ATTACHMENT RAM-3
DETAILS ON METHODOLOGIES AND PROCEDURES EMPLOYED BY HM 5.3

A. Bottom-Up Cost Modeling in HM 5.3

HM 5.3 is a bottom up cost model that constructs a network based on detailed and granular information such as the amount and location of local exchange services demand, network component capacities and costs, and an estimate of the expenses needed to efficiently operate the network being constructed. It thus contrasts with models that try to decompose total costs or revenues of the ILEC into their constituent parts. Such models are often referred to as "top-down" models. The methodology employed by HM 5.3 is also in marked contrast to ILEC models that utilize network and cost statistics derived from the existing local exchange network. HM 5.3 models the entire local exchange network in order to ensure the model reflects appropriate synergies between different parts of the local exchange network and to assign shared and common costs in a consistent fashion.

Specifically, HM 5.3 proceeds in the following seven major steps. First, it determines the amount and location of current demand for the ILEC's local exchange services. In doing so, it uses geo-coded customer location data when available, combined with a method of assigning surrogate locations when geocoded location information is not available for all customers. This process is described in Section 5.2 of Exhibit RAM-4. It represents one of the most profound differences from other cost models, and reflects a state-of-the-art approach to more precisely determining customer locations. To the extent that data are available on the types and locations of services other than POTS, the model utilizes those data to also estimate costs for such services.

Second, the model groups, or "clusters," adjacent customers, and associates those clusters with serving areas that can be efficiently served by available local exchange technology. In doing so, it determines the size, shape, location, number of lines, and serving wire center of each such cluster. The clustering process is described in Section 5.3 of RAM-4. Once these clusters are identified, the model incorporates ILEC-specific data on local terrain attributes and assigns these attributes to the customer clusters according to the cluster locations, in order to identify circumstances in which the terrain attributes will cause installation costs to increase over their normal levels.

Third, based on the forward-looking network architecture an efficient ILEC would deploy today, the model determines the amounts of various network components needed to support the known demand for the elements and services in question. In doing so, it employs numerous optimization routines that ensure: (1) the use of outside plant structures that are most technically and economically suited to particular local conditions; (2) the appropriate economic choice of feeder technology between copper cable and fiber-based digital loop carrier systems; and (3) efficient interoffice fiber optics transport rings based on the widely-utilized Synchronous Optical Network ("SONET") family of standards.

Fourth, using public information, proprietary information provided by the incumbent in question under protective agreements, and experts' analyses of the availability, capacities, and costs of network assets and facilities available in the marketplace today, which are provided to the Model through user inputs, the model estimates the investment required to purchase and deploy the requisite quantities of each identified component considering detailed engineering design, material, and labor. The ability to set meaningful values for these inputs has been aided by the exhaustive analysis of inputs undertaken by the FCC in connection with its work on the universal service subsidy model in some cases.

Fifth, the model determines the cost of operating and maintaining the network, taking into account forward-looking, relevant capital carrying costs, network operations, maintenance, customer operations, and corporate overhead costs. Again, various parameters required to make these calculations are provided to the model through user inputs, and as appropriate the user can specify whether certain expenses are to be allocated on a per-line or relative investment basis.

Sixth, the model calculates per-unit UNE costs, network interconnection costs, and the cost of universal service. At the user's discretion, these results can be displayed by line density range,[1] individual wire center, or by grouping wire centers into "zones" using criteria defined by the user.

Finally, the model run produces outputs and associated intermediate results that are available for public scrutiny, both in hard-copy and electronic form.

B. Summary of the Methodology Used to Develop Loop Investments

HM 5.3 uses a demographic and geological database produced by Taylor Nelson Sofres Telecoms ("TNS") based on Verizon California data on the types and locations of its services as combined with publicly available data concerning conditions in those areas. This database is provided with the model. The database organizes this information into groups, or clusters, of customers that have the properties of a telephone company distribution serving area. The process of locating and clustering customers is described in Section C of this exhibit. The following table indicates the parameters for a given cluster contained in the database.

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[1] Line density refers to the number of lines served per square mile. Many aspects of telephone network design, and associated investments and cost, are dependent on line density -- meaning they differ according to whether the area served is rural (low density), suburban (medium density) or urban (high density). Density zones in the model range from 0-5 lines per square mile at the low end to greater than 10,000 lines per square mile at the high end.

