ("the Joint Sponsors") to calculate required loop investments.[2] HAI's goal in both these efforts was to model the economic costs of all narrowband local telephone services provided to business and residence customers, including access services provided to interexchange carriers ("IXCs").[3] In addition to computing efficient total network costs, the model computes the economic costs of the individual network elements that are used to provide narrowband telephone services.

The HM develops estimates of economic costs through an engineering model designed to specify the network structure that can provide most efficiently the required telephone services to all customers. As such, it conforms to the Total Service Long Run Incremental Cost ("TSLRIC") pricing rules and standards delineated in Appendix 1 to this document. The HM adopts realistic, but conservative, assumptions concerning the factors influencing prospective network costs to ensure that its economic cost estimates are reasonable and reflective of efficient local exchange carrier ("LEC") construction planning processes.

---

1 While most recently, Version 2.1 of the Hatfield Model was presented to the Commission by MCI in, "The Cost of Basic Network Elements: Theory, Modeling and Practice," March 29, 1996, there are several earlier versions. The original Hatfield Model (Version 1.1), was sponsored by MCI in 1994 to gauge the subsidy associated with universal service. This model costed residential access to the first point of switching, local usage, touch tone, white pages listings and access to 911, operator and directory assistance service. The model assumed a scorched earth approach, no direct interoffice trunking and homogeneous population density zones. This model evolved in two directions. Version 2.0, which costed all local services, was introduced in a Maryland price cap proceeding in late 1995. Version 1.2 was also introduced in late 1995 in Pennsylvania to gauge universal service subsidy needs. In Version 1.2, the scorched earth approach was replaced with a scorched node approach using outputs from the Benchmark Cost Model ("BCM") to size loop plant requirements.

2 Users must obtain the BCM from the Joint Spnsors in order to use it as an input to the HM.

3 The specific network that the model costs is one that is capable of carrying all switched voice/narrowband telephone services that are offered within an exchange area. To the extent that the network elements used to provide these services are also capable of providing other services (e.g., ISDN, special access, or private line services), their costs are estimated as well.

The Hatfield Model is flexible It uses public information made available from the Federal Communications Commission ("the Commission") and industry publications for its basic input data In addition, the HM will easily accept substitute proprietary or company-specific information Users may apply the HM to any LEC or geographic area, because the necessary inputs are publicly available The HM's table driven structure and the nature of its output reports, facilitate a variety of flexible uses of the model

The sections that follow provide a more detailed discussion of the HM's structure, processes and operations. In particular, this document describes only the portions of the model that address the cost of the local network and its individual elements. This document does not address Universal Service or subsidy issues. Section II describes the HM and its potential applications. Section III documents in detail the Model's inputs and processes used to determine the most efficient network structure that will serve the required level of customer demand and describes the derivation of unbundled network element TSLRICs from this optimized network model. Section IV displays some numeric results derived by the Model.

II. GENERAL DESCRIPTION OF THE HATFIELD MODEL AND ITS POTENTIAL APPLICATIONS

The Hatfield Model develops estimates of the economic costs (TSLRIC) of providing local telephone services by determining the specifications of a local network, using most efficient practices and best forward-looking technologies, to meet the total demand for local narrowband telephone services. By doing this, the model simulates the construction and operations decision-making of an efficient local service provider that must create and operate a new network to meet current and reasonably forecasted demand levels for narrowband telephone services. In simulating the construction of these hypothetical networks, the model incorporates realistic assumptions concerning the LECs' ability to adopt and implement efficient, cost minimizing production techniques.

A. EFFICIENT FORWARD-LOOKING PRODUCTION

As required by TSLRIC study principles, the Hatfield Model assumes that the LEC acts as an efficient, cost minimizing producer of basic telephone services and makes rational, forward-looking investment decisions over a long-run planning horizon. The HM assumes that all plant related investments and expenses are variable. The Model optimizes these investments and expenses by configuring the least-cost network required to serve existing demand, subject to constraints reflecting a conservative assessment of the LECs' ability to change some of the underlying physical characteristics of their embedded networks.

