

1 REBUTTAL TESTIMONY OF

2 DON J. WOOD

3 ON BEHALF OF MCI

4 DOCKET NO. 960980-TP ~~960847~~

5 September 30, 1996

6
7 Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

8 A. My name is Don J. Wood, and my business address is 914 Stream Valley Trail,
9 Alpharetta, Georgia 30302. I provide consulting services to the ratepayers and
10 regulators of telecommunications utilities.

11
12 Q. HAVE YOU PREVIOUSLY FILED TESTIMONY IN THIS PROCEEDING?

13 A. Yes, I filed direct testimony in this docket on August 26, 1996. I have also filed
14 both direct and rebuttal testimony on behalf of AT&T in Docket No. 960847-TP,
15 which has been consolidated with this proceeding.

16
17 Q. WHAT IS THE PURPOSE OF YOUR REBUTTAL TESTIMONY?

18 A. The purpose of my rebuttal testimony is to respond to the criticisms of the Hatfield
19 Model included in the testimony and exhibit of Gregory M. Duncan on behalf of
20 GTE Florida Incorporated ("GTEFL").

21
22 Q. PLEASE PROVIDE YOUR RESPONSE TO DR. DUNCAN'S TESTIMONY.

23 A. Dr. Duncan's direct testimony in this docket simply adopted his direct testimony
24 in the AT&T arbitration docket. Therefore I will likewise adopt my rebuttal
25 testimony filed on September 24, 1996 in the AT&T/GTEFL docket as my rebuttal

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to Dr. Duncan in this proceeding.

Q. IN YOUR DIRECT TESTIMONY YOU STATED THAT COMPLETE DOCUMENTATION DESCRIBING THE OPERATION OF THE HATFIELD MODEL IN DETAIL WAS STILL BEING DEVELOPED. HAS THAT DOCUMENTATION BEEN COMPLETED?

A. Yes. I have attached a copy of that documentation to this testimony as Exhibit ____ (DJW-4).

Q. DOES THAT CONCLUDE YOUR TESTIMONY?

A. Yes.

Model Description

Hatfield Model

Version 2.2, Release 2

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

September 4, 1996

TABLE OF CONTENTS

I. INTRODUCTION1
 A. OVERVIEW1
 B. EVOLUTION OF THE HATFIELD MODEL1
 C. PURPOSE OF THIS DOCUMENT3
II. STRUCTURE OF THE MODEL3
 A. GENERAL NETWORK COMPONENTS DESCRIPTION3
 1. Loop description4
 2. Interoffice network description6
 B. OVERVIEW OF MODEL ORGANIZATION8
 1. BCM-PLUS loop input data file9
 2. Line Converter Module9
 3. BCM-PLUS Data Module10
 4. BCM-PLUS Loop Module10
 5. Wire Center Module10
 6. Convergence Module11
 7. Expense Module11
 C. MODULE DESCRIPTIONS11
 1. BCM-PLUS Input Data File11
 2. Line converter module12
 3. BCM-PLUS Data module14
 4. BCM-PLUS Loop Module15
 5. Wire Center Investment Module21
 6. Convergence module29
 7. Expense Module33
III. SUMMARY41

APPENDIX A Summary of Changes Between Releases 1 and 2 of the
Hatfield Model, Version 2.2

APPENDIX B Instruction Manual

APPENDIX C Default Values of User-Adjustable Inputs

I. INTRODUCTION

A. OVERVIEW{PRIVATE }

The Hatfield Model has been developed by Hatfield Associates, Inc. (HAI), of Boulder, Colorado, at the request of AT&T and MCI. Its purposes are: 1) to estimate the forward-looking economic cost of unbundled network elements referenced in § 252(d)(1)(A) and (B) of the Telecommunications Act of 1996 based on Total Element Long Run Incremental Cost (TELRIC) principles;¹ and 2) in a separate calculation using consistent procedures and input data, to estimate the forward-looking economic cost of the basic local telephone service that is the target of universal service funding mechanisms.²

B. EVOLUTION OF THE HATFIELD MODEL

The original version of the Hatfield Model was developed to produce estimates of the TSLRIC of basic local telephone service as part of an examination of the cost of universal service. This original model was a "greenfield" model in that it assumed all network facilities would be built without consideration given to the location of existing wire centers or transmission routes. When the original Benchmark Cost Model (BCM1)³ became available, HAI revised the original Hatfield Model to incorporate certain loop investment data

¹ TELRIC is the term used by the Federal Communications Commission to refer to the total service long run incremental cost (TSLRIC) of unbundled network elements.

² The definition of basic universal service used in the model includes the following functional components:

single-line, single-party access to the first point of switching in a local exchange network;

usage within a local exchange area;

touch tone capability;

a white pages directory listing; and

access to 911 services, operator services, directory assistance, and telecommunications relay service for the hearing-impaired.

Excluded from this definition are many other local telephone company services, such as toll calling, interexchange carrier access, custom calling and CLASSSM features, and private line services, although the existence of such services is taken into account in developing the cost estimates for unbundled elements.

³ The Benchmark Cost Model is a model of basic local telephone service developed by MCI, NYNEX, Sprint, and U S WEST.

produced by BCM1. As a result, the Hatfield Model became a "scorched node" model that developed efficient, forward-looking network investments and costs for basic universal service based on existing wire center locations. Thus, this new version of the Hatfield Model combined results from BCM1's loop modeling (based on actual population distributions) with the extensive wire center and interoffice calculations from the earlier Hatfield Model.

Early in 1996, an expanded version of earlier Hatfield Models, referred to as the Hatfield Model, Version 2.2, Release 1, was developed to estimate the costs for unbundled network elements. It was submitted to the Federal Communications Commission (FCC) in CC Docket No. 96-98 on May 16 and 30, 1996, accompanied by descriptive documentation.⁴ On July 3, 1996, this model was placed into the record of CC Docket No. 96-45 to assist the Commission in determining the economic costs of universal service.⁵

The Hatfield Model, Version 2.2, Release 2 (hereafter HM2.2.2), described in this document, estimates the efficient, forward-looking economic cost of both unbundled network elements and basic local telephone service. This release incorporates a number of enhancements over earlier versions.⁶ HM2.2.2 derives certain of its inputs and methods from the BCM-PLUS model. The BCM-PLUS model is a derivative of BCM1 that has been developed for and is copyrighted by MCI Telecommunications Corporation.⁷ Furthermore, because populated data workfiles now accompany HM2.2.2, Release 2 executes more quickly than Release 1, and without required user intervention.

The Hatfield Model comprises several workbook files in Microsoft Excel 7.0 for Windows 95 or Windows NT. An automated front end interface permits the user to select the study area to be modeled and to enter any desired user-adjustable input assumptions. The entire model will then execute without any

⁴ See, Appendix E of the *Comments* of AT&T in CC Docket No. 96-98, In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996, and Appendix D of AT&T's *Reply Comments*. In the same proceeding, MCI submitted results based on an earlier "greenfield" version of the Model as Attachment 1 to its *Comments*.

⁵ Ex parte submission of L. Sawicki, MCI.

⁶ Appendix A to this documentation contains a summary of the differences between Release 1 and Release 2 of Version 2.2 of the Hatfield Model.

⁷ On July 3, 1996, Sprint Corporation and U S WEST presented version 2 of the BCM (BCM2) to the FCC. NYNEX and MCI are not sponsors of BCM2. A careful review by HAI indicates that all of BCM2's relevant enhancements over BCM1 are already present in the Hatfield Model. Furthermore, the Hatfield Model has important attributes and capabilities that are not available in the BCM2.

required user intervention.⁸ Although AT&T and MCI typically have run HM2.2.2 for 49 continental U.S. study areas (Bell Operating Companies "BOCs" plus Southern New England Telephone Company), it may be run for any Tier 1 study area.⁹

C. PURPOSE OF THIS DOCUMENT

This document describes: 1) the structure and operation of HM2.2.2, and 2) inputs to the model, emphasizing those that can be changed by the user and their default values. It should be emphasized that the model provides a large number of inputs that can be altered by the user. However, the default values for these inputs are believed to be appropriate based on the experience and engineering judgment of HAI personnel and other subject matter experts.

II. STRUCTURE OF THE MODEL

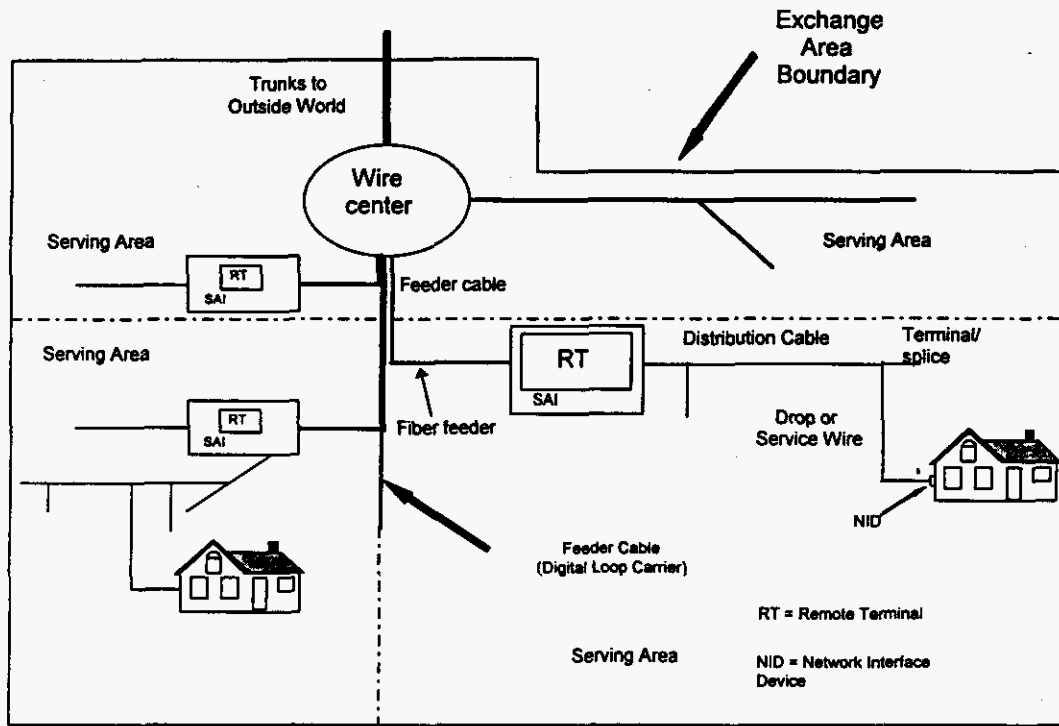
A. GENERAL NETWORK COMPONENTS DESCRIPTION

This section describes generally the network components modeled in HM2.2.2. Figures 1, 2 and 3 depict the relationships among the network components discussed in the following sections.

⁸ Documentation of this automated user interface is provided in Appendix B.

⁹ AT&T has retained telecommunications consultants from the Deloitte & Touche Consulting Group (and not Deloitte & Touche, LLP as might have been inferred from the prior reference to "Deloitte & Touche" in footnote 7 of AT&T's August 9, 1996 *Further Comments* in CC Docket No. 96-45), to provide additional Hatfield support. Deloitte & Touche Consulting Group personnel have: (1) provided analytical support to Hatfield and AT&T personnel; (2) assisted with data entry, results interpretation, and version and release testing; and (3) worked to improve the Hatfield Model's user interfaces, as well as to identify other areas for improvement with regard to the operation of the model.

1. Loop description



dicsys2b

Adopted from Engineering and Operations in the Bell System, 1983

Figure 1 Loop components

a) General loop description

The local loop begins at a physical demarcation frame within the central office building (wire center). Copper cable feeder facilities terminate on the vertical side of the main distributing frame (MDF) in the wire center. Fiber optic feeder cable serving integrated digital loop carrier terminates on a fiber distribution frame in the wire center. At its distant end, the local loop terminates at the Network Interface Device (NID) at the customer's premises.

Loop cables are supported by "structures." These "structures" may be underground conduit, poles, or trenches for buried cable. Underground cable is distinguished from buried cable in that underground cable is placed in conduit, while buried cable comes into direct contact with soil.¹⁰

¹⁰

While the conduit supporting underground cable is placed in a trench, buried cable may either be placed in a trench or be directly plowed into the earth.

b) Local Loop Components**(1) NID**

The demarcation point between the local carrier's network and the customer's inside wiring is known as the Network Interface Device (NID). This device terminates the drop wire and is an access point that may be used to isolate trouble between the carrier's network and the customer's premises wiring.

(2) Drop

A drop wire extends from the NID at the customer's premises to the block terminal at the distribution cable that runs along the street or the lot line.

(3) Block Terminal

The block terminal is the interface between the drop and the distribution cable. With aerial distribution cable, the block terminal is attached to a pole in the subscriber's backyard or at the edge of a road. If the distribution cable is buried, then the block terminal is contained within a pedestal.

(4) Distribution Cable

Distribution cable runs from each of the block terminals to the Serving Area Interface (SAI), also called a "cross box" or Serving Area Concept (SAC) box or connection. Distribution cable connects the feeder cable with all customer premises within a Census Block Group (CBG). The model assumes that each CBG contains one SAI, and that the SAI is placed one quarter of the way into the CBG. Distribution structure components may consist of poles, trenches and conduit. Manholes normally are not used in distribution facilities.

(5) Feeder facilities

Feeder cable may be copper wires or optical fibers. Feeder cables extend from the wire center to the SAIs. The Hatfield Model assumes that there is a standard feeder distance beyond which optical feeder cable will be installed and Digital Loop Carrier (DLC) equipment will be used to serve subscribers.

Feeder structure components also include poles, trenches and conduit. Manholes are also normally installed in conjunction with underground feeder cable. Manhole spacing is a function of population density and the type of feeder cable used. Manholes installed for underground fiber cable are normally farther apart than are manholes used with copper cables because the lightness and flexibility of fiber cable permits it to be pulled over longer lengths than copper cable. The costs of structure components are normally shared among at least three utilities, e.g., electric utilities, local exchange companies (LECs) and cable television (CATV) operators.

2. Interoffice network description

This section describes generally network components at the wire center and interoffice level. Figures 2 and 3 illustrate the relationships among the components described below.

