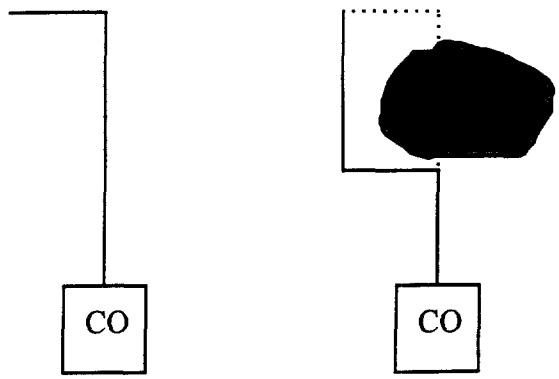
model does not account for the additional cable length associated with changes in elevation.



Note: In the above example, the linear length of cable on the left is equal to the total linear length of cable on the right

Cable is normally routed along roadways, or close to roadways. Open, cross country routes are seldom used anymore because of difficulties in securing rights of way, and gaining access at all times. The normal maximum grade for roads in a 7% grade. This equates to an angle of 3.5 degrees. Computing the maximum effect of such a change in elevation would result in a maximum extra length of only about 20 feet over a distance of 3 miles (15,000 ft). Therefore, the impact of elevation is negligible.

e. General:
While some observers may find a variety of terrain factors appealing, actual experience indicates that costs for structure and cable placement vary widely as a function of competitive bidding practices. The following examples indicate results of actual inquiries to contractors. The wide variance is more an effect of rigorous bidding in a competitive market, than terrain conditions.

Operation	High	Low	Average
Trenching in Pavement 12"w x 36"d			
Metro or City w/ restoral	$63.00	$42.00	$52.50
Rural w/ restoral	$ 9.87	$ 8.50	$ 9.19
Trenching in Sand or Gravel 12"w x 36"d			
Suburban/Rural w/ backfill	$ 6.00	$ 2.50	$ 4.23
Plow Cable 36" depth			
Suburban	$ 4.00	$ .85	$ 2.08
Rural	$ 1.75	$ .80	$ 1.15
Bury Drop Wire	$ .90	$ .70	$ .78

11. ***The models, at least in part, rely on Bellcore's Local Exchange Routing Guide, which may not include all wire centers. Do the models reflect all wire center locations? Should the models reflect all wire center locations? Do the models include host-remote configurations when it is efficient to do so?***

We are unaware of any wire center nodes on the public switched network that are not listed in Bellcore's LERG[2]. Because Bellcore is also the issuer of NPA-NXX assignments, it would be puzzling if it had issued NPA-NXXs that were not associated with wire centers in its LERG. Furthermore, because the LERG is the database used by all LECs and IXCs to route calls to all NPA-NXXs, any wire center that is not included in the LERG would not be able to receive calls from other carriers (and this is all carriers to our knowledge) that uses the LERG for routing instructions. Thus, because the HM constructs local networks to incorporate any wire center in the LERG, it should reflect all wire center locations. This said, it should be reiterated that because the HM follows this scorched node methodology, the network that it equips is demonstrably much more expensive than would need to be equipped if it were permissible to consolidate certain wire centers and serve extant demand from fewer wire centers than is done currently.

The larger telephone companies do not purchase switching equipment on a switch by switch or line by line basis. They typically negotiate for large purchases of switching equipment over several years These contracts include host and remote new switches and additional line equipment, software, and other equipment for existing switches. The switching investment per line that the Hatfield model uses from a publicly available source mimics this process by providing the cost of switching on an averaged line basis that blends the cost of new and growth equipment for both host and remote switching units for multiple vendors. This more closely resembles the true way in which switching costs are incurred rather than looking at the cost of individual switches separately from remotes, or looking at new switch costs versus growth additions.