Cluster Input Data Table		
State	Density Lines/SQ Mile	HU-50+
CLLI	Rock Depth	Mobile
Company	Rock Hard	Other
Neca_ID	Surf Text	Firms
Group	Water Depth	Employees
CBG	Total Lines	FracWCLine
Cluster Group	Total Bus Lines	AvgLoopDist
Overall Quad	Total Res Lines	TotOutLine
Overall Omega	Special Lines	Total Strand Distance
Overall Alpha	Public Lines	Non-Switched Lines[2]
Radial Dist Feet	Single Line Business	Non-Switched DS-1 Lines
Cluster/Outlier Indicator	Households	Switched DS-1 Lines
Outlier Quad	1-HU detach	High Cap Optical Lines
Outlier Omega	1-HU attach	DS-3 Optical Lines
Outlier Alpha	HU-2	ISDN Lines
Outlier Radial Distance	HU-4	ADSL Shared Lines
Total Area	HU-5-9	ADSL Dedicated Lines
Aspect Ratio	HU-10-19	Optical Services Strand Distance[3]
Company State	HU-20-49	

Among other data, this information includes the ILEC wire center that serves a given cluster, the location of the cluster relative to its serving wire center, the cluster's size and shape, the number of lines of each service type in the cluster, and the geological attributes of the land in which the cluster is located—the type of soil, depth and hardness of bedrock, and water table depth.

The model treats each customer cluster as a distribution serving area.[4] Starting from an SAI located at the center of the cluster, it lays out a sufficient number of route miles of appropriately-sized distribution cable to reach all the customer locations within the cluster. It also determines the number of block terminals and splices, number and length of the individual "drops" from the distribution cable to the individual customer premises, and the numbers of network interface devices of various sizes and types needed to serve all the customer locations in the database. When the ILEC in question has provided data on the locations of services in addition to POTs, the model determines if a given cluster contains one or more services that

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[2] Voice-grade analog of DS-0 digital non-switched circuits

[3] In some jurisdictions, this information is not available. The HM 5.3 Model Description discusses the use of this parameter and the alternative method used by the Model when the information is not available.

[4] At the user's discretion, the model will also divide a serving area into more than one distribution area, in each of which is placed a separate Serving Area Interface (SAI), with connecting cables running from the centroid of the cluster to each of the SAIs.

require fiber to the customer location; if so, fiber cables are extended into the distribution plant in adequate sizes and distances to support those services.

The model invokes two methods to ensure it calculates an appropriate amount of copper distribution cable to serve each cluster. First, the cluster database contains a so-called "strand distance," which is an independent measure of an amount of route mileage required to connect all the points that represent customer location to each other. The strand distance is related to a graph theory concept referred to as a Minimum Spanning Tree ("MST") that is required to connect the point in a graph (in this case, the customer locations in a cluster). But unlike a true MST, which would calculate distances based on connecting points with straight lines, the strand distance used in the model provides for the extra distance required to connect points via "right angle routing," in which the connection between any two points follows a "horizontal, then vertical" path in a Cartesian coordinate system. This recognizes that cables cannot always be routed in a straight line between any two points, and therefore conservatively overestimates the number of route miles.[5] At the user's discretion, the model ensures that the total route miles of distribution cable it produces in each cluster is equal to the strand distance for that cluster.

Second, the model ensures that the amount of distribution route distance it estimates for each cluster provides enough cable to reach the corners of the cluster rectangle that may be occupied by customers, using right-angle routing. For a cluster with two customer locations, this minimum distance is the sum of the height and width of the rectangle less two drop lengths for the cluster's density zone, under the assumption that customers are located at diagonally opposite corners of the rectangle. With this minimum, there is enough cable to form a "Z" that connects opposite corners of the rectangle. For instance, starting, say, at the upper left corner, such a cable would extend to the right along the upper edge of the rectangle to the mid-point of the upper side, drop straight down through the middle of the rectangle to the bottom edge (intersecting the SAI along the way), and then travel towards the right along the bottom edge of the rectangle. For a cluster with three customer locations, the minimum distance is the sum of the height and 1.5 times the width less three drop lengths, assuming customers are located at three corners of the rectangle; the additional amount of cable is sufficient to also extend from the middle vertical cable segment to the upper right or lower left corner. Finally, for a cluster with four or more customer locations, the minimum distance is the sum of the height and twice the width of the rectangle less four drop lengths, assuming customers are located at all four corners of the rectangle; this provides sufficient cable to extend to all four corners from the middle vertical cable segment.

Each customer cluster is assigned to the ILEC wire center whose serving area encompasses the cluster (clusters are constrained to fall within the boundaries of a single wire center serving area). The model extends feeder cable from the SAI of each cluster back to the cluster's serving wire center along four main feeder routes, with sub-feeder extensions from the main feeder route to the SAI in each cluster. The main feeder cables and associated outside plant structures