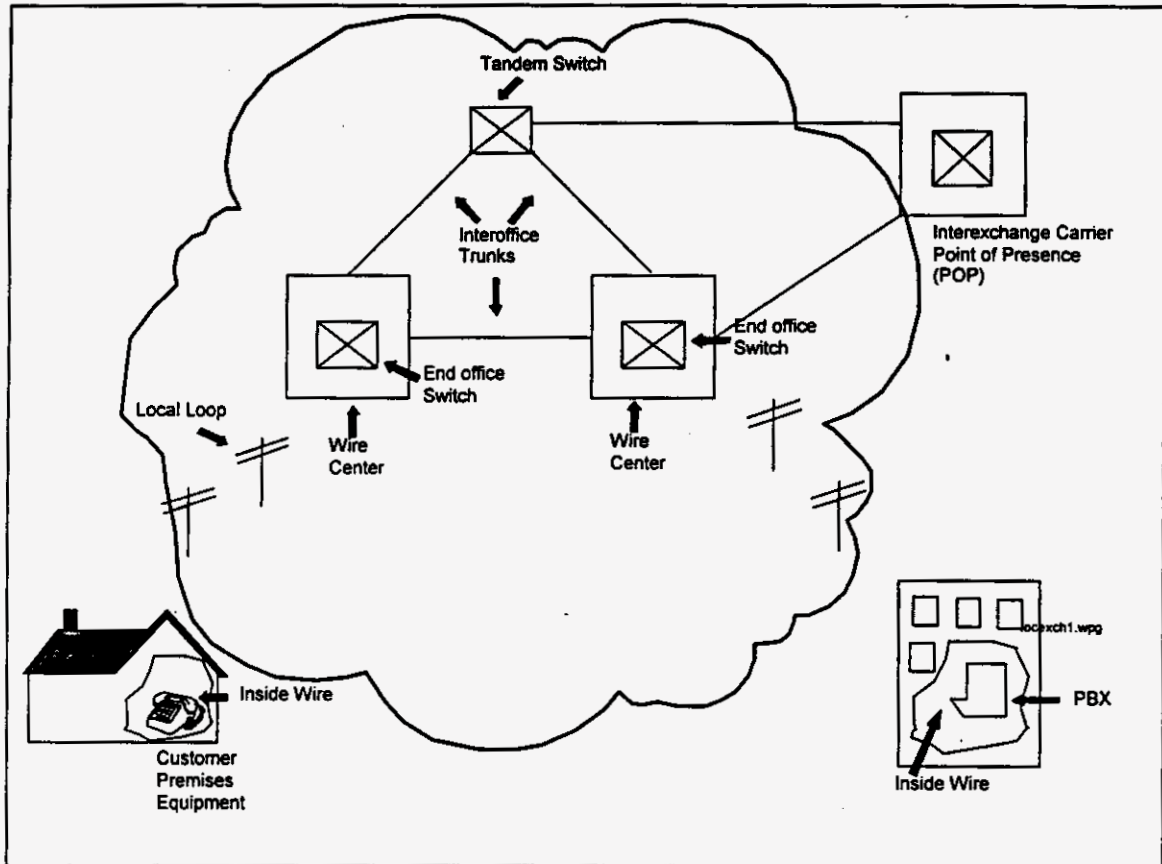


Figure 2 Interoffice network

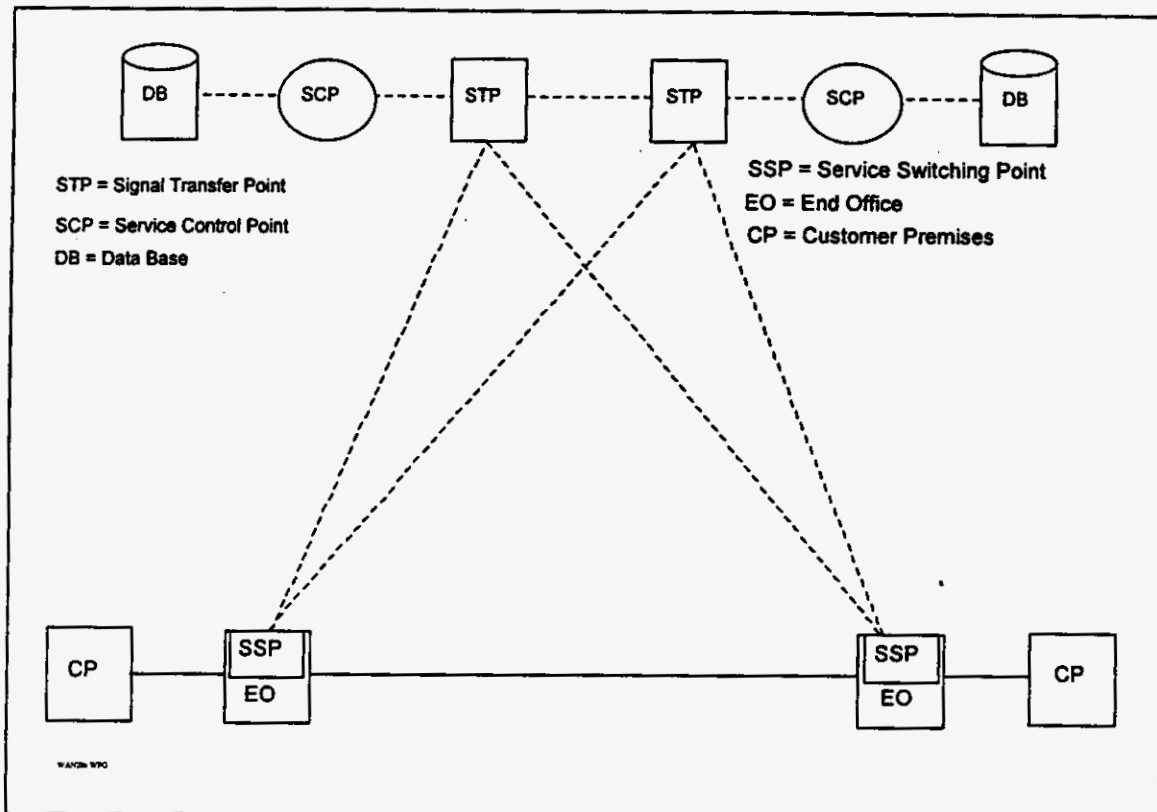


Figure 3 Signaling network components

a) Wire center

The wire center is a location from which local feeder routes emanate. A wire center normally contains at least one End Office (EO) switch and also may contain a tandem office, a Signal Transfer Point (STP), an operator tandem, or any combination of these facilities. Wire center physical facilities include a building, power and air conditioning systems, separate rooms housing switches, transmission equipment, distributing frames and entrance facilities for interoffice and loop cables.

b) End office switch

The end office switch provides dial tone to the switched access lines it serves. It also provides connections to other end offices via direct trunks, to tandem switches via tandem trunks, and to operator tandems via operator trunks. The model computes the numbers of trunks for each route according to input traffic assumptions and the breakdown of business, residential, and public access lines served by each end office switch.

c) Tandem switch

Tandem switches interconnect end office switches via tandem trunks. These trunks provide an alternate route for traffic between end offices when direct routes are unavailable. The tandem also may route access traffic between end offices and interexchange carriers' (IXC's) points of presence (POPs). Tandem switching functions often are performed by switches that also perform end office functions.

d) Signal transfer point

STPs route signaling messages between switching and control entities in a Signaling System 7 (SS7) network via signaling links between STPs and SS7-compatible end offices and tandems (called Service Switching Points "SSPs") as well as Service Control Points (SCPs). STPs are equipped in mated pairs, with at least one pair in each LATA.

e) Service switching points

SSPs are SS7-compatible end office or tandem switches. They communicate with each other and with SCPs through signaling links, which are 56 kbps dedicated circuits connecting SSPs with the mated STP pair serving the LATA.

f) Service control points

SCPs are databases residing in an SS7 network that contain various types of information such as IXC identification or routing instructions for 800 numbers in regional 800 databases and customer line information in Line Information Databases (LIDB).

B. OVERVIEW OF MODEL ORGANIZATION

Figure 4 shows the relationships among the various modules contained within HM2.2.2. An overview of each component module follows.

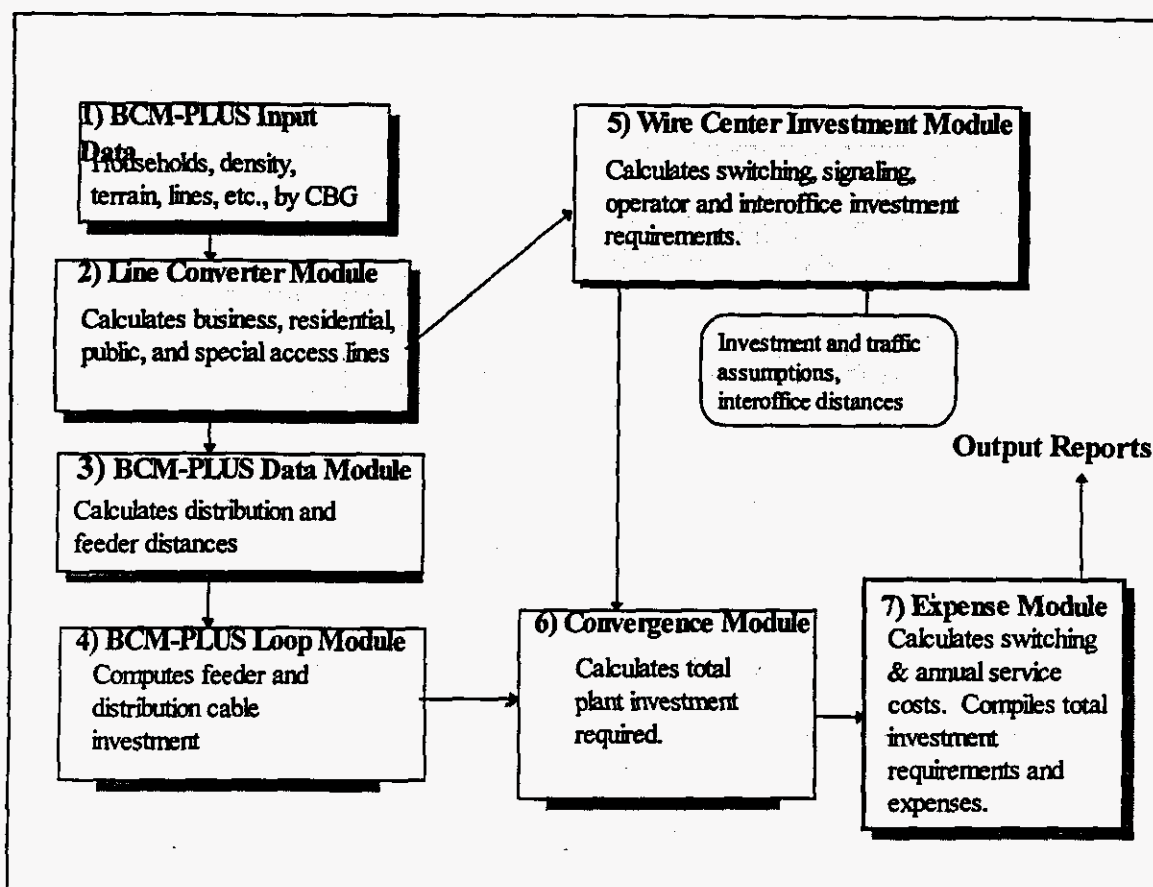


Figure 4 Hatfield Model Organization Flow Chart

1. BCM-PLUS loop input data file

The BCM-PLUS input data for the model generally consist of the original BCM state-by-state worksheets filed with the FCC.¹¹ The input household counts in each CBG (which in BCM1 were derived from 1990 Census Bureau data) have been replaced with 1995 household counts estimated from more recent Census Bureau data. As the following section discusses, HM2.2.2 modifies these BCM-PLUS data in several significant ways.

2. Line Converter Module

The model calculates all network costs on a per line basis, thus it must first determine the total access lines of all types within each CBG. The Line Converter Module transforms the Census data included in the BCM-PLUS input data files (which contain only household counts for each CBG) into total line counts by

¹¹ These data are for all states except Alaska. While the pertinent data for Alaska are included with BCM2, the BCM2 sponsors have placed more restrictive terms in the BCM2 license agreement that prohibit the use of these data for modeling use here.

customer type. The Line Converter Module performs this function while recognizing that residential subscriber penetration is less than 100%, that some residences contain second lines, and that business, public, and special access lines need also to be added. The module adds these latter line types based on other of its input data that indicate the number of business employees in each CBG. These line number calculations, which are performed on a CBG by CBG basis, are also required to accord with the number of lines that the incumbent LEC (ILEC) reports for the study area in ARMIS.

3. BCM-PLUS Data Module

The Data Module computes the distribution and feeder cable lengths necessary to serve each CBG and determines facilities placement difficulty according to geological parameters included in the BCM-PLUS input data.

4. BCM-PLUS Loop Module

The Loop Module estimates cable investments in each CBG according to the distribution and feeder lengths calculated in the Data Module. The module selects either fiber or copper feeder cable according to a user-adjustable parameter that specifies the feeder distance beyond which fiber is to be installed. The module then determines the size of copper or fiber cable required to serve each CBG according to user-adjustable maximum engineered fill levels for each population density range. Once the module has determined the required types and sizes of cable, it computes the total investment in feeder and distribution cables.¹²

5. Wire Center Module

The Wire Center Module computes investment in wire centers, switching (including end offices, tandems, and operator tandems), signaling, and interoffice transmission facilities. It uses line totals by type across all CBGs served by the wire center, along with user-adjustable traffic inputs, to estimate required switching capacities.

The model determines switching and interoffice capacity sufficient to serve all demand in the service area studied. HM2.2.2 derives its switch investment estimates by using data on typical per-line prices paid by BOCs, GTE and other independents,¹³ and data from Table 2.10 of the FCC's *Statistics of Communications Common Carriers*, which provides the average number of access lines served by existing LEC switches.

¹² A later module, the Convergence Module, adds investment for placement and "structure" (conduit, poles, trenching, and manholes), as well as other components, including SAIs, terminals, splices, subscriber drops and NIDs.

¹³ See *U.S. Central Office Equipment Market -- 1994*, McGraw-Hill.

6. Convergence Module

The Convergence Module combines output of the Loop Module (loop cable investments) with that of the Wire Center Module (per-line wire center and interoffice investments). The Convergence Module also adds investment in SAIs, buried, underground and aerial cable placement, terminals and splices, drop wires, NIDs, and structure components including poles, conduit, and manholes. Output from this module contains total investment for all plant categories by density range.

7. Expense Module

The Expense Module uses output from the Convergence Module to produce monthly costs of Unbundled Network Elements (UNEs) and basic local service. These costs include the annual user cost of capital for network investment (e.g., depreciation, return, and tax on return), network operating and maintenance expenses, and other per-line expenses incurred by ILECs in the provision of local service and UNEs. This module uses investment, revenue and expense data relationships that are available from ILEC ARMIS reports and allows the user to set different economic lives for various plant categories as well as adjust capital structure parameters.