12. ***Do the models accurately estimate the total demand for lines in a particular geographic area, such as a Census block group, wire center, or service area?***

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[2] Releases 1 and 2 of Version 2.2 of the Hatfield model have used CBG input data from the BCM+ model, which itself relies on input data developed for the original BCM. It has come to our attention that some of these input data (as prepared by the BCM sponsors) may have been faulty. As a result, it is possible that certain wire centers may have been missed. These deficiencies should not occur in Release 3 of the Hatfield model.

What types of lines (e.g., residential, single-line business, multiline business, and special access) are, or should be, included in a model's estimated demand for lines? Can the model estimate the incremental cost of adding households to the network.

The HM2.2.2 uses a combination of U.S. Census Bureau data on households by CBG, ARMIS data on number of residence, business, public and special access lines by study area, and Dun and Bradstreet data on number of business employees by census tract to estimate the total demand for lines in each CBG. CBGs are associated with wire centers based on closest distance. Because the technology used in local networks to supply business (single and multi-line), public and special access lines is relatively indistinguishable, and because the LEC enjoys economies based on its total provision of these lines, the demand for all of these lines must be combined (as the HM does) when estimating the efficient forward-looking cost of a local exchange network. Because the HM does not engineer newly placed facilities to 100 percent of capacity, spare exists within the HM to add customer service at nominal short run incremental cost. The long run cost of adding capacity may also be calculated by augmenting initial network demand requirements.

13. ***All of the models appear to base repair and maintenance and retail costs on historical costs. In some cases this is done based on a historical relationship between investment and expenses as reported in ARMIS; in other cases they are based on per line amounts. For these categories of expense, to what extent are these historical expenses a reasonable approximation of forward looking expenses? How are gains in productivity due to technological advances and increased competitive pressure captured by the model's estimates or repair and maintenance costs?***

Reasonable approximations of forward-looking expenses may be developed on the basis of historical information, provided that such estimates focus on forward-looking digital technologies only. In most cases, however, the use of historical data results in expense estimates that are overstated, because they would not reflect any non-investment related efficiency gains or process improvements that might be implemented in response to increased competitive pressure, and because historical data may reflect unwanted variation due to accounting, management and engineering choices.

14. ***Do the retail costs--the cost of bill production, billing inquiries, sales and advertising--developed for your model reflect the costs associated with the***

services included in the revenue benchmark included in the Recommended Decision? What share of your retail costs are associated with bill production and billing inquiries? How are retail costs developed to capture the costs of services included in the revenue benchmark while excluding retail costs associated with services not included in the revenue benchmark, such as intraLATA toll?

Bill production and billing inquiry costs currently account for 89 percent of the total retail costs included in the Hatfield Model's calculation of basic universal service costs. Since the current model was developed prior to the Joint Board's Recommended Decision, it does not reflect the extra retail costs that may be associated with all of the services included in the revenue benchmark. These additional costs are, however, minimal.

15. ***How is depreciation expense treated in the current version of the model? In particular, describe in detail the set of plant categories considered and the asset lives or economic depreciation rates associated with each. Justify, if possible the default choices made in the model. Describe the extent to which the model has sufficient built-in flexibility to accurately reflect differing decisions by the FCC and state commissions regarding depreciation rates. Are there enough distinct categories of plant to accurately model forward looking depreciation expense? For example, should asset lives for conduit necessarily be the came as cable lives?***

The Hatfield Model performs the capital recovery calculations within the Expense Module. Investment amounts for the Unbundled Network Elements are taken from the Convergence Module output. The model uses investments for the following categories: Loop Distribution, Loop Feeder, Loop Concentration, End Office Switching, Wire Center, Tandem Switching, Operator Systems, Transport Facilities, Signal Transfer Point, Service Control Point, Signaling Links, Public Telephones, and General Support.