B. ADOPTION OF APPROPRIATE TECHNOLOGIES

The technologies considered in the Model are forward-looking. As such, they are those an efficient LEC would adopt if it were to begin today to rebuild its telephone

service network from the bottom up For outside plant calculations, a technology mix composed of a digital loop carrier, copper distribution and feeder plant and optical fiber feeder plant is assumed The HM does not consider hybrid coaxial cable because there is a continuing controversy over whether it is the least-cost technology for providing narrowband service Wireless technologies are also excluded because, though promising, they are not yet a proven or generally available primary local service alternative that is a quality or economic substitute for wireline local service. The particular architecture chosen for a serving area reflects an assessment of the least-cost method of providing telephone service to a serving area. For example, the feeder and distribution plant sizing algorithms choose the minimum quantity and size of cables to meet total demand and reflect the tapering of feeder cable segments as routes extend away from the wire center

Switching cost calculations in the model use digital switching and current demand characteristics. Switching capacities are consistent with those of present generation digital switches, such as AT&T's 5ESS® and the Northern Telecom DMS-100®. The HM assumes that the LECs have deployed fully SS7 signaling capabilities throughout the local exchange network.

C. FIXED WIRE CENTER LOCATIONS

The HM is a "scorched node" study because it uses the Benchmark Cost Model ("BCM") loop investment assumption that treats the LECs' current wire center locations as "fixed" nodes in a reconstructed local network. Because this approach does not allow for relocating wire centers to minimize the total cost of providing telephone service, this assumption creates an upward bias in the model's estimates of local service costs.

D. EXISTING GEOGRAPHY AND CHARACTER OF DEMAND

The Hatfield Model considers only those investments required to support the efficient provision of traditional narrowband telephone services. The Model does not cost out speculative investments to accommodate provision of broadband services or potential demand stimulation from possible enhanced service applications. Nor does the Model inflate demand estimates to account for overbuilt official networks.

The HM incorporates demand for both business and residence service, including second residence lines, through adjustments to BCM line counts of households by Census Block Group ("CBG"). By engineering the network so that current demand only partially fills its capacity, the Model accommodates growth in the demand for such services, including all basic network functions underlying local telephone service. The HM sets these network fill factors at levels an efficient local service provider would expect to achieve. The HM varies network fill factors by population density zone, an assumption that accommodates cost differences resulting from differences in rates of population growth across density zones. The HM does not use current LEC network fill factors because such factors reflect LEC inefficiencies (induced for example, by overbuilding to accommodate plans to enter new markets).

The Hatfield Model meets additional design criteria by providing a flexible, generic structure for estimating company-specific TSLRICs for basic telephone services and for unbundled network elements that the LEC may supply to its carrier customers. The specific inputs used to drive the present model are uniformly available for all companies and study areas and can be modified easily to reflect any other forward-looking, company-specific or proprietary information a user may wish to use. Required inputs derived from the BCM and underlying demand measures are now available for all study areas. Residence and business line counts and information concerning current period expenses and costs, are directly available for all companies that file ARMIS reports. Though the exact prices LECs paid for particular capital goods are generally proprietary, the HM obtains information concerning prevailing prices for outside plant and switching facilities through public industry sources. Finally, the best practices and economic principles on which the model rests transcend company boundaries.