C. MODULE DESCRIPTIONS

1. BCM-PLUS Input Data File

BCM-PLUS includes input data files organized by state. Each state file contains a list of that state's CBGs. CBGs are assumed to be served from the nearest existing wire center.¹⁴ Each CBG appears as a separate record in a Microsoft Excel 7.0 spreadsheet, and each record includes a set of geometric parameters describing the physical relationship (distance and direction) between the center of the CBG and the wire center serving it. The data also contain certain geological parameters associated with the CBG that indicate bedrock depth, bedrock hardness, and soil type.¹⁵ The input data file also contains the estimated number of households in each CBG as of 1995.

¹⁴ Because wire centers are associated with specific telephone companies, the model may be run on a company-specific basis.

¹⁵ Studies of the effects of these parameters on the estimate of placement difficulty show that the parameters affect overall results only slightly. The HM2.2.2 Convergence Module produces much more accurate estimates of placement investment with user-adjustable inputs than did the original BCM with its undocumented input assumptions. As noted in the text, however, HM2.2.2 (continued)

2. Line converter module

a) Overview

HM2.2.2 engineers loop facilities for residence, business, public and special access lines. As shown in Figure 5, the Line Converter Module calculates total access line counts for each CBG, as well as overall line totals for use in the BCM-PLUS Data Module and the Wire Center Investment Module. The Line Converter Module replaces the household count in each CBG with estimated total access lines, including business, public, special access, and first and second residential lines. This allows the BCM-PLUS Loop Module to calculate the sizes of feeder and distribution cables required to serve the existing demand.

b) Description of inputs and assumptions

The Line Converter module uses access line demand data from the Operating Data Reports, ARMIS 43-08, submitted to the FCC annually by all Tier 1 LECs.¹⁶ HM2.2.2 thus incorporates the following data.

- Residential access lines, both analog and digital. These totals measure all residential switched access lines, including flat rate (1FR) and measured rate (1MR) service.¹⁷
- Business access lines, including analog single line, analog multiline and digital. These totals include flat rate business (1FB) and measured rate business (1MB) single lines, PBX trunks, Centrex lines, hotel/motel long distance trunks and multi-line semi-public lines.¹⁸
- Special access lines, including analog and digital. These totals include dedicated lines connecting end users' premises to an IXC POP, but do not include intraLATA private lines.¹⁹

increases feeder and distribution cable lengths in the presence of shallow bedrock or rocky soil types for routing of facilities around areas with difficult placement conditions.

¹⁶ See, Reporting Requirements for Certain Class A and Tier 1 Telephone Companies (Parts 31, 43, 67 and 69 of the FCC's Rules), CC Docket No. 86-182, 2 FCC Rcd 5770 (1987) (ARMIS Order), modified on recon., 3 FCC Rcd, 6375 (1988). Tier 1 LECs are those with more than \$100 million in annual revenues from regulated services. This includes over 50 carriers.

¹⁷ Revision of ARMIS USOA Report (FCC Report 43-02) for Tier 1 Telephone Companies and Annual Report Form M, AAD 92-46, DA 92-1405, released October 16, 1992, Appendix C, at FCC Report 43-08 - Report Definition for Table S-3, page 2.

¹⁸ *Id.* at 1-2.

¹⁹ *Id.* at 2-3.

- Public access lines, which include lines associated with coin (public and semi-public) phones, but exclude customer owned pay telephone lines.²⁰

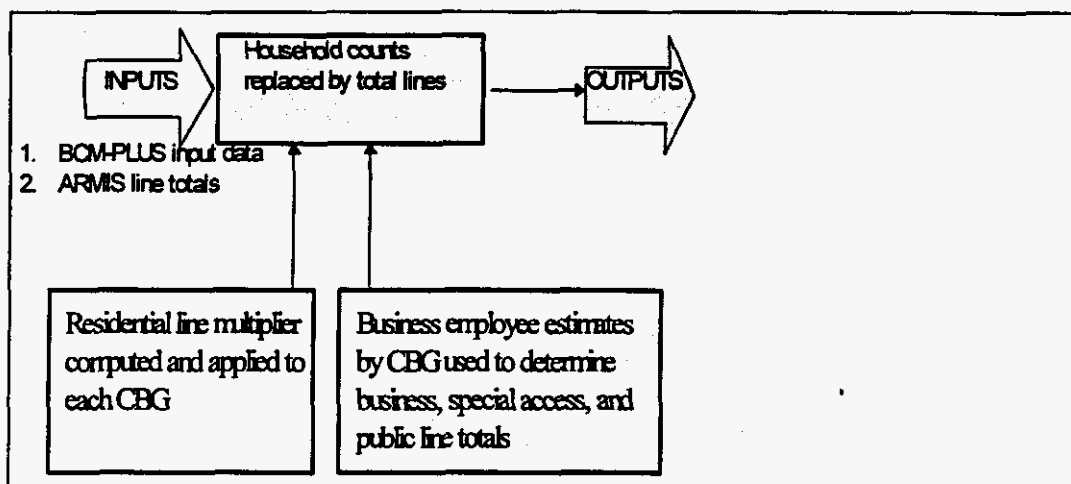


Figure 5 Line Converter Module

c) Explanation of calculations

In order to estimate loop plant investment properly, the model must consider the demand for all services, *e.g.*, business, first and second residential, special access and public access lines, within each CBG. Presumably, these service-specific demand data are known to the ILECs at a wire center or finer level. But because the ILECs have declared these data to be proprietary, absent Commission directive they are not available for incorporation into HM2.2.2.²¹

The Line Converter Module uses ARMIS access line data to assist in estimating total line counts per CBG. To compute residential lines in each CBG, the module multiplies the household count by the ratio of total reported residential access lines to total households. This accounts for total household penetration and multiple residential lines via a single average factor. The module similarly computes business lines in each CBG by multiplying the number of business employees in each CBG by the ratio of total reported business lines to total employees in the study area. Special access and public line calculations also are

²⁰

Id. at 2.

²¹

Some BOCs, notably the Southwestern Bell companies, formerly published this information for use by their interexchange carrier customers, but the practice apparently has been discontinued. See, Southwestern Bell, *Interexchange Customer Information Handbook*, Volume IV (End Office Profile), 1987.

based on business employee counts because both services are closely associated with businesses.

d) Description of module outputs and connection to next module

The primary output from the Line Converter Module is the Input Data File -- with household counts in each CBG replaced by total residential, business, special access and public lines. The other data in the Input Data File pass through the module unchanged for eventual use by both the BCM-PLUS Data Module and the Wire Center Module.

3. BCM-PLUS Data module

a) Overview

The BCM-PLUS Data Module uses Line Converter Module output to calculate feeder, subfeeder, and distribution cable lengths. The BCM-PLUS Data Module uses the distance between each CBG and its serving wire center, and the area of each CBG, to estimate feeder and distribution cable lengths. In areas of increased placement difficulty, generally those CBGs with shallow bedrock (within one foot of the surface) or having rocky (*e.g.*, "bouldery") soil types, the Data Module increases the calculated feeder and distribution distances to allow for routing of facilities around these rocky conditions.

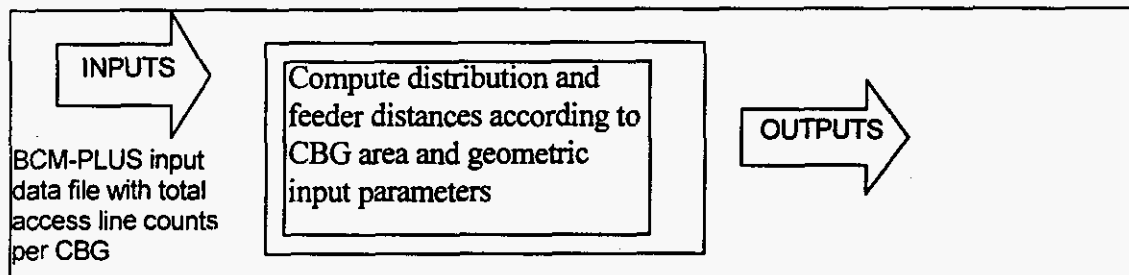


Figure 6 Data Module

b) Description of inputs and assumptions

The Data Module bases its loop length calculations on the following assumptions.

- Feeder cable extends from the wire center to an SAI located midway between the edge and the center of the CBG.
- There are four main feeder routes that leave each wire center, with sub-feeder routes placed at 90 degree angles from the main feeder routes.
- Customer premises are spaced uniformly across a CBG.

- Distribution cables extend from the SAI within the CBG to terminals serving several customers' premises.
- A variable number of equal-length distribution cables serve each CBG. The area of the CBG determines the length of each cable, and the CBG line density determines the number of cables.

A more detailed description of the model's feeder route design is contained in the documentation to Release 1.²²

c) Explanation of calculations

Distribution Distance -- BCM-PLUS uses geometric relationships to calculate distribution distances. The distribution distance is the average distance between a customer premises and the SAI. The module calculates the average distribution distance within a CBG to equal 0.625 times the length of one side of the CBG.

SAI placement -- The Data Module adds sufficient feeder cable to place the SAI at a point midway between the CBG boundary and its center. This approach comports with telephone company outside plant engineering practices.

d) Outputs

The output of the BCM-PLUS Data Module includes total line counts per CBG, along with feeder and distribution cable lengths. Other parameters include "cable multipliers" used in a previous version to estimate combined placement investment. Because HM2.2.2 calculates separately cable placement and structure investments, these values are not used by BCM-PLUS.

4. BCM-PLUS Loop Module

This section discusses inputs and calculations in the BCM-PLUS Loop Module.

a) Module overview

The BCM-PLUS Loop Module estimates loop cable facilities investment for HM2.2.2. The Loop Module employs a "bottoms-up" network design process that uses forward-looking loop plant engineering and planning practices, publicly-available information on component prices, and least-cost cable sizing algorithms to estimate the outside plant investment appropriate to a TELRIC-based analysis.

²²

See, note 4, *infra*.

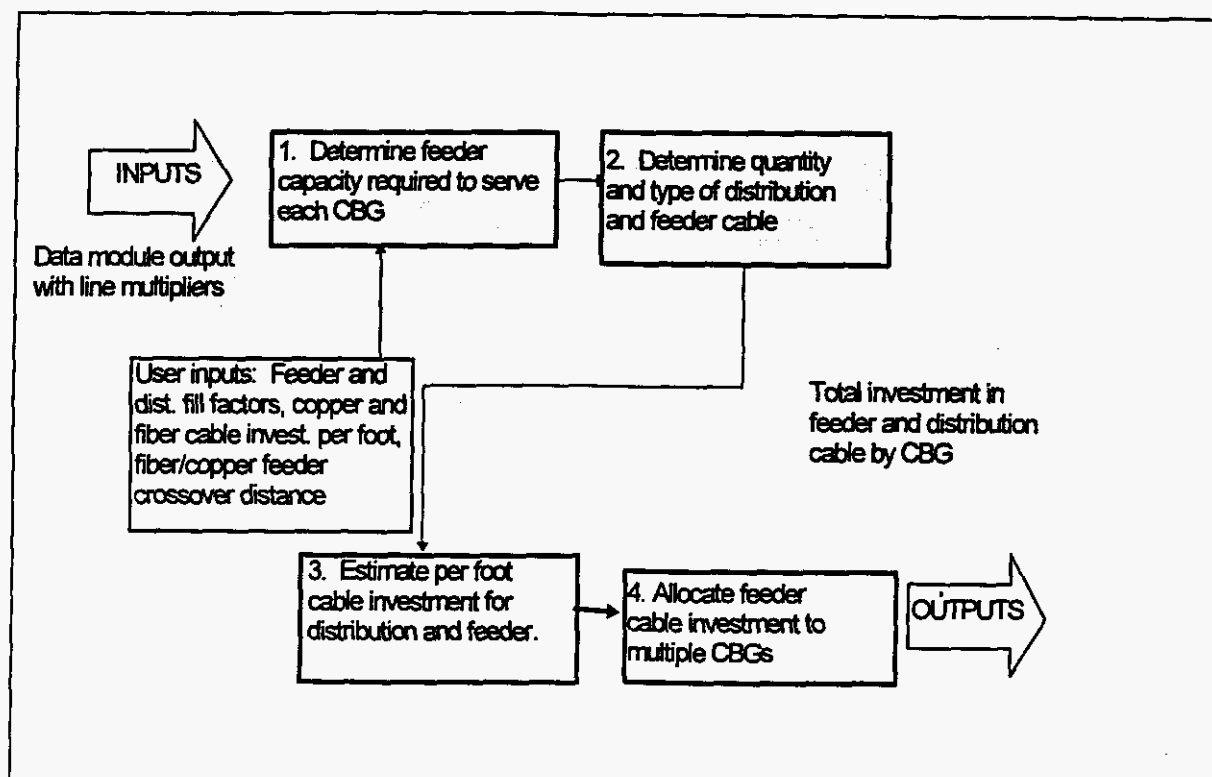


Figure 7 BCM-PLUS Loop Module

b) Description of inputs and assumptions

Inputs to the Loop Module include the per-foot investment cost for copper and fiber cable, the distance at which fiber feeder cable is installed, the number of DS-0s that can be carried on a single fiber, and the number of fibers required to feed a DLC remote terminal. There are separate per-unit investment tables for distribution, copper feeder, and fiber feeder cables. These tables show the assumed per-foot investment for cables having different cross sections. The default numbers in these tables assume discounted cable materials prices, along with per-unit costs for installation, engineering, and delivery.

c) Inputs derived from the Data Module

The following outputs from the Data Module are used as inputs by the Loop Module.

Feeder and Distribution Distances -- These are the feeder, sub-feeder and distribution lengths calculated for each CBG. The main feeder distance (called the "B" distance in the model) for each CBG is expressed as the incremental distance from the CBG to the CBG served by that feeder that is the next closest to the wire center (the "B segment" length). The formula used to develop B segment length is to first match the CBG with all others served by the same wire center and within the same quadrant (*i.e.*, on the same main feeder route). The module

then calculates the B segment length for each CBG by subtracting from its total B length the total B length associated with the next CBG closer to the wire center. Segmentation of the main feeder in this way allows the Loop Module to simulate the tapering of cable facilities along the feeder route.