The economic lives used in the Hatfield Model are derived from the official LEC Uniform System of Accounts depreciation rates approved by the FCC. The expected lives in years by plant account are modified to reflect the future net salvage percentages to produce adjusted lives in years by plant account for the LEC being studied. These data are taken from the "Parameter Report" filed by the LECs with the Commission. The formula we used to adjust the projected life by plant account is:

$$\text{Adjusted Life in years} = \frac{\text{Projected Life in years}}{(1-(\text{Future Net Salvage percentage} / 100))}$$

The adjusted lives in years by USOA plant account are combined and weighted where necessary to estimate the economic lives for the UNEs. The following table illustrates the mapping of accounts to UNE:

UNE CATEGORY	USOA ACCOUNTS
Loop distribution	2421, 2422, 2423 - metallic plus 2411 and 2441
Loop feeder	2421, 2422, 2423 - combo metallic & fiber plus 2411 and 2441
Loop concentration	2232
End office switching	2212
Wire Center	2121
Tandem switching	2212
OS investment	2220
Transport facilities	2421, 2422, 2423 - fiber plus 2411 and 2441
STP	2212
SCP	2212
Signaling Links	2421, 2422, 2423 - fiber plus 2411 and 2441
Public telephones	2351
General support	2112,2115,2116,2122,2123,2124

These adjusted projected lives are weighted within each UNE category by the Hatfield Model calculated total investments in each account to produce the economic life for the UNE category.

Once the economic lives are determined, the expense module calculates, on a straight line basis, the depreciation expense for the UNE category. Total investment costs to be recovered include depreciation expense plus capitalized Federal Income Taxes and capitalized return on investment. The total amount of depreciation expense over the economic life of the plant is normalized by calculating the present value of these depreciation flows, discounted by the weighted average cost of capital. This results in the capital expense shown within the model.

Each LEC study area will have its own set of sanctioned depreciation lives. If an individual State Commission requires a different set of projection lives and or future net salvage percentages, the model accepts easily those new parameters by USOA account.

16. ***The BCM2 includes 75% of 133.89 per year or $8.34 per month per line to reflect non-plant related expenses such as marketing and customer operations.***

The adjustable 10% overhead figure in the Hatfield model is the only similar component. Should costs for customer or corporate operations be a fixed amount per line? If not, what should be the basis for allocating these costs? To what extent should basic local service be charged with marketing or customer operations expense?

The 10% factor in the Hatfield model utilized to capture corporate overheads is not the only non-plant related expense in the Hatfield Model corresponding to the BCM2 $8.34/month. General support expenses, for example, are also included. Many of the other expenses picked up by the BCM2 figure are likely to be captured, where appropriate, by other expense loadings in the Hatfield model In theory, all of these costs could be attributed to basic local service using either a multiplier such as the 10% or on a per line basis. The issue becomes determining how much of the cost category to attribute to basic local service. While the two methods can arrive at the same result, using a multiplier can more easily spread the overheads across the various functions.

The only customer operations costs attributed to basic local service in the current model are billing, billing inquiry and white pages listings. Other components are either compensated for by separate rate elements (Service order processing is compensated through non-recurring charges, not monthly charges) or are more correctly attributed to other services

17. ***Can a single proxy model be used to estimate the cost of the local exchange network for universal service support and for other objectives such as the pricing of network elements or access reform? Does a network specifically dedicated to universal service objectives differ in a significant way from the summation of network elements envisioned in Section 251? Are there insurmountable problems in the treatment of common costs in the different uses of the model? Describe specifically the modifications, if any, that would be required if a single model is used for multiple objectives.***

Not only is it eminently feasible for a single proxy model to be used to estimate the cost of the local exchange network for universal service support, unbundled network elements and access reform, but it is vital that a single model be used to meet all of these objectives. Because of economies of scope and density, it is clear that the most economical way to provide universal service is on a local network that also is used to provide other local services such as local toll services, business services, access services and special services. Thus the unbundled elements that new competitive carriers will wish to purchase from incumbent LECs are identical to those that the incumbent LEC will use to provide universal service or access service.