E. POTENTIAL APPLICATIONS OF THE HATFIELD MODEL

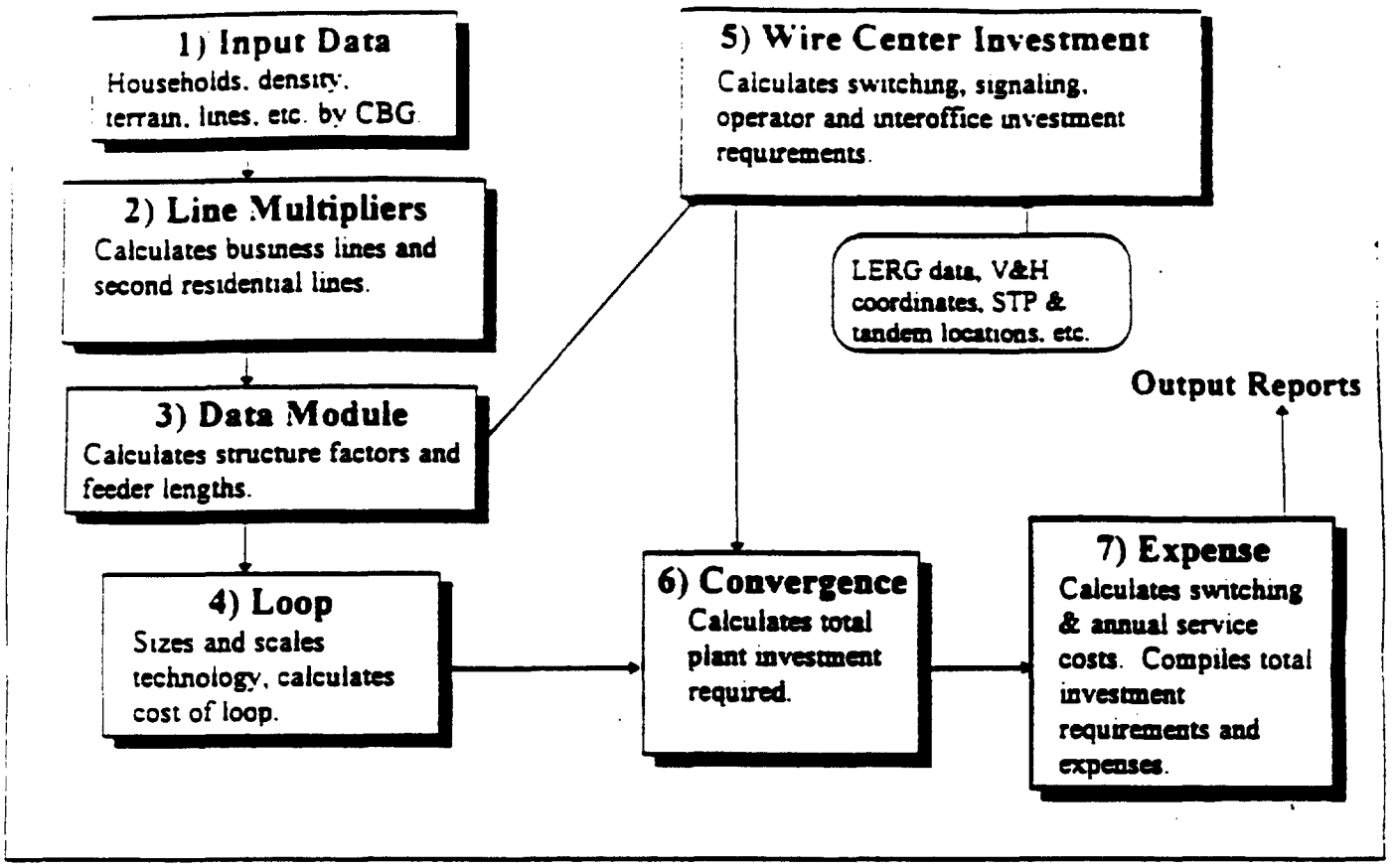
The Hatfield Model can be used for a variety of applications for which TSLRIC estimates are required. The Model's primary application is to develop estimates of the TSLRIC and local access of unbundled network elements and interconnection services that compose local exchange service. The Model may also be used to assess economic subsidy requirements by identifying those areas in which the TSLRIC of basic local service exceeds the tariffed rate for that service and by quantifying any resultant economic shortfall.

III. STRUCTURE OF THE MODEL

A. OVERVIEW OF MODEL ORGANIZATION

The Hatfield Model contains seven functional modules. It uses output from three components of the BCM to determine loop investment. It couples this with its own modules to produce the wire center and outside plan investments necessary to provide switching, signaling, operator and trunking functions -- along with their required support expenses. Figure 1 shows the relationships among these modules. An overview of each component module follows.

Figure 1 Hatfield Model Organization Flow Chart



1. Input Data

There are two categories of raw data upon which the Hatfield model relies. They are CBGs (based on Census Bureau statistics) and wire center specific data (based on Local Exchange Routing Guide ("LERG") data).[4]

The specific CBG data used by the model are: 1) number of households; 2) CBG land area in square miles; 3) position relative to nearest wire center; and 4) local geological factors including rock depth, rock hardness, water table and surface texture. The current locations of individual wire centers and their particular technical specifications (as reported in the LERG) are also entered as variables into the cost model.