The model also computes a "subfeeder" distance (called the "A" distance within the model) which is the distance from the main feeder route to the SAI in CBGs that are not astride the main feeder route.

d) User Specified Inputs

Because the Loop Module simulates the "bottoms up" development of a network, it requires several inputs specifying the type and purchase price for copper distribution cable and copper and fiber feeder cable, as well as maximum engineered cable fill factors that vary by density range. Because the actual prices paid for these components may vary from carrier to carrier, these values may be adjusted, if appropriate, by the user. The model, however, contains HAI's best estimates as default values for cable investment per foot and cable fill factors. These default values for fill factors and cable investment per foot are as follows:

Density (lines/sq. mi.)	Feeder fill	Distribution fill
0 - 5	0.65	0.50
25 - 200	0.75	0.55
200 - 650	0.80	0.60
650 - 850	0.80	0.65
850 - 2550	0.80	0.70
> 2550	0.80	0.75

Fiber feeder cable investment per foot (including engineering, delivery and installation)	
Fiber cable size(strands)	Investment per foot
12	\$2.90
18	\$3.20
24	\$3.50
36	\$4.10
48	\$4.70
60	\$5.30
72	\$5.90
96	\$7.10
144	\$9.50
216	\$13.10

Copper feeder cable investment per foot (including engineering, delivery and installation)	
Pairs in sheath	Investment per foot
100	\$2.50
200	\$4.25
400	\$7.75
600	\$11.25
900	\$16.50
1200	\$21.75
1800	\$32.25
2400	\$42.75
3000	\$53.25
3600	\$63.75
4200	\$74.25

Distribution cable investment per foot (including engineering, delivery and installation)	
Copper cable sizes	Investment per foot
25	\$1.19
50	\$1.63
100	\$2.50
200	\$4.25
400	\$7.75
600	\$11.25
900	\$16.50
1200	\$21.75
1800	\$32.25
2400	\$42.75
3600	\$63.75

Other user inputs are discussed in the feeder plant section below.

e) Distribution plant

This section examines components of the distribution facilities. The model assumes that all distribution cables serving a CBG are of equal length. The number of distribution cables per CBG varies by density range as shown below.

Density (lines/sq. mi.)	Number of cables
0 - 5	2
5 - 200	4
200 - 650	4
650 - 850	4
850 - 2,550	6
> 2550	8

The larger number of cables serving higher density CBGs reflects the fact that households will tend to be distributed more uniformly across densely populated CBGs than across less dense CBGs. In addition, customer premises plot sizes will be smaller. Lower numbers of cables serving lower density CBGs reflect the fact that customer premises will either be concentrated along a few roads, or clustered in towns rather than being distributed uniformly.

Mix of aerial and underground plant for distribution -- Distribution cables typically connect with the feeder network at one or more SAIs and run along streets within a defined area. Distribution plant may be aerial (carried on poles), underground (placed in conduit), or buried (plowed directly in the ground or placed in a trench without conduit). The proportions of aerial, underground and buried cable are user-adjustable variables set in the Convergence Module.

Unit Costs for Distribution Cable -- The default cable investment figures shown in the preceding table include discounted materials prices, engineering, delivery to the site, and placement or installation.²³ These costs are added to other loop investments in the Convergence Module, described later.)

Fill Factors for Distribution Cable -- The Loop Module permits users to input values specifying the maximum engineered level of plant utilization or "fill" for distribution and feeder cable.²⁴ Engineered cable fills are always less than 100% in practice, with some spare pairs necessary to accommodate unforeseen growth, breakage and line administration.

The effective fill factors achieved by the Hatfield Model are even lower than the engineered fill factors because the model requires that the next larger available cable size be installed to accommodate the engineered fill.

f) Feeder plant

Feeder cables extend along any of four routes from the wire center to one or more points where they are cross-connected to the distribution network. Depending on required feeder capacity, distance or economics may dictate that feeder be provisioned using various sizes of copper cabling, or fiber cables in conjunction with DLC systems. The Loop Module assumes that a CBG will be served with fiber-fed DLC equipment whenever the feeder length exceeds a user-adjustable threshold value (the default is 9,000 feet); otherwise it assumes copper feeder cable.

The user may specify the number of fibers assigned per DLC remote terminal. The default value is four. Similarly, the number of equivalent voice

²³ Placement investment consists of pulling underground cable through conduit and mounting aerial cable on poles. It should not be confused with the actual "structure" investment in poles, conduit and manholes, or in the installation of structure components.

²⁴ A cable fill factor represents the ratio of working lines (measured in terms of voice grade equivalent channels or copper wire pairs) to minimum installed line capacity.

circuits (DS-0s) that may be carried on this fiber may be set by the user. The default value is 2016, or 3 DS-3s.

Mix of aerial and underground plant for feeder -- These values are set in the Convergence Module, as they are for distribution cable.

g) Explanation of calculations

The Loop Module's calculations include the following:

- Selection of copper or fiber feeder cable to serve each CBG according to the user-adjustable threshold feeder distance (default is 9,000 ft).
- Sizing of main feeder segments to accommodate the cumulative capacity requirements along the route.
- Determination of the type and quantity of feeder facilities and distribution cables to meet each CBG's capacity requirements.

Applying unit investment costs to estimate total investment in loop cables -

- The fundamental feeder length calculations, including the sharing of feeder sheath by multiple CBGs lying on a common route, are essentially unchanged from those described in the Release 1 documentation. The BCM-PLUS Data Module does, however, extend the SAI location into each CBG halfway to its center.

The BCM-PLUS Loop Module computes distribution cable lengths as 0.625 times the length of a side of the CBG. The number of cables serving a CBG varies according to the CBG's density range, as described in the Data Module discussion above. The Loop Module sizes the distribution cables according to the specified fill factor and number of cables in each CBG.

h) Description of model outputs

The Loop Module produces total investment by CBG for distribution and feeder cable. The Loop Module's "costing" worksheet contains these investments and is sent to the Convergence Module to determine overall network investment.

5. Wire Center Investment Module

a) Overview

This Module produces network investment estimates in the following categories:

Switching and wire center investment -- This category includes investment in local and tandem switches, along with associated investments in wire center facilities, including buildings, land, power systems and distributing frames.

Signaling network investment -- This includes investment in STPs, SCPs and signaling links.

Transport investment -- This category consists of investment in transmission systems supporting local interoffice (tandem and direct) trunks, intraLATA toll trunks (tandem and direct) and access trunks (tandem and direct). The model also separately calculates investment in operator trunks.

Operator Systems investment -- This includes investments in operator systems positions and operator tandems. The module allows the operator positions to be located at a distance from the operator tandem.

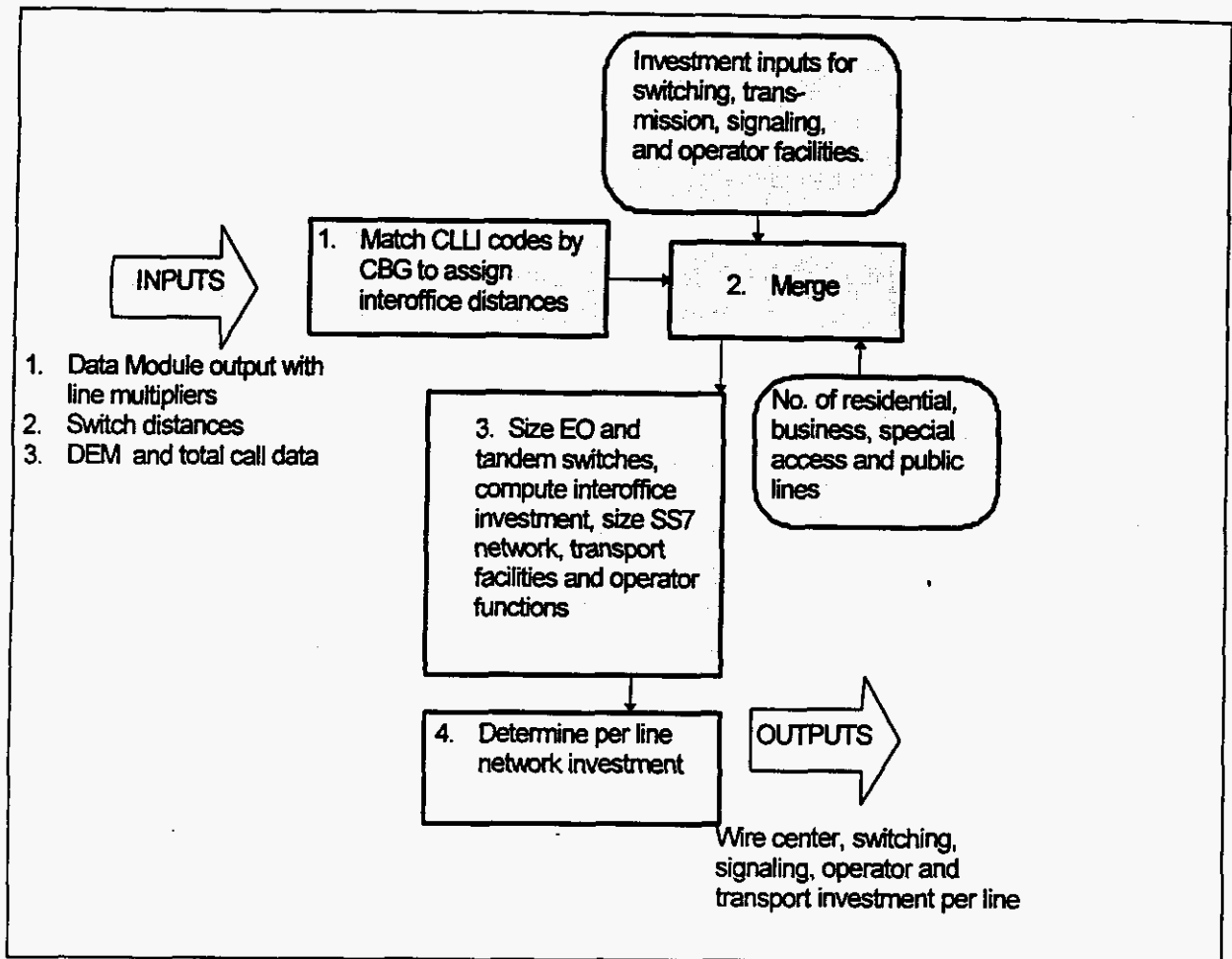


Figure 8 Wire Center Module

b) Description of inputs and assumptions

For the wire center module to compute required switching and transmission investments, it must have as inputs total line counts for each wire center, interoffice distances, traffic peakedness assumptions, as well as inputs describing the distribution of total traffic among local intraoffice, local interoffice, intraLATA toll, interexchange access and operator services. This module takes as data inputs overall line counts obtained from the Line Converter Module and interoffice distances for the calculation of transmission facilities investment.²⁵

²⁵

The HM2.2.2 includes a set of interoffice distance calculations produced from wire center location information from Bellcore's Local Exchange Routing Guide (LERG). Because AT&T has now gained a site license for use of these data, users of the Hatfield Model no longer need to obtain their own copies of the LERG.

There are many user-adjustable input assumptions in the Wire Center module. The following sections discuss these assumptions, and Appendix C includes additional tables showing all of the default values for the module's input parameters.

c) Traffic assumptions

Many of the calculations in the Wire Center module rely on traffic assumptions suggested in Bellcore documents.²⁶ These inputs, which the user may alter, assume 1.3 busy hour call attempts (BHCA) per residential line and 3.5 BHCA per business line. Total busy hour usage is then determined based on published Dial Equipment Minutes (DEM) information. Other inputs, which may be changed by the user, specify the fraction of traffic that is interoffice, the fraction of traffic that flows to operator services, the local fraction of overall traffic, as well as breakdowns between direct-routed and tandem-routed local, intraLATA toll, and access traffic. Appendix C contains tables showing the default settings for these parameters.

d) Explanation of calculations

The following sections describe the calculations used to generate investments associated with switching, wire centers, interoffice transport, signaling and operator systems functions.

(1) Switching investment calculations

The Module places at least one end office switch in each wire center. It sizes the switches placed in the wire center by adding up all the switched lines in the CBGs served by the wire center, then compares this line total to the maximum allowable switch line size. This parameter is user-adjustable, but its default setting is at 100,000 lines with a fill factor of 0.80, yielding a maximum effective switch line size of 80,000. By default, the model will equip the wire center with a single switch if the number of switched access lines served by the wire center is no greater than 80,000. If a wire center serves 90,000 lines, the model will compute the investment required for two 45,000 line switches.²⁷ The wire center module also compares the BHCA produced by the mix of lines served by each switch with a user-adjustable processor capacity (default set at a maximum of 600,000 BHCA) to determine whether the switch is line-limited or processor real-time-limited.

²⁶ Bell Communications Research, *LATA Switching Systems Generic Requirements, Section 17: Traffic Capacity and Environment*, TR-TSY-000517, Issue 3, March 1989.

²⁷ If multiple switches are required in the wire center, they are sized equally to allow for maximum growth on both switches.

Once the model determines the end office switch line size, it calculates the required investment per line from an investment function that relates per-line switching investment to switch line size. The data defining this function were obtained from a publicly-available study of the central office equipment market published annually by McGraw-Hill.²⁸ This study shows the average investment per new line of digital switching paid by BOCs to be \$102, and by independents to be \$235, in 1995.²⁹ The model combined these figures with average BOC (11,200) and independent (2,761) switch line sizes derived from data published in the FCC's *Statistics of Communications Common Carriers*, along with information on much larger switches obtained from switch manufacturers to develop the complete investment function.³⁰ The above per-line investment figures are for the entire end office switch, including trunk ports. These investment figures are then reduced by \$16 per line to remove trunk port investment that will be accounted for in the module's trunk calculations. Figure 9 shows the resulting investment curve.

²⁸ Northern Business Information study: *U.S. Central Office Equipment Market -- 1995*, McGraw-Hill.

²⁹ These per-line average prices represent investments over all types of switching, including remote switching systems, hosts, and stand-alone end office switches. Through this scaling, the switching investment curve thus represents automatically the cost of the average profile of remote, host, and stand-alone applications of end office switches.

³⁰ Federal Communications Commission, *Statistics of Communications Common Carriers*, Tables 2.3 and 2.4, 1994 edition.