Furthermore, many new competitive LECs, AT&T and MCI included, will wish to use unbundled network elements bought from the incumbent LEC to provide universal service to their customers. If different proxy models are used to calculate the cost of unbundled network elements and universal service support, this would frustrate many goals. First, the economic principles of efficient costs are identical – regardless of whether universal service or unbundled elements are being costed. Thus, the Joint Board's determination (in CC Docket No. 96-45) that the appropriate cost of universal service is its long-run forward-looking economic cost not only is completely correct, but it is in complete concert with the finding by the FCC (in CC Docket No. 96-98) and numerous state commissions that long-run forward-looking economic cost is also the correct cost concept for unbundled network elements. Basic economics permits no other finding. To use separate models to calculate the costs of these items would of necessity, to the extent the models differ, result in economically inefficient costing of at least one of the items.

If unbundled elements are costed (and therefore) priced inconsistently from the universal service that they are used to produce, either uneconomic arbitrage opportunities will arise (e.g., if unbundled elements are costed using a model that produces costs that are below those calculated by the proxy model used to cost universal service support, uneconomic opportunities will exist for carriers to provide universal service through the purchase of below-cost unbundled elements from the LEC), or new carriers will be dissuaded from offering universal service (e.g., if unbundled elements are costed using a model that produces costs that are above those calculated by the proxy model used to cost universal service support).

The above reasons why the same proxy model should be used to cost universal service as unbundled network elements are all equally cogent in favor of using a single model also to cost access. The same network is used to provide all services. The efficient economic principles are identical. And to use separate models is to invite either uneconomic construction of access-only networks, or to ensure that customers are not permitted to make economically rational decisions about the purchase of long distance service versus local service.

Not only are there no insurmountable problems in treating common costs in different uses of the proxy model, but use of a single model ensures that common costs are treated consistently – and never allocated at less than, or more than 100% of their total amount. In particular, it is important to recognize that there are several item classifications across which costs may be common. The first is in the classification of network elements. Costs may be common among different network elements, or common among network elements and non-network portions of the telephone company. The HM, because it costs consistently the complete collection of unbundled network elements, captures all of the first variety of common costs, and allocates them equiproportionately across the network elements that they benefit. Hatfield analysis has shown that common costs of the second

variety are de minimis to statistically insignificant. To the extent that they exist, they are captured in the HM's 10% loading for variable corporate overheads. Because the HM builds the costs of services such as universal service and access from the network elements that comprise them, the calculated cost of each of these services includes a share of these common costs is proportion to its use of the constituent network elements.

The further category of common costs are those that may be common across different services. A consistent allocation of these costs across services is ensured by the HM's ability to define dynamically service costs based on fractional use of network elements. Furthermore, because the HM can be used to cost simultaneously all services (e.g., local, access, toll, universal, business, residence, etc.) produced by the local network, over or under allocations of common costs can be prevented.

No modifications are necessary to the Hatfield model to ensure consistent calculation of the forward-looking economic costs of universal service, access, and unbundled network elements.

Attachment 1

Model Description:

Hatfield Model, Version 2.2, Release 2

Model Description

Hatfield Model

Version 2.2, Release 2

Hatfield Associates, Inc.
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September 4, 1996

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APPENDIX B Instruction Manual

APPENDIX C Default Values of User-Adjustable Inputs

I. INTRODUCTION

A. OVERVIEW

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 produced by BCM1. As a result, the Hatfield Model became a "scorched node"

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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 CLASS^{SM} 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.

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 required user intervention.[8] Although AT&T and MCI typically have run

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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.

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

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.