[4] "Local Exchange Routing Guide," Bellcore 1995. Users must obtain these data from Bellcore.

2. Line Multiplier

Since the model calculates all network costs on a per line basis, it must first calculate the number of second residential, business, public and special access lines within each CBG. Because the U.S. Census Bureau collects only household data and the FCC's Statistics of Communication Common Carrier or ARMIS 43-08 reports line data aggregated across all services, the model must apply multiplier factors to account for these additional access lines.

This calculation is based upon two assumptions: 1) multipliers must be greater than zero, and 2) increases in population density result in higher ratios of residence second lines and business lines to the number of households. Thus, the outputs of the Line Multiplier Module are estimates of total lines in a CBG and a table of line totals and line multipliers for six different population density ranges. Population density is measured by households per square mile and is broken into six categories: 0-5, 5-200, 200-650, 650-850, 850-2,550 and greater than 2,550 households per square mile. Labeling for these density zones is given in Table 1.

Table 1 Density Zone Households Per Square Mile

Density Zone	Households/Sq. Mile
1	0-5
2	5-200
3	200-650
4	650-850
5	850-2550
6	> 2550

3. Data Module

The Data Module calculates so-called "structure factors" for distribution and feeder cable plant that take into account the degree of difficulty associated with placing and installing cable under varying terrain and population density conditions. The module uses CBG data and line multipliers to first determine the quantity and type of outside plant required based on spatial geometry, density and distance of the CBG from the wire center. The HM also incorporates the particular geologic characteristics of each CBG (such as rock hardness, soil type, surface texture and water table depth) into its structure factors.

4. Loop Module

The Loop Module uses the structure factors calculated in the Data Module and estimates cable investments per unit length to determine the total required loop investment per CBG. To determine the full network loop investment, the module selects copper feeder technology for CBGs with loops less than 12,000 feet and selects fiber feeder technology for CBGs with loops longer than 12,000 feet. The module then determines the

size of copper or fiber cable required to serve each CBG, given prescribed fill levels and population density. Once the module has determined the required type and size cable, the Loop Module calculates the necessary total distribution, feeder and supporting structure investment using the Data Module's structure factors.

5. Wire Center Module

The Wire Center Module is a Hatfield extension to the BCM. It calculates wire center and interoffice facilities investments on a per line basis. This module quantifies investments associated with end office switches, trunks, signaling links, wire centers, signal transfer points ("STPs"), tandems (including operator tandems) and operator positions. The module uses the CBG household and line multipliers and the location of wire centers as detailed in the LERG to determine required switching capacities and interoffice investments.

In keeping with TSLRIC principles, the model determines network capacity sufficient to serve all demand in its service area. The HM derives its switch investment estimates by using both typical per-line prices paid for by Bell Operating Companies, GTE and other independents,[5] and from Table 2.10 of the FCC's Statistics of Communications Common Carriers, which provides the average number of access lines served by a LEC switch.

6. Convergence Module

The Convergence Module combines output of the Loop Module (loop installation, material and structural investments) with the Wire Center Module (per-line wire center and interoffice investments). The convergence module reports by density ranges the number of lines by type, number of households and investment in categories such as distribution, feeder, switching, tandems, trunks, etc.

7. Expense Module

The Expense Module uses output from the Convergence Module to determine efficient annual capital carrying costs for the investments needed to build up a local telecommunications network that reflects TSLRIC principles. This module uses investment, revenue and expense data that are available from LEC annual ARMIS reports and depreciation factors by plant category and it is capable of using individual LEC's levels of financial leverage and cost of debt and equity.

The Expense Module also calculates support expenses based on certain ratios between these expense items and the investments they support.

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[5] See *U.S. Central Office Equipment Market -- 1994*, McGraw-Hill.