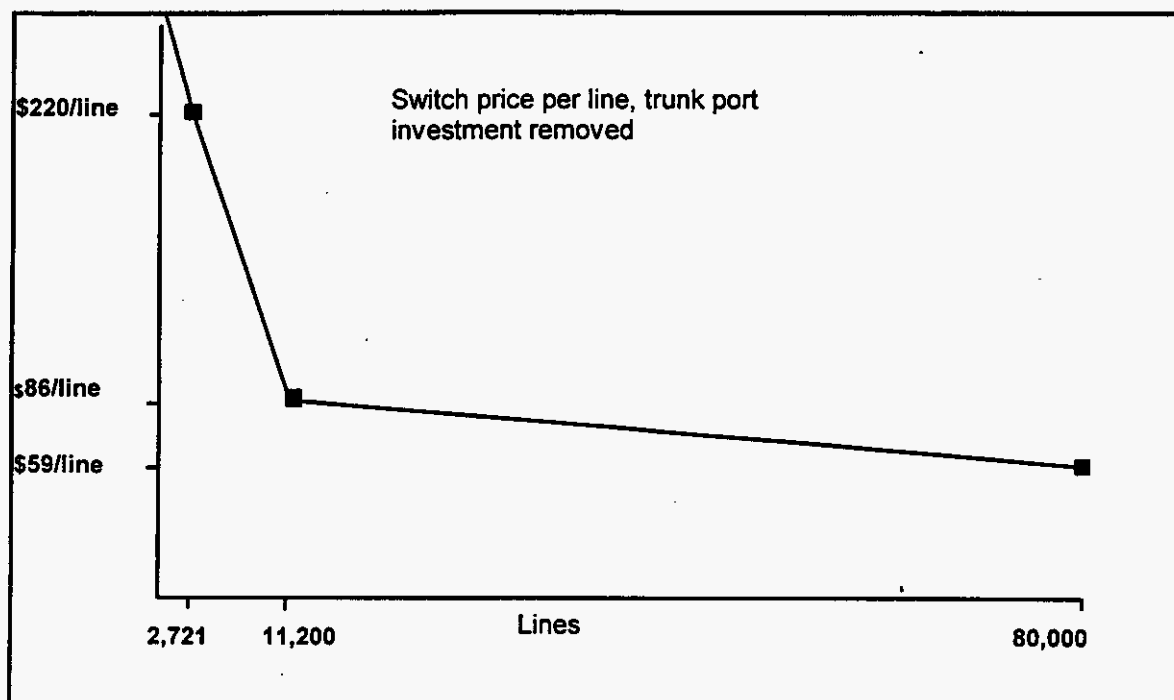


Figure 9 Switching investment curve

The wire center module uses existing tandem and end office wire center locations for computing interoffice transmission investments. A preprocessing step, relying on licensed LERG data, produces end office-to-tandem, end office-to-STP, tandem-to-STP, and STP-to-STP distances in a table that then is used by the module to estimate interoffice transmission facility investments. The module computes investments for end office and tandem "A" signaling links, "C" signaling links between the STPs in a mated pair, and it estimates investments in "D" signaling link segments that an interconnecting carrier such as an IXC may lease from the ILEC.

Tandem and operator tandem switching investments are computed according to assumptions contained in an AT&T report on interexchange capacity expansion costs filed with the FCC.³¹ The investment calculation assigns a price to switch "common equipment," switching matrix and control structure, and adds to these amounts the investment in trunk interfaces. The numbers of trunks and their related investments, are derived from the transport calculations described below. The module recognizes that a significant fraction of local tandems also perform end office switching functions, and the inputs allow the user to vary the

³¹ AT&T, "An Updated study of AT&T's Competitors' Capacity to Absorb Rapid Demand Growth," filed with the FCC in CC Docket No. 79-252, April 24, 1995 ("AT&T Capacity Cost Study").

sharing of tandem common equipment with end office use. The default sharing value is 40%.

Wire center investments required to support end office and tandem switches are based on assumptions regarding the size of room required to house a switch (for end offices, this size varies according to the line sizes of the switch), construction costs, lot sizes, land acquisition costs and investment in power systems and distributing frames. The default values are shown in Appendix C.

The model computes required wire center investments separately for each switch. For wire centers housing multiple end office switches, the wire center investment calculation adds switch rooms to house each additional switch. Tandem wire center calculations assume the maximum switch room size, and further assume the tandem will reside in a wire center that contains at least one end office switch.

(2) Transport calculations

The traffic and routing assumptions listed above, along with the total mix of access lines served by each switch, form the basis for the model's transport calculations. The model determines the overall breakdown of traffic per subscriber according to the traffic assumptions and computes the numbers 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 direct and tandem routing. These traffic fractions are applied to the total traffic generated in each wire center according to the mix of business and residential lines and appropriate per-line offered load assumptions. These trunk loading assumptions include a user-adjustable maximum trunk utilization of 27.5 CCS in the busy hour.³²

The distance preprocessing calculations estimate interoffice distances using existing wire center and tandem locations. The calculation assumes rectilinear routing between end offices and tandems, and between switches and STPs. The resulting distances are greater than if they were calculated as airline mileage.

Average direct-route distances for local, intraLATA and access traffic are set as user-definable inputs. It is not possible to compute these values from wire center locations because existing exchange area definitions determine whether routes will carry local, intraLATA toll, or access traffic. In addition, the locations

³²

The 27.5 CCS value is based on an AT&T estimate of maximum per trunk utilization. See, AT&T Capacity Cost Study.

of IXC POPs may not be publicly available. Because of these factors, the default distances for direct transport are 10 miles for local routes, 25 miles for intraLATA routes, and 15 miles for access routes. The user may alter these values.

The model contains explicit transport facilities investment calculations to produce both termination and per-mile investments, each expressed per DS-0 (a 64 kbps voice-equivalent circuit). The assumptions underlying these calculations include the facilities capacity expressed at a default SONET transmission rate of OC-12, multiplexer installed price per end, regenerator spacing and investment, buried/underground/aerial composition, manhole spacing and investment, pole spacing and investment, along with ancillary investments such as splicing, optical patch panels, and "pigtail" (short connectorized fibers between strands in the cable and the optical patch panel) investment. Interoffice investment calculations also include a "sharing" factor that accounts for the sharing of structure used by feeder and interoffice facilities. This eliminates double-counting of structure between feeder and interoffice routes. The amount of sharing, expressed as a percentage of interoffice route miles, is a user-adjustable input. The default value is 25%.

(3) Tandem switch calculations

The module scales the investment in tandem switch common equipment according to the total number of tandem trunks computed for the study area. By doing so, it thus avoids equipping maximum-capacity tandems whenever a LATA is served by multiple tandems. The calculations also recognize that a significant fraction of tandems in practice are "Class 4/5" offices that serve both tandem and end office functions. A sharing fraction may be set by the user to reflect the incidence of such dual-purpose switches.

(4) Signaling network calculations

The Wire Center Module uses the preprocessed interoffice distances to compute signaling link investment for end office and tandem A links, C links between the STPs in a mated pair, and D link segments. The investment per link-mile is the same as the computed per-DS-0 investment described above.

The model always equips at least two signaling links per switch. It also computes required SS7 message traffic according to the call type and traffic assumptions described earlier. User inputs define the number and length of ISDN User Part (ISUP) messages required for interoffice call control. Default values are six messages per interoffice call attempt with twenty-five octets per message. These values are those assumed in the AT&T Capacity Cost Study.

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. Default values, also obtained from the AT&T Capacity Cost Study, are two messages per transaction, at 100 octets per message, and 10% of all calls requiring TCAP generation. If the message traffic from a given switch exceeds the link capacity (also user-adjustable and set at 56 kbps and 40% occupancy as default values), the model will add links to carry the computed message load. The total link distance calculation includes all the links required by a given switch.

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). The maximum investment per STP pair is set at \$5 million, and may be changed by the user. These default values derive from the AT&T Capacity Cost Study. The STP calculation scales this investment based on the number of links the model requires to be engineered for the study area.

SCP investment is expressed in terms of dollars of investment per transaction per second. The transaction 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. The default SCP investment is \$20,000 per transaction per second and is based on a number reported in the AT&T Capacity Cost Study.

(5) Operator systems calculations

Operator tandem and trunk requirements are based on the operator traffic fraction inserted by the user into the model and on the overall maximum trunk occupancy value of 27.5 CCS discussed above. Operator tandem investment assumptions are the same as for local tandems.

Operator positions are assumed to be based on current personal computer terminal technology. The default operator position investment is \$3500. The Model includes assumptions for maximum operator "occupancy" expressed in CCS. The default assumption is that each position can be in service 27.5/36 of the busy hour. This value is related to the maximum trunk occupancy assumption described above. Also, because many operator services traditionally handled by human operators may now be served by announcement sets and voice response systems, the model includes a "human intervention" factor that reflects the fraction of calls that require human operator assistance. The default factor is 10, which is believed to be a conservative estimate. (A factor of ten implies that one out of ten calls will require human intervention).

6. Convergence module

The Convergence Module combines the loop cable investments produced by BCM-PLUS with the wire center, switching, transport, signaling and operator

systems investments calculated by the Wire Center Investment Module. The output of the Convergence Module is the complete collection of network investments stated by density range for use by the Expense module.

The module adds structure investment to the loop cable investments produced by the Loop Module based directly on the number of sheath miles of cable to be installed. The previous version of the Hatfield Model relied on BCM estimates of loop structure components which were calculated by applying “cable multipliers” to loop cable investment. The cable multipliers produced estimates of structure that varied directly with cable investment. In some cases, the structure estimates per unit length were unacceptably low. The multiplier approach also improperly made structure investment a function of cable materials price discounts.

In Release 2, the Convergence Module includes user-defined inputs for conduit investment, pole investment and spacing, manhole investment and spacing, trenching and direct burial investment, and breakdowns of aerial, buried, and underground cable. Although the Loop Module cable investment inputs include values for aerial and underground cable, where buried cable is required the Convergence Module adds an incremental amount per foot to represent the increased investment in armoring that is characteristic of cable intended to be directly buried. The default assumptions, which vary by density range, appear in Appendix C. There are separate sets of default inputs for distribution, copper feeder and fiber feeder facilities.³³

The following tables display the default values for structure type:

Distribution Structure			
Density Range	Aerial Fraction	Buried Fraction	Underground Fraction
0 - 5	0.50	0.50	-
5 - 200	0.50	0.50	-
200 - 650	0.50	0.50	-
650 - 850	0.50	0.50	-
850 - 2550	0.40	0.50	0.10
> 2550	0.65	0.05	0.30

³³ The HM2.2.2 Convergence Module still performs certain loop-related calculations. These were originally included in this module to correct deficiencies in the initial BCM loop calculations. HAI has chosen to keep these additional calculations in the Convergence Module even after the incorporation of BCM-PLUS into HM2.2.2.

Copper Feeder Structure			
Density	Aerial Fraction	Buried Fraction	Underground Fraction
0 - 5	0.50	0.45	0.05
5 - 200	0.50	0.45	0.05
200 - 650	0.50	0.45	0.05
650 - 850	0.40	0.40	0.20
850 - 2550	0.10	0.10	0.80
> 2550	0.05	0.05	0.90

Fiber Feeder Structure			
Density Range	Aerial Fraction	Buried Fraction	Underground Fraction
0 - 5	0.35	0.60	0.05
5 - 200	0.35	0.60	0.05
200 - 650	0.35	0.60	0.05
650 - 850	0.20	0.60	0.20
850 - 2550	0.10	0.10	0.80
> 2550	0.05	0.05	0.90

The Convergence Module adds several components to the loop cable investments produced by the Loop Module: NIDs, SAIs, terminals and subscriber drops. The drop and terminal/splice values are added for each line directly. The model computes one NID per household and one NID for every four (a user-adjustable value) business lines. The default per-unit investments are \$30 for the NID (obtained from discussions with subject matter experts); \$40 for the drop (taken from the New England Telephone Incremental Cost Study³⁴), and \$35 for the terminal and splice.

The SAI investments depend on whether copper or fiber feeder cable feeds a particular CBG. If the feeder cable is copper, the SAI is a simple cross-connect arrangement. This arrangement's investment is obtained from a table listing SAI installed prices by total lines served. For optical feeder cable, the SAI consists of an optical patch panel for connecting the cable to the remote terminal, along with an associated cross-connect for connecting the subscriber loops to the analog side of the remote terminal. Investment assumptions for both types of SAIs include engineering, a housing, and site preparation, along with common equipment and

³⁴

NYNEX, 1993 New Hampshire Incremental Cost Study

per-line investments in channel units. A separate fill factor applies to the number of lines served by each set of common equipment.

Structure investment (*i.e.*, poles, conduit, trenches, and manholes) generally are shared among utilities, typically LECs, CATV operators, electric utilities, and others, including competitive access providers (CAPs) and IXC's. To the extent that several utilities may place cables in common trenches, conduits or on common poles, it is appropriate to share the costs of these structure items among them. Because the Convergence Module reports investments in different structure separately to the Expense Module, the user may select the fraction of each type of distribution and feeder structure investment that should be assigned to local telephone service.

The Convergence Module also adds investment for integrated DLC equipment. Inputs include site and power, common equipment, and per-line investment in channel units. The module allows two types of DLC equipment as described in the Release 1 documentation: TR-303-compatible SLC[®]-2000 equipment, used in all but the lowest density zone, and proprietary equipment manufactured by Advanced Fibre Communications, a California company, in the 0-5 lines per square mile range.

The Convergence Module produces investments in the following categories for each of the six density ranges:

- Distribution (aerial, buried, and underground copper cable and associated structure)
- Concentration (DLC remote terminal and associated investment in power, site preparation, and housing)
- Feeder (aerial, buried and underground fiber and copper feeder cable and associated structure)
- Switching (end office and tandem switching investment)
- Wire center (end office and tandem wire center investment)
- Operator services (operator tandem switching, tandem wire center, trunks and operator positions)
- Transport (common and dedicated)
- STPs
- SCPs
- Signaling links
- NID, drop, terminal and splice, and SAI

In addition, the Convergence Module output sheet summarizes line and trunk counts, and passes other parameters, such as tandem routing fractions and DEMs, to the Expense Module. Line counts include residential, business, special access and public access lines, and the module also reports households in each density range.

7. Expense Module

a) Overview

The Expense Module provides per-line and per-month cost summaries for each unbundled network element defined by the model, and for basic universal service. It does so by calculating capital carrying cost, operating expenses, network operation expenses, and attributable support expenses for each of eleven UNEs plus public telephone terminal equipment.

The Expense Module uses the output of the Convergence Module to capitalize the investments needed for each UNE and the per-line investments for basic universal service. The module requires investment, revenue and expense data reported by individual LECs in their annual ARMIS reports. The Module's other required inputs are capital structure parameters (e.g., debt/equity ratio, costs of debt and equity) as well as the total network investment produced by the Convergence Module.

The Expense Module uses ARMIS data to calculate several expense-to-investment ratios to be applied to the investments in different plant categories as computed by the model. It also uses estimates of LEC revenues, tax rates, costs of debt and equity and economic service lives for various types of network equipment.

This section describes the inputs and assumptions of the Expense Module, including ARMIS data, capital structure parameters and expense factors built into the module. It also explains the calculations used to determine capital costs and operating expenses.