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

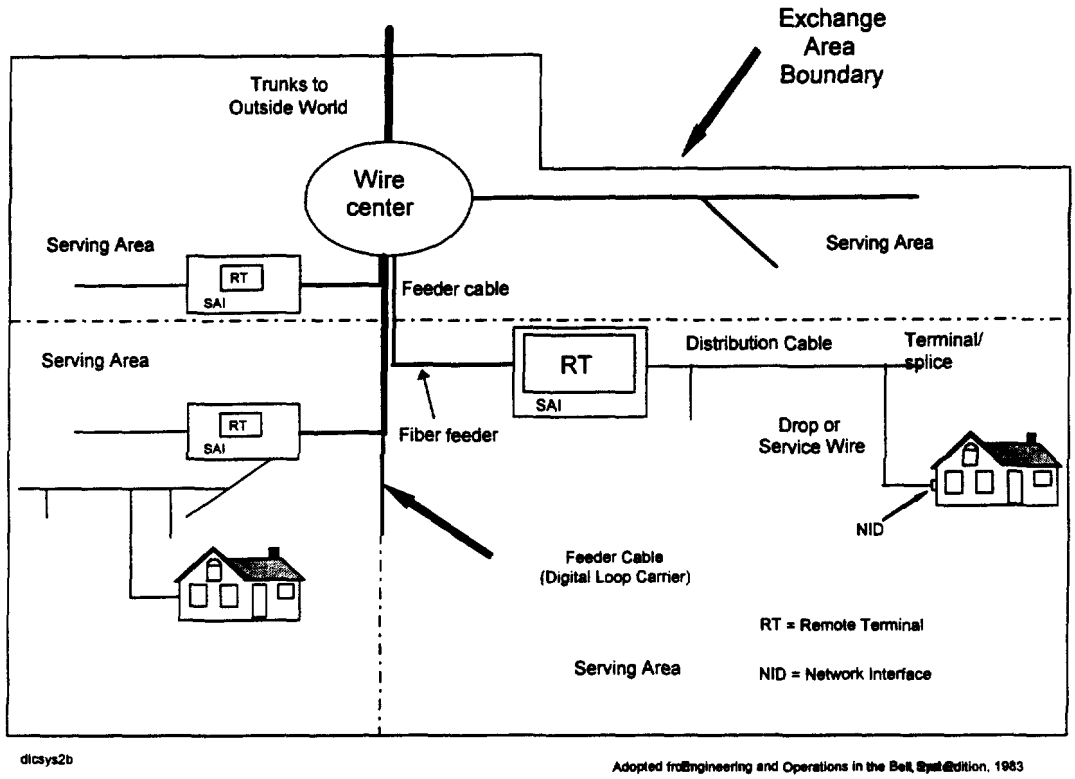

Figure 1 Loop components

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.