B. INPUT DATA FILE

1. Overview

The purpose of the data input or "Input Data" file is to incorporate into the HM objective publicly reported and company neutral topographical data and demographic statistics for use throughout the model. These data are derived from U.S. Census Bureau STF3 data, NECA Tariff 4 CLLI data,[6] and USGS Satellite Survey Data.[7] In addition, the Joint Sponsors used "ARC INFO" and "Map Info" software to translate the government data into parameters that match the BCMs input needs.[8]

2. Description of Inputs and Assumptions

In addition to three cells designated to identify a specific serving area (wire center or CLLI, company and CBG number), there are a total of eleven elements that are collected in the BCM Input Data File. They are:

Measurements of Distance to Centroid, Quadrant, Omega and Alpha[9] – These variables locate the CBG with respect to the wire center. There are four quadrants surrounding a wire center. The Alpha and Omega values are angles used to determine feeder and distribution lengths. Omega is the angle that determines in which quadrant of the serving area the CBG falls. Alpha is the angle between the line directly linking the wire center and the center of the CBG and the link followed by the main feeder route serving the CBGs quadrant. The Data Module will use these measurements to determine the feeder, sub-feeder and distribution lengths. The Loop Module uses these values to compute material and placement investment and to share feeder investment among the several CBGs served by a common feeder route. The Joint Sponsors used "ARC INFO" and other software to map CBGs to the nearest wire center and to determine these geometric parameters.[10]

Geographic Information – As part of the Input Data File, the BCM uses total CBG household counts and areas obtained from census data. The HM uses these values to calculate population density. The Data Module identifies the six zones of population density.

Terrain Variables – The model incorporates terrain variables extracted from USGS Satellite Survey data. These include water table depth, depth to bedrock, bedrock hardness and surface texture. In the Data Module, these variables help to determine additional cost

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6 Common Language® Location Identifier. Common Language® is a trademark of Bell Communications Research.

7 CC Docket 80-286, Joint Sponsors, December 1, 1995 filing, at IV-7, IV-8.

8 CC Docket 80-286, Joint Sponsors, December 1, 1995 filing, at IV-7, IV-8.

9 CC Docket 80-286, Joint Sponsors, December 1, 1995 filing, at IV-10 through IV-12.

10 CC Docket 80-286, Joint Sponsors, December 1, 1995 filing, at IV-10 through IV-12.

factors for installing different types of cable Some of the variables are quantitative (Rock Depth and Water Table Depth), while others are qualitative (Rock Hardness and Surface Texture) The Data Module assigns numeric values to this qualitative data.

Table 2 below presents the minimum and maximum values for these data from the first 200 CBGs reported for Colorado to illustrate the range and type of the geological variables

Table 2 Variable from the BCM Input Data File and High and Low Values Surveyed from First 200 CBGs in Colorado

Variable	Column	Data Type	High	Low
Centroid Distance	G	Quantitative	104472.61	143.59
Total Households	H	Quantitative	1215.00	29.00
Area	I	Quantitative	569.78	0.06
Density	J	Quantitative	9098.91	0.09
Rock Depth	K	Quantitative	60.00	11.20
Rock Hardness	L	Textual	HARD	SOFT
Surface Texture	M	Textual	*	*
Water Table Depth	N	Quantitative	6.00	4.11
*There are nearly 200 different surface texture types assigned values of 1 or 0.				

3. Description of Module Outputs and Connection to Next Module

The BCM Input Data File, with the line counts substituted for household counts, serves as the input file for the BCM Data Module. In addition, it functions as a repository of essential data that all the subsequent modules draw upon to calculate network investments, including the Line Multiplier Module, the BCM Loop Module and Wire Center Investment Module.

C. LINE MULTIPLIER MODULE

1. Overview

A key feature of the Hatfield Model is that it takes into account all significant sources of demand for loop facilities, including residence, business, public and special access lines, rather than focusing strictly on primary residential access line demand as the BCM does. The Line Multiplier Module makes this extension to the BCM. As shown in Figure 1, this module calculates total access line counts for each CBG and provides these data to the BCM's Data Module.

The HM incorporates all access line demand to account for any potential the scale or scope economies associated with the provision of both residence and non-residence services. As a result, the Hatfield Model can provide reasonable estimates of business loop investment.