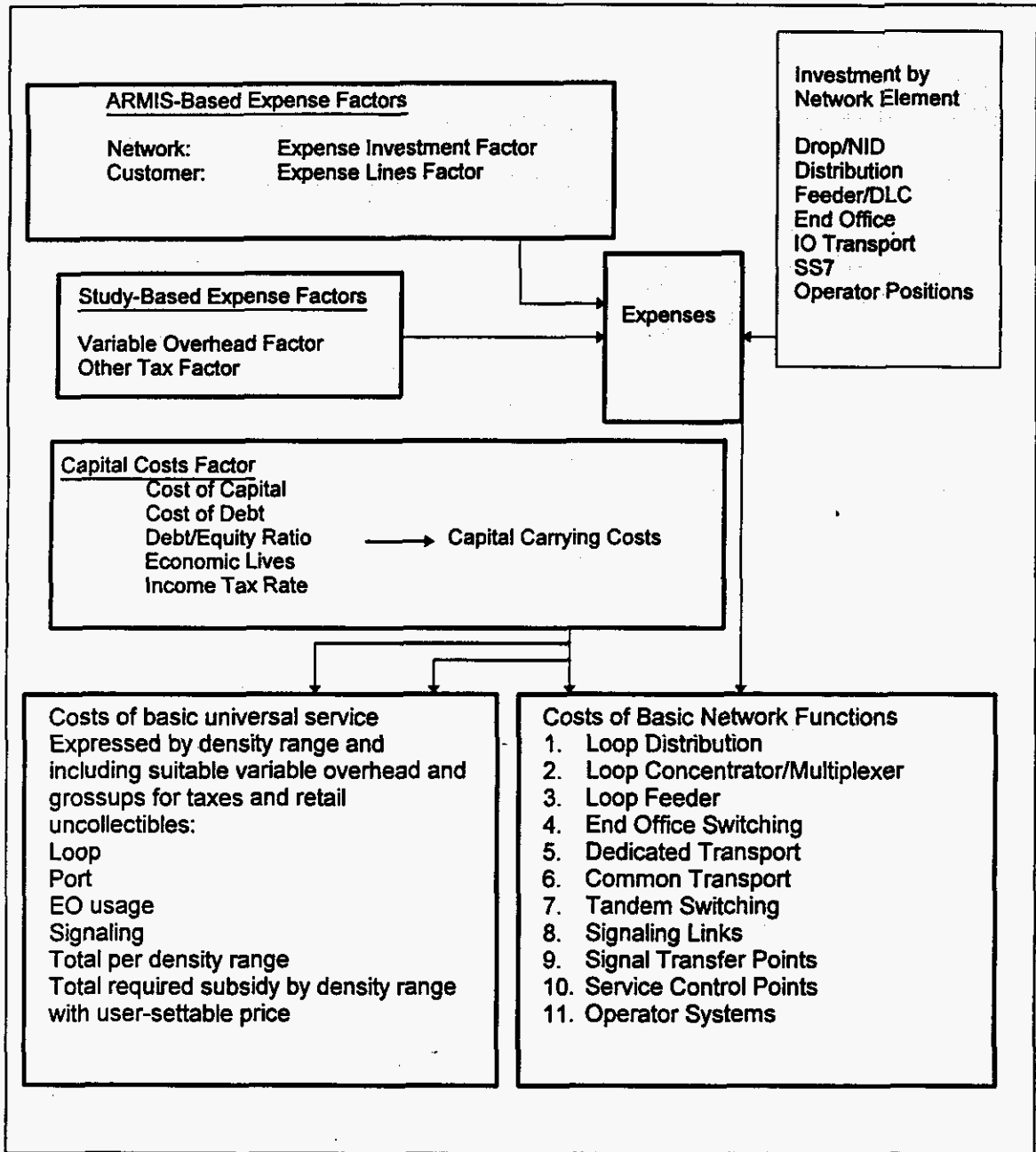


Figure 10 Expense Module

b) Description of inputs and assumptions

(1) ARMIS data

The ARMIS data used in the Expense Module include investment and operating expenses and revenues for a given local carrier and state. These data are used to derive the total investments, expenses and revenues for each UNE. The

investment, expense and revenue categories are listed below, and described in detail in the Calculations section.

- (a) plant specific operations
 - end office and tandem switching -- digital switching, operator systems
 - transmission -- circuit equipment, transmission
 - information origination and termination -- public telephone, terminal equipment
 - cable and wire facilities -- poles, cable, conduit

- (b) plant non-specific operations
 - provisioning
 - power
 - plant operations
 - network administration
 - testing
 - general support equipment -- land, buildings, vehicles, furniture, office and other equipment

In addition, ARMIS data include local network service revenues by the following categories:

- access revenue -- end user, switched and special access revenue
- basic service revenue
- long distance network revenue

(c) Capital structure parameters

The Expense Module requires capital structure parameters to calculate the carrier's Weighted Average Cost of Capital (WACC), which is a discount factor used to calculate capitalized costs of UNEs and basic local service. Parameters required are for the carrier's debt/equity ratio, cost of debt, and cost of equity.

(d) Factors built into the expense module

The module uses a number of ratios and factors to calculate monthly per-line loop and annual switching costs. These factors are explained in detail in the Calculations section.

(e) Other user inputs

There are several explicit user inputs to the Expense Module, including economic lives by plant category, variable overhead factor, forward-looking Network Operations expense reduction factor, similar forward-looking expense factors for switching and circuit equipment, other taxes (principally franchise fees), and structure assignment factors. The model uses the latter to assign structure investment to telephone subscribers. Generally, plant structure (conduit, poles, and trenches) will be shared by several service providers. The structure assignment parameters in the Expense Module allow the user to vary the amount of structure investment for aerial, underground, and buried feeder and distribution facilities assigned to telephone users. The default value is 0.33 for all categories.

Other user inputs include an explicit value for the monthly cost per line for local number portability (set at a default of \$0.25/line/month), a quantity used in estimating basic local service monthly costs. There is also a monthly factor of \$1.22 per line that accounts for bill generation and bill inquiries relating to basic local service. The model includes a value for the NID's annual maintenance expense, the default is \$3.00 per NID. There is an input for carrier-to-carrier customer expense, set at \$1.56 per line per year, which is used in the determination of UNE costs. This default value derives from Tier 1 LEC expenses for servicing the access accounts of their IXC customers reported in ARMIS 43-04 for 1995.

Appendix C shows all user inputs to the Expense Module.

c) Explanation of calculations

The Expense Module is driven primarily by the calculated annual capital cost and operating expenses of the carrier(s) under study. All costs are summarized for each of the eleven UNEs. The algorithms used to determine these amounts are described below.

(1) Capital costs

The model calculates annual capital cost for each UNE based on the net plant investment, the expected service life (depreciation), the return on the net asset and the grossed-up income tax on the return of the net asset. The model assumes straight-line depreciation and assumes that cash flows are in arrears (*i.e.*, return from assets, tax gross-ups and depreciation are applied at the end of each year).

The WACC, the capital structure, and the cost of debt and equity must be provided for the modeled entity. Based on these data, the model calculates the investments required for each UNE. The model then determines the appropriate levelized monthly cost of these investments based on the economic lives for each of the UNEs.

(2) Operating Expenses - General

Operating expenses are derived from historic expense factors which are calculated from balance sheet and expense account information reported in carriers' ARMIS reports. These expense factors are applied to the investments developed by the Hatfield Model to determine associated operating expense amounts.

Certain expenses, particularly those for network maintenance, are strongly related to their associated capital investments. The Expense Module estimates these expenses using factors computed from the carrier's ARMIS reports. Other expenses, such as network operations, vary directly with the number of lines provisioned rather than with capital investment. Expenses for these elements are scaled by the number of access lines supported. Uncollectibles expense is calculated as a percentage of revenues.

(3) Network-Related Expenses and Expense Factors

The Expense Module assigns network-related expenses to each of eleven UNEs, plus public telephone terminal equipment. The module also assigns the cost of capital, expenses, total investment and attributable support expense to each UNE.

These network and non-network operating expenses are added to annual capital costs to determine the total economic cost of each UNE. Each network-related expense is described below:

Network Support -- This category includes the expenses associated with motor vehicles, aircraft, special purpose vehicles, garage and other work equipment.

Central Office Switching -- This includes end office and tandem switching, as well as equipment expenses.

Central Office Transmission -- This includes circuit equipment expenses associated with transport investment.

Cable and Wire -- This category includes expenses associated with poles, aerial cable, underground/buried cable and conduit systems. This expense varies directly with capital investment.

Network Operations -- The Network Operations category includes power, provisioning, engineering and network administration expenses.

The Expense Module uses specific forward-looking expense factors for digital switching and for central office transmission. These values derive from the New England Telephone Incremental Cost Study. The module similarly computes forward-looking Network Operations expenses based on corresponding ARMIS-

reported expenses. Because total Network Operations expense is strongly line-dependent, the model computes this expense as a per-line additive value based on ARMIS-reported total Network Operations expense divided by the number of access lines, then deducting 30% of this quotient to produce a forward-looking estimate.³⁵

(4) Non-network-related operating expenses and expense factors

The Expense Module assigns non-network related expenses to each density range based on its proportion to total expenses in each category. Each of these expenses is described below.

Variable support -- Historical variable support expenses for LECs are substantially higher than those of similar service industries operating in more competitive environments. Based on studies of these variable support expenses in competitive industries, such as the interexchange industry, the model applies a conservative 10% variable support factor to the total costs estimated for UNEs as well as basic local service.

General Support Equipment -- The module calculates investments for furniture, office equipment and general purpose computers. The Model uses actual 1995 company investments to determine the ratio of investments in the above categories 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 of these items are then calculated in the same way as recurring costs for network investment.

(5) Revenues

Revenues are used to calculate the uncollectibles factor. This factor is a ratio of uncollectibles expense to adjusted net revenue. The module computes both retail and wholesale uncollectibles factors. The retail factor is applied to basic local telephone service monthly costs and the wholesale factor used in the calculation of UNE costs.

d) Outputs of the Expense Module

The Expense Module displays results in a series of reports which depict detailed investments and expenses for each UNE for each density range, summarized investments and expenses for all UNEs, unit costs by UNE and total

³⁵ Although forecasting forward-looking expenses is difficult, there is evidence that the 30% reduction from currently reported per-line Network Operations expense is conservative. Testimony before the California Public Utilities Commission (Testimony of R. L. Scholl, Universal Service Proxy Cost Models, April 17, 1996, p. 11) states that Pacific Bell's forward-looking Network Operations expenses are 55% less than current per-line values computed from Pacific Bell's 1994 ARMIS data.

annual and monthly network costs, as well as basic local service costs per household.

(1) **Unbundled Network Elements outputs**

The Hatfield Model produces cost estimates for eleven UNEs, plus public telephone terminal equipment. These UNEs represent an unbundling of the local exchange network into discrete functions, which can be used singly or in any combination to furnish services. The UNEs are described below and their interrelationships are illustrated in Figure 11.

Loop Distribution -- The individual communications channel originating from the DLC remote terminal or SAI and terminating at the customer's premises. In the Hatfield Model, this UNE also includes the investments in NID, drop and terminal/splice.

Loop Concentrator/Multiplexer -- The DLC remote terminal at which individual subscriber traffic is multiplexed and connected to loop distribution for termination at the customer's premises. The Hatfield Model includes DLC equipment and SAI investment in this UNE.

Loop Feeder -- The facilities on which subscriber traffic is carried from the line side of the end office switch to the DLC remote terminal or SAI. The UNE includes copper feeder and fiber feeder cable, plus associated structure investments (poles, conduit, etc.)

End Office Switching -- The facility connecting lines to lines, or lines to trunks. The end office represents the first point of switching. As modeled in the Hatfield Model, this UNE includes the end office switching machine investments and associated wire center costs, including distributing frames, power, land and building investments.

Operator Systems -- The systems that process and record special toll calls, public telephone toll calls, and other types of calls requiring operator assistance, as well as Directory Assistance. The investments identified in the Hatfield Model for the Operator Systems UNE include the operator position equipment, operator tandem (including required subscriber databases), wire center and operator trunks.

Dedicated Transport -- The full-period, bandwidth-specific interoffice transmission path between LEC wire centers or between LEC wire centers and an IXC POP. It provides the ability to offer individual and/or multiplexed switched and special services circuits between switches. Interoffice transport investments that provide dedicated transport are assigned to this UNE.

Common Transport -- A trunk between two switching systems on which traffic is commingled to include LEC traffic as well as traffic to and from other local or interexchange carriers. These trunks may originate at an end office and terminate at a tandem switch or at another end office. Interoffice transport investments that provide common transport are assigned to this UNE.

Tandem Switching -- The facility that provides the function of connecting trunks to trunks for the purpose of completing interoffice calls. Similar types of investments as are included in the End Office Switching UNE are also reflected in the Tandem Switching UNE.

Signaling Links -- Transmission facilities in a signaling network that carry all out-of-band signaling traffic between end office and tandem switches and STPs, between STPs, and between STPs and SCPs. Signaling link investment developed by the Hatfield Model and assigned to this UNE.

Signal Transfer Point -- This facility provides the function of routing TCAP and ISUP messages between network nodes (end offices, tandems and SCPs). The model estimates STP investment and assigns it to this UNE.

Service Control Point -- The node in the signaling network to which requests for call handling information (e.g., translations for local number portability) are directed and processed. The SCP contains service logic and customer specific information required to process individual requests. The model estimates SCP investment and assigns it to this UNE.

(2) Universal Service Fund Outputs

The calculation of costs for basic local service is based on the costs of the UNEs constituting this service. These are the loop, local portions of end office and tandem switching, transport facilities for local traffic, and the local portions of signaling investment. No operator services or SCP investments are included. In addition, these UNE cost elements are adjusted to accommodate other items such as retail uncollectibles rather than wholesale uncollectibles. Finally, certain retail expenses required by basic local service, such as billing and bill inquiry, directory listings, number portability costs, etc. are added.

For illustrative purposes, the USF sheet in the expense module compares the monthly cost per line in each density range to a user-adjustable "affordable" monthly price for local service (which include the End User Common Line charge). If the cost exceeds the "affordable" price, the model accumulates the total required annual subsidy at the stated price level according to the number of households in each density range.