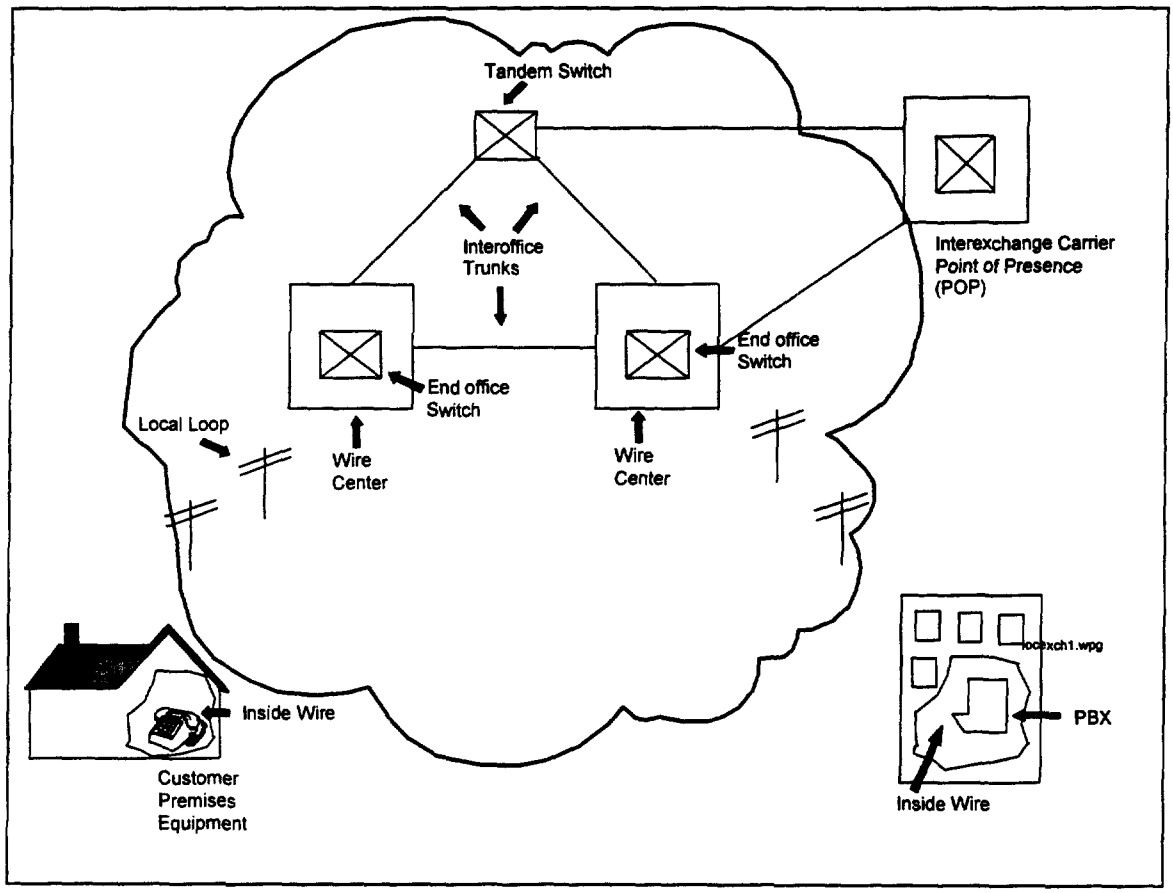

Figure 2 Interoffice network

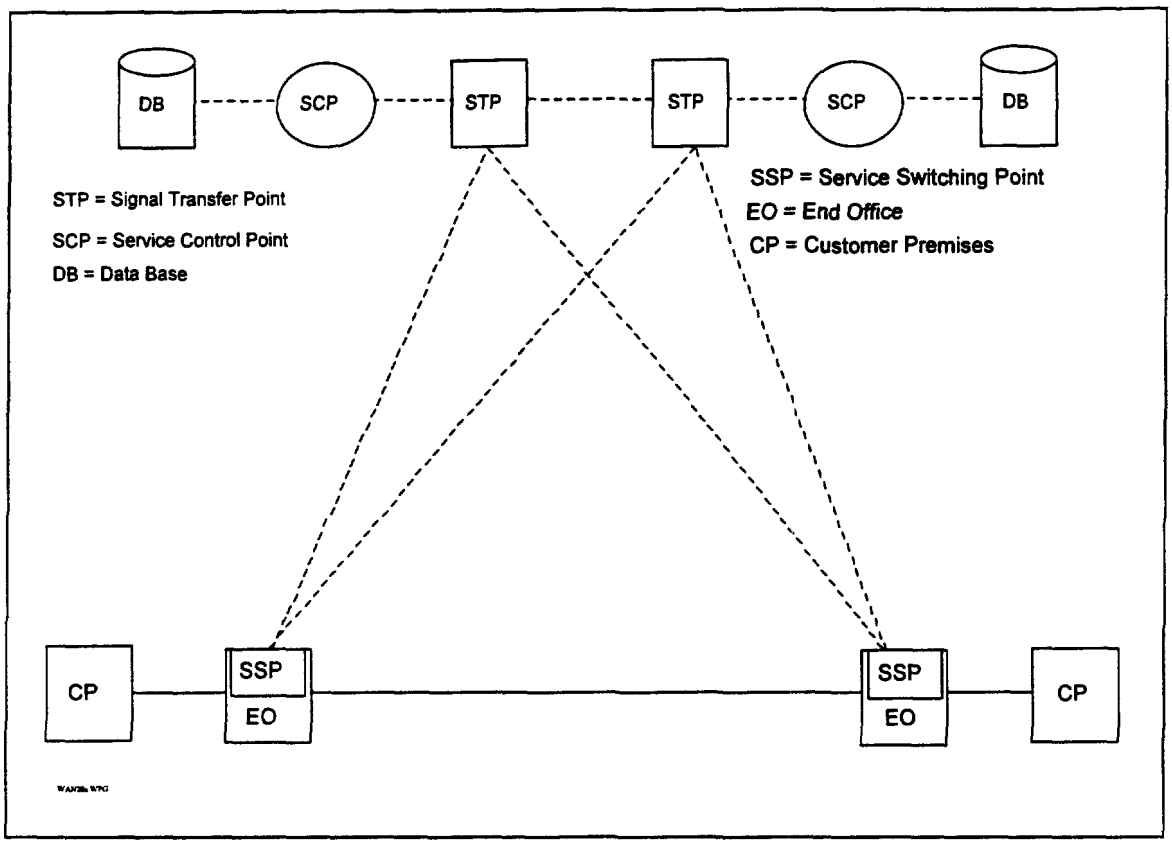

Figure 3 Signaling network components

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.