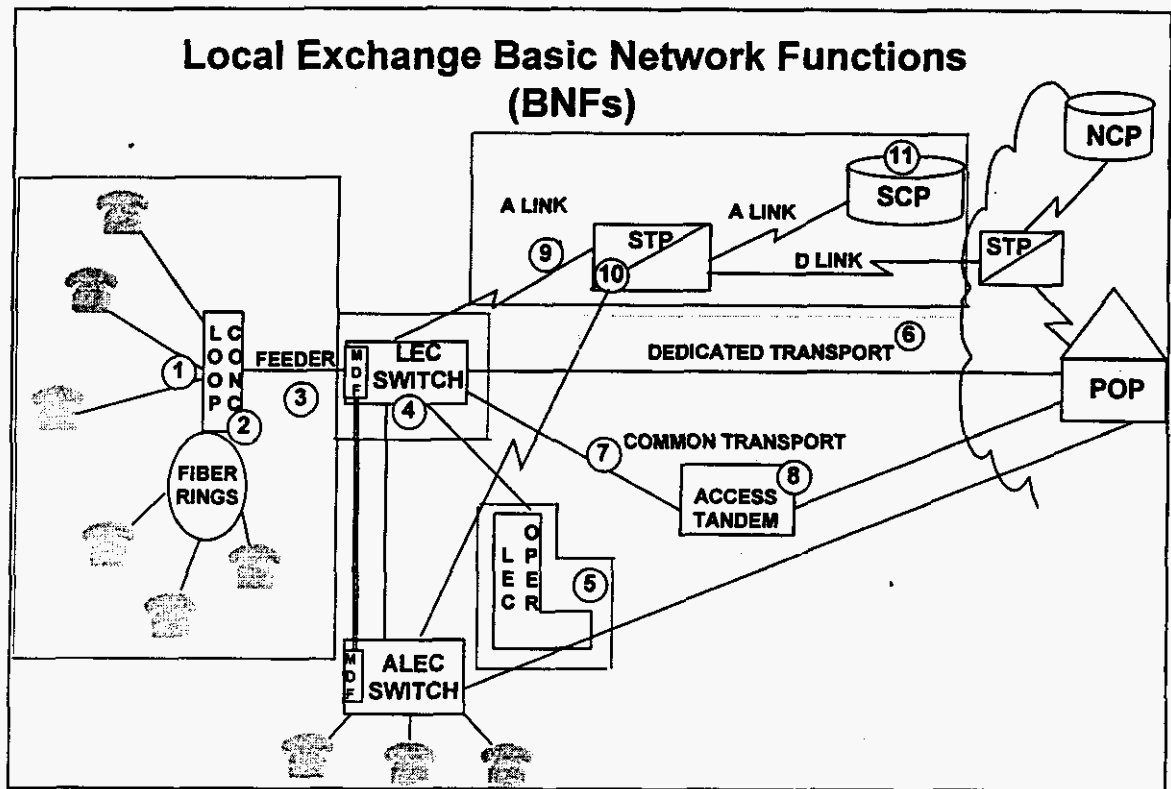


Figure 11 Local Exchange Network Elements

III. SUMMARY

In its Version 2.2, Release 2 formulation, the Hatfield Model estimates reliably and consistently both the forward-looking economic cost of unbundled local exchange network elements and the forward-looking economic cost of basic local telephone service. Because both of these calculations are performed in adherence to TELRIC/TSLRIC principles, Hatfield Model cost estimates provide an accurate basis for the efficient pricing of unbundled network elements and the calculation of efficient universal service funding requirements.

HM2.2.2's methodology is transparent, and it uses public source data for its inputs. These default input values represent the developers' best judgments of efficient, forward-looking engineering and economic practices. But, because many of these inputs are adjustable, users of HM2.2.2 can use the model's automated interface to model directly and simply any desired alternative scenario.

Appendix A

Summary of Changes Between Releases 1 and 2 of the Hatfield Model, Version 2.2

This document describes changes made to the Hatfield Model Version 2.2 between Release 1 and Release 2. The discussions refer specifically to changes incorporated in Release 2 that modify the updated Release 1 version as filed publicly with the FCC on May 30, 1996.

A Benchmark Cost Model (BCM) derivative work called BCM-PLUS has been developed for and copyrighted by MCI Telecommunications Corporation and incorporated into the Release 2 version of the Hatfield Model (which, in this description, is known as HM2.2.2, for Hatfield Model Version 2.2 Release 2). HM2.2.2 also includes an automated user interface with dialog boxes that allow the user to change options and adjust inputs. The interface automates the running of the model as well.

BCM-PLUS Modules

Data module

1. Input and output sheets include an additional column containing business line counts per census block group (CBG).
2. Feeder and distribution distances are increased by 20% in the presence of rocky terrain to accommodate routing of facilities around difficult placement conditions.
3. Feeder length calculation modified to place SAI inside CBG by one-fourth the length of a CBG side.

Loop module

1. The distance at which fiber feeder is assumed is now user-adjustable. In the original BCM, the model assumed fiber feeder cables for total loop lengths of 12,000 ft or greater. In the new version, the calculation is based on total feeder length, and the threshold distance may be adjusted by the user to any value. The default setting is 9,000 ft.

2. The DS-0 capacity per fiber is now adjustable with a default value of 2016 (equivalent to 3 DS-3s). In the original version, the model included a fixed capacity of 672 DS-0s (1 DS-3) per fiber.

3. The number of fibers required per digital loop carrier remote terminal is now adjustable. The default setting is four fibers, which is the same as the value fixed in the original BCM.

4. Lookup tables for optical feeder cable investment now allow user adjustment of cable sizes. The default maximum cable size is now 216 fibers. In the first BCM version, the maximum cross sections for optical and copper fiber and distribution cables were fixed. Also, fiber and copper cable investments per unit length have been adjusted to include engineering, delivery, and installation in addition to material investment. The original BCM did not include installation, engineering, and delivery in this table. The default distribution cable investment table now includes 25-pair cable.

5. The module now computes varying numbers of distribution cables according to density range to accommodate different population distributions in high and low density ranges.

6. Density ranges are now expressed in terms of lines per square mile instead of households per square mile.

Hatfield Model modules

Line Multiplier (now Line Converter) Module:

1. The original Line Multiplier Module used user-specified line multipliers that varied by density range to estimate total residential, business, special access, and public lines. The new Line Converter module applies uniform multipliers to all CBGs to compute residential access lines in each density zone. The business, special access, and public line calculations are based on data that estimate the number of business employees in each CBG. All line totals are computed to match those shown in the ILEC's most recent ARMIS 43-08 reports.

2. The input data contains estimated 1995 household counts per CBG in place of the 1990 counts in the original BCM data.

3. The module computes CBG density in terms of lines, instead of households, per square mile.

Wire Center Investment Module

1. The module removes previous double-counting of trunk ports by reducing the input per-line switching investment by \$16 per line, because the model separately calculates the investment in trunk ports for the switches in each wire center and adds the total trunk port investment to the total switching investment in each wire center.
 2. STP size is now scaled by the number of A links in the study area; the model previously equipped maximum-capacity STPs in all cases.
 3. The module now computes Signaling System 7 C and D link investments, where it previously calculated only A link investments.
 4. The transmission facilities investment, expressed as investment per DS-0-mile, is now calculated explicitly for each of the following routes:
 - common (tandem)
 - local direct
 - intra LATA direct
 - IXC switched access direct
 - special access
- The calculations allow separate user assumptions for optical patch panels, optical multiplexers, regenerator investment and spacing, installation costs, mix of buried/underground/aerial plant, and manhole and pole spacing and installation.
5. The module eliminates double counting of structure costs typically shared between interoffice and feeder facilities.
 6. The model now contains reconciled usage calculations between the Expense Module and Wire Center Investment Module.
 7. Operator services positions may now be remote from the operator tandem. The user may select the distance; the default value is zero.
 8. The module now includes tandem-to-POP switched access direct transport facilities.
 9. The end office capacity limits now include entries for switch traffic; they previously included line and processor real-time limits. There are also separate holding time multipliers for business and residence lines to allow users to compute the effects of increased holding time on costs.

10. The module now uses pre-processed interoffice distance data derived from end office, tandem, and STP locations listed in the Local Exchange Routing Guide. This facilitates the running of the model.

Convergence Module

1. The module now separately computes structure costs for aerial, buried, and underground facilities, including poles, conduit, trenching, and manholes. The model independently treats underground and buried cable. The new version eliminates previous double counting of terminals and splices. All structure factors, including the mix of aerial, buried, and underground distribution and feeder facilities are user definable.

2. Digital loop carrier investment is now computed from "ground up." The calculation includes site, housing, power, engineering, common equipment (including multiplexing at the wire center), and line cards.

3. The new version corrects a previous calculation error in local direct and local tandem trunk investment.

4. Default settings eliminate optical multiplexers from the Serving Area Interface. Sufficient fiber capacity exists to allow dedicated fibers to serve each remote terminal, as is consistent with current practices.

Expense Module

1. The module allows economic lives of up to 50 years to be input, (previous maximum permitted life was 32 years).

2. Consistent with the new structure calculations and incorporation of separate underground and buried facilities inputs, the model now calculates separate expense factors for the following network components:

- Aerial cable
- Underground cable
- Buried cable
- Poles
- Manholes
- Conduit

Previously, only aerial and underground factors were calculated.

3. Double counting of DLC terminations and end office line circuits is eliminated.

4. Trunk port costs can now be estimated per DS-0 or per minute.
5. Default user inputs for cost of debt, equity, and debt/equity ratio have been changed.
6. Separate uncollectibles rates for retail and carrier-to-carrier are specified.
7. The module eliminates a previous triple counting of NID (other terminal equipment) investment.
8. Drops are now computed per household rather than per line basis.
9. Dedicated trunking calculations have been reconciled between the Expense Module and the Wire Center Investment Module.
10. IXC switched access and local interconnection unit costs have been added to a new "Cost Detail" worksheet in the Expense Module.
11. NID expenses are now based on ARMIS-reported regulated expense per line (other terminal account); they previously included all "other terminal" expenses and, as a result, overstated NID maintenance expenses.
12. A user-definable carrier-to-carrier customer service expense has been added. Its default value is set at \$1.56/line/year -- based on ARMIS 43-04 data on current ILEC expense in serving IXC's access accounts.
13. The new version includes a NID monthly cost calculation in the "Cost Detail" worksheet.
14. Structure sharing fractions have been expanded to allow the user to set independent parameters for aerial, buried, and underground distribution and feeder structure. Default values are 0.33 for all categories.
15. The module now contains a Universal Service Module with the following features:
 - Network cost built up from UNEs
 - Network Operations factored to reflect local service only
 - Local number portability costs have been added as a user input; with a default setting of \$0.25 per line per month.

Instruction Manual

Hatfield Model Version 2.2, Release 2

Automated Interface

I. GETTING STARTED

A. SYSTEM REQUIREMENTS

The Hatfield Model (HM) Automated Interface requires the following minimum PC system components to run properly:

- Pentium 133 MHz processor or higher
- 128 MB RAM or more
- CD-ROM drive
- Microsoft Windows 95 or Windows NT operating system
- Microsoft Excel version 7.0

B. TERMINOLOGY

The following terminology is used in this documentation when referring to the Hatfield Model and its components:

HM Modules: The HM Modules are the six functional Excel files which comprise the HM. They are Line Converter, Data Master, Loop Master, Wire Center, Convergence, and Expense.

HM Interface: The user interface to the Hatfield model, which is contained in the Excel file HM_Interface.xls. (Figure 1 shows what the HM Interface looks like.)

Workfile: A workfile is an Excel file created by the HM which contains state-specific HM data and outputs, and can reflect user-specified input parameters. Although the workfile is created by the HM, the user must provide a filename.

Data Template: The data template is a special workfile which contains the default inputs for each state. Data templates use a filename convention which looks like: AZ_rhoc_tmplt.xls. Data templates should not be modified by HM users.

C. DIRECTORY STRUCTURE

The HM Interface assumes a basic directory structure as follows:

- HM modules should be stored in C:\hatfield modules
- HM data templates should be stored in C:\hatfield templates

The HM Interface allows users to specify which directories the HM components reside in by selecting 'HM Tools/Set Up Paths and Directories', but it is recommended that the default settings be used.

CD-ROM users should ensure that the paths and filenames point to the appropriate CD-ROM drive (e.g., D:\).

II. RUNNING THE HATFIELD MODEL

D. CREATING A NEW WORKFILE

- Select 'HM Tools/New HM Workfile...'
- Select the appropriate state from the dialog box.
- Select 'HM Tools/Save HM Workfile...' to give the workfile a unique name.
- Press 'GO!'
- Save Expense Module when HM is done calculating
- Select 'HM Tools/Close HM Workfile...' when finished

E. MODIFYING AN EXISTING WORKFILE

Once a workfile has been created, it can be modified to reflect different input parameters. To modify an existing workfile:

- Select 'HM Tools/Open HM Workfile...'
- Modify inputs as necessary, using process described below
- Press 'GO!'
- Save Expense Module when HM is done calculating
- Select 'HM Tools/Close HM Workfile...' when finished

F. CHANGING USER INPUTS

The HM contains several hundred user-adjustable parameters, each of which can be easily modified using the HM Interface. To change a user input, open the appropriate workfile, and select the desired category of inputs from the 'HM Inputs' menu. A dialog box will appear, in which alternative inputs may be specified. (See Figure 2.) If the workfile is saved, the alternative inputs will be saved with it. However, default inputs can always be restored by clicking the 'Reset Defaults' button on the input dialog box.

G. TROUBLESHOOTING

- If the HM Interface displays 'Cannot find file...' errors, ensure that the paths and filenames are correctly specified in the 'HM Tools/Set Paths and Filenames...' menu.
- In the unlikely event that the HM crashes, it is always best to restart.

Figure 1: HM Interface

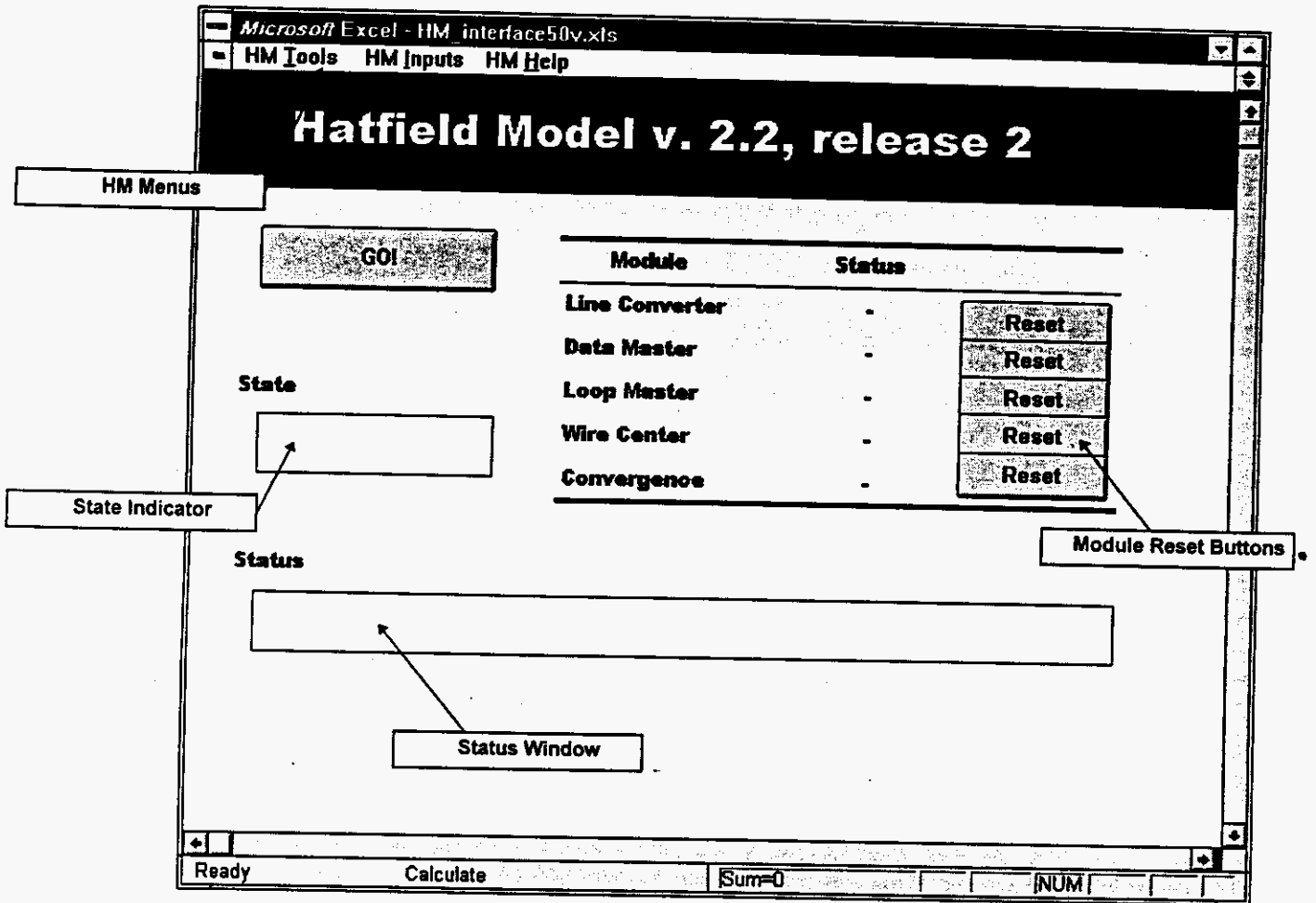


Figure 2: Sample User Input Dialog Box

Misc Loop Investment Inputs						
Drop Investment per line	NID Investment per line	Terminal & Splice per line	Avg lines per business location	SAI Investment, installed		
				copper	fiber feeder	
\$40.00	\$30.00	\$35.00	4	0	\$500.00	\$2,500.00
				100	\$700.00	\$2,700.00
				200	\$900.00	\$2,900.00
				400	\$1,100.00	\$3,100.00
				600	\$1,300.00	\$3,300.00
				900	\$1,500.00	\$3,500.00
				1200	\$1,700.00	\$3,700.00
				1800	\$1,900.00	\$3,900.00
				2400	\$2,100.00	\$4,100.00
				3000	\$2,300.00	\$4,300.00
				3600	\$2,500.00	\$4,500.00

Distribution structure assigned to telephone		Distribution cable size	SAI Investment, installed	
Structure	Value		copper	fiber feeder
Aerial	0.33	0	\$500.00	\$2,500.00
Buried	0.33	100	\$700.00	\$2,700.00
Underground	0.33	200	\$900.00	\$2,900.00

Feeder structure assigned to telephone		Distribution cable size	SAI Investment, installed	
Structure	Value		copper	fiber feeder
Aerial	0.33	400	\$1,100.00	\$3,100.00
Buried	0.33	600	\$1,300.00	\$3,300.00
Underground	0.33	900	\$1,500.00	\$3,500.00

BCM-PLUS Loop Module Inputs

Cable fill factors

density	Feeder	Distribution
0	0.65	0.5
5	0.75	0.55
200	0.8	0.6
650	0.8	0.65
850	0.8	0.7
2550	0.8	0.75

DS-0s per fiber	Fibers per RT	
DLC case	2016	4
AFC case	2016	4

Fiber feeder distance threshold, ft
9,000

Fiber feeder cable inv per foot

Cable Size	u/g	aerial
216	\$ 13.10	\$ 13.10
144	\$ 9.50	\$ 9.50
96	\$ 7.10	\$ 7.10
72	\$ 5.90	\$ 5.90
60	\$ 5.30	\$ 5.30
48	\$ 4.70	\$ 4.70
36	\$ 4.10	\$ 4.10
24	\$ 3.50	\$ 3.50
18	\$ 3.20	\$ 3.20
12	\$ 2.90	\$ 2.90

Distribution cable inv per ft

Cable Size	u/g	aerial
3600	\$ 63.75	\$ 63.75
3000	\$ 53.25	\$ 53.25
2400	\$ 42.75	\$ 42.75
1800	\$ 32.25	\$ 32.25
1200	\$ 21.75	\$ 21.75
900	\$ 16.50	\$ 16.50
600	\$ 11.25	\$ 11.25
400	\$ 7.75	\$ 7.75
200	\$ 4.25	\$ 4.25
100	\$ 2.50	\$ 2.50
50	\$ 1.63	\$ 1.63
25	\$ 1.19	\$ 1.19

Copper feeder cable inv per ft

Cable Size	u/g	aerial
4200	\$ 74.25	\$ 74.25
3600	\$ 63.75	\$ 63.75
3000	\$ 53.25	\$ 53.25
2400	\$ 42.75	\$ 42.75
1800	\$ 32.25	\$ 32.25
1200	\$ 21.75	\$ 21.75
900	\$ 16.50	\$ 16.50
600	\$ 11.25	\$ 11.25
400	\$ 7.75	\$ 7.75
200	\$ 4.25	\$ 4.25
100	\$ 2.50	\$ 2.50

Wire Center Investment Module Inputs

EO switching and traffic parameters

switch real-time limit, BHCA

lines	limit
1	10,000
1,000	50,000
10,000	200,000
40,000	600,000

switch traffic limit, BHCCS

lines	limit
1	10,000
1,000	50,000
10,000	500,000
40,000	1,000,000

switch maximum line size

100,000

switch max line fill

0.80

switch max processor occupancy

0.90

processor feature loading multiplier

1.00

switch installation multiplier

1.1

Interoffice parameters

operator traffic fraction

0.02

total interoffice traffic fraction

0.65

direct-routed fraction of local interoffice

0.98

Transmission parameters

maximum trunk occupancy, CCS

27.5

trunk port, per end

\$ 100.00

average direct route distance, miles

10

average trunk usage fraction

0.3

Tandem switching parameters

real time limit, BHCA

1,500,000

port limit, trunks

120,000

common equipment investment

\$ 1,000,000

maximum trunk fill

0.8

maximum real time occupancy

0.9

common equipment intercept factor

0.25

switch price/line size references

switch price per line, less trunk circuits @ \$

220.00 \$ 86.00 \$ 59.00

switch line size

2,782 11,200 80,000

BH fraction of daily usage

0.10

Annual to daily usage reduction factor

270

residential holding time multiplier

1.0

business holding time multiplier

1.0

(offered load assumed for afternoon busy hour)
call attempts/BH

residential

1.3

business

3.5

Signaling parameters

STP link capacity

720

STP maximum fill

0.8

STP investment, per pair, fully equipped

\$ 5,000,000

STP common equipment investment, per pair

\$ 1,000,000

link termination, both ends

\$ 900

signaling link bit rate

56,000

link occupancy

0.4

C link cross section

24

ISUP messages per interoffice BHCA

6

ISUP message length, bytes

25

TCAP messages per transaction

2

TCAP message length, bytes

100

fraction of BHCA requiring TCAP

0.10

SCP investment/transaction/second

\$ 20,000

Wire Center Investment Module Inputs

Operator position parameters

investment per position	\$	3,500
maximum utilization per position, CCS		27
operator intervention factor		10
operator position remote distance, mi		0

Wire center parameters

lot size, multiplier of switch room size		2
tandem/EO wire center common factor		0.40

Power and frame investment

served lines in wire center		sum of power and frame
0	\$	10,000
1,000	\$	20,000
5,000	\$	40,000
25,000	\$	100,000
50,000	\$	500,000

Switch room size table

switch size, lines		floor area required
0		500
1,000		1,000
5,000		2,000
25,000		5,000
50,000		10,000

Construction costs, per sq ft

switch size, lines		construction, \$/sq ft
0	\$	75
1,000	\$	85
5,000	\$	100
25,000	\$	125
50,000	\$	150

Land price, per sq ft

lines in wire center		price/sq ft
0	\$	5.00
1,000	\$	7.50
5,000	\$	10.00
25,000	\$	15.00
50,000	\$	20.00

Toll traffic inputs

local call attempts		
call completion factor		0.70
intraLATA calls completed		
interLATA intrastate calls completed		
interLATA interstate calls completed		
local DEMs, thousands		
intrastate DEMs, thousands		
interstate DEMs, thousands		
tandem-routed fraction of total intraLATA traffic		0.2
average direct intraLATA route distance, mi		25
tandem-routed fraction of total interLATA traffic		0.2
average direct access route distance, mi		15

Interoffice transport investment

Terminal Investment		Unit Cost
Number of fibers		24
FOT capacity, DS-3s		12
FOT fill		0.80
FOT, installed	\$	43,000
Pigtails	\$	60
Panel	\$	1,000
EF&I, per hour	\$	55
Medium Investment		
Fraction of structure assigned to telephone		0.33
Fraction of structure shared with feeder		0.25
Distance, mi		41
Regenerator spacing, mi		40
Regenerator investment, installed	\$	15,000
Fiber cable inv/ft	\$	2.00
Placement	\$	2.00
Splice spacing, ft		20,000
Splice cost	\$	15.00
Trenching/ft	\$	45.00
Resurfacing/ft	\$	10.00
Conduit/ft	\$	4.00
Number of tubes		2
Manhole spacing		1,000
Manhole inv per manhole	\$	5,000
Total Conduit		
Buried installation/ft	\$	5.00
Pole inv.	\$	450
Pole spacing		150
Weighting		

Wire Center Investment Module Inputs

Public telephone, per station	\$	1,200		
			underground	0.3500
			buried	0.5000
			aerial	0.1500

Appendix C

Convergence Module Inputs

drop investment per line	\$	40
NID investment per line	\$	30
terminal and splice per line	\$	35
average lines per business location		4

Distribution cable size	SAI investment (installed)	
	copper feeder	fiber feeder
0	\$ 500.00	\$ 2,500.00
100	\$ 700.00	\$ 2,700.00
200	\$ 900.00	\$ 2,900.00
400	\$ 1,100.00	\$ 3,100.00
600	\$ 1,300.00	\$ 3,300.00
900	\$ 1,500.00	\$ 3,500.00
1200	\$ 1,700.00	\$ 3,700.00
1800	\$ 1,900.00	\$ 3,900.00
2400	\$ 2,100.00	\$ 4,100.00
3000	\$ 2,300.00	\$ 4,300.00
3600	\$ 2,500.00	\$ 4,500.00

Digital loop carrier inputs

BCM "SLC" (TR-303)

site, housing, and power per RT	\$	3,000
maximum lines		672
RT fill factor		0.90
common equipment investment	\$	42,000
channel unit investment per line	\$	75

BCM "AFC"

site, housing, and power per RT	\$	2,500
maximum lines		100
RT fill factor		0.90
common equipment investment	\$	10,000
channel unit investment per line	\$	150

Convergence Module Inputs

Distribution structure inputs

density range limit	aerial fraction	buried fraction	underground fraction	buried installation/foot	conduit installation/foot
0	0.50	0.50	-	\$ 2.00	\$ 25.00
5	0.50	0.50	-	\$ 2.00	\$ 25.00
200	0.50	0.50	-	\$ 2.00	\$ 25.00
650	0.50	0.50	-	\$ 3.00	\$ 25.00
850	0.40	0.50	0.10	\$ 3.00	\$ 45.00
2550	0.65	0.05	0.30	\$ 20.00	\$ 70.00

pole spacing, feet	150
pole investment	\$ 450
conduit investment per foot	\$ 1.00 w/o trenching
manhole investment, per manhole	\$ 3,000
buried cable armoring multiplier	1.10

Feeder structure inputs

Copper

density range limit	aerial fraction	buried fraction	underground fraction	manhole spacing, f	buried installation/foot	conduit installation/foot
0	0.50	0.45	0.05	800	\$ 2.00	\$ 25.00
5	0.50	0.45	0.05	800	\$ 2.00	\$ 25.00
200	0.50	0.45	0.05	800	\$ 2.00	\$ 25.00
650	0.40	0.40	0.20	800	\$ 3.00	\$ 25.00
850	0.10	0.10	0.80	600	\$ 3.00	\$ 45.00
2550	0.05	0.05	0.90	400	\$ 25.00	\$ 75.00

pole spacing, feet	150
pole investment	\$ 450
conduit investment per foot	\$ 1.00 w/o trenching
manhole investment, per manhole	\$ 3,000
buried cable armoring multiplier, Cu	1.10

Fiber

density range limit	aerial fraction	buried fraction	underground fraction	manhole spacing, f	buried installation/foot	conduit installation/foot
0	0.35	0.60	0.05	2000	\$ 2.00	\$ 25.00
5	0.35	0.60	0.05	2000	\$ 2.00	\$ 25.00
200	0.35	0.60	0.05	2000	\$ 2.00	\$ 25.00
650	0.20	0.60	0.20	2000	\$ 3.00	\$ 25.00
850	0.10	0.10	0.80	2000	\$ 3.00	\$ 45.00
2550	0.05	0.05	0.90	2000	\$ 20.00	\$ 70.00

Buried cable armoring per foot, fiber	\$ 0.20
---------------------------------------	---------

Appendix C

Expense Module Inputs

Debt fraction	0.45	Structure fraction assigned to telephone	
Cost of Debt	0.077		
Cost of Equity	0.119	distribution	
corporate overhead factor	0.100	aerial	0.33
other taxes factor	0.050	underground	0.33
operating state and local income tax factor	0.010	buried	0.33
billing/bill inquiry per line per month	\$ 1.22		
directory listing per line per month	\$ 0.15	feeder	
- service order processing fraction of 6623	0.346	aerial	0.33
forward-looking network operations factor	0.700	underground	0.33
- alternative CO switching factor	0.0269	buried	0.33
- alternative circuit equipment factor	0.0153		
EO traffic-sensitive fraction	0.70		
per-line monthly LNP cost	\$ 0.25		
Carrier-carrier customer service, per line per year	\$ 1.56		
NID expense per line per year	\$ 3.00		
DS-0/DS-1 crossover	24		
DS-1/DS-3 crossover	28		
- Switch line circuit offset per DLC line	\$ 35.00		
economic life and tax inputs			
tax rate	0.40		
economic life -- 50 years maximum			
loop distribution	20		
loop feeder	20		
loop concentrator	10		
end office switching	14.3		
wire center	37		
tandem switching	14.3		
OS investment	8		
transport facilities	19		
STP	14		
SCP	14		
links	19		
public telephones	9		
general support	7		