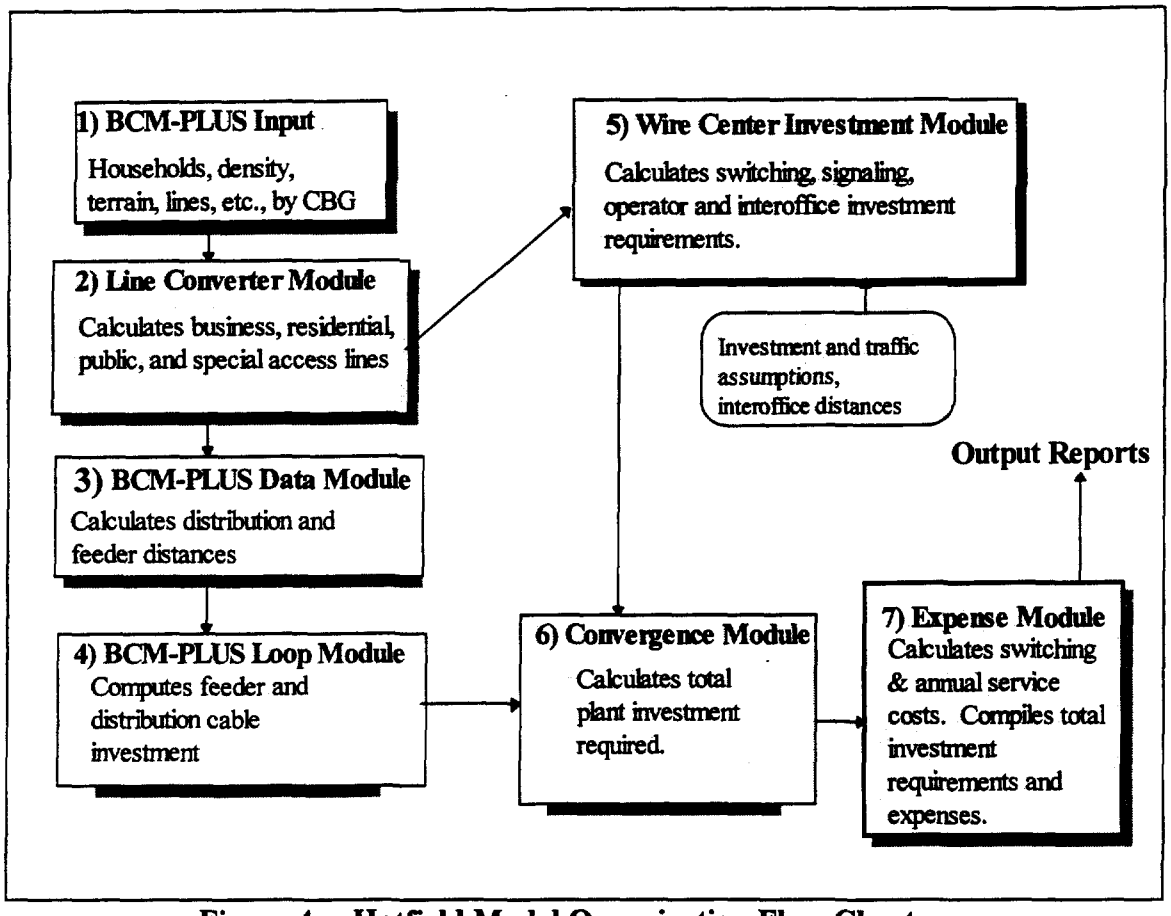

Figure 4 Hatfield Model Organization Flow Chart

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.

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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.

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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 increases (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]

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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]

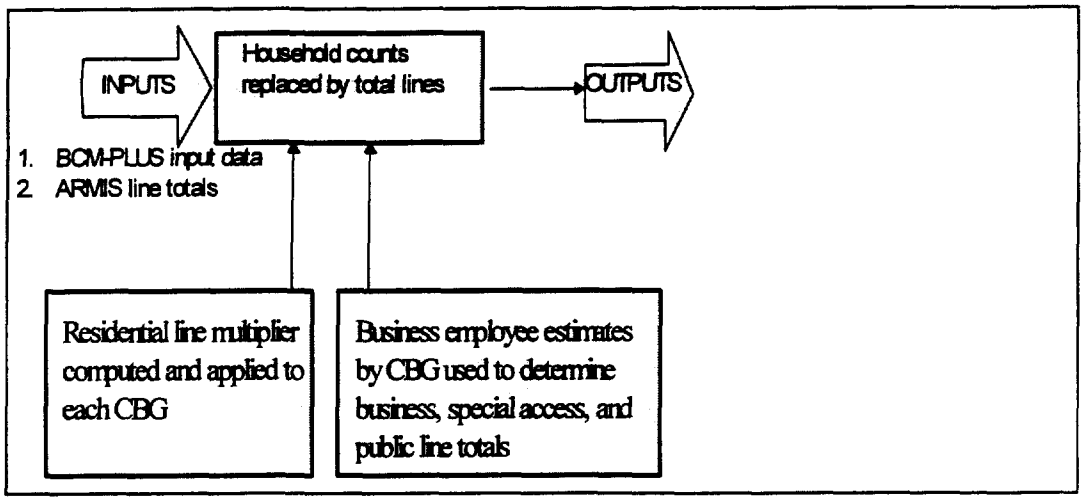

Figure 5 Line Converter Module

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.

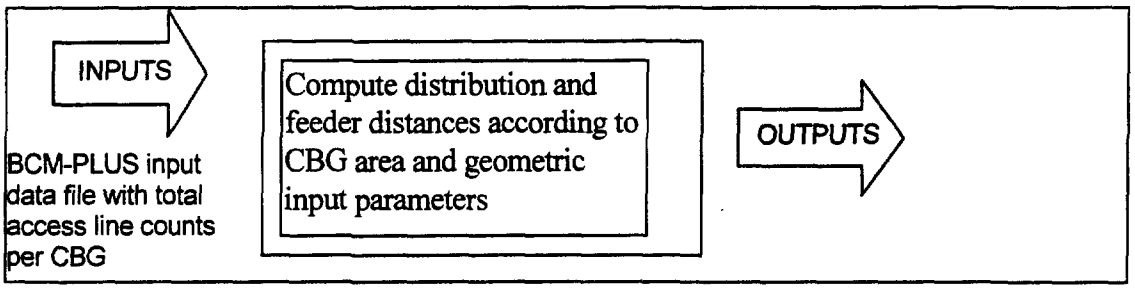

Figure 6 Data Module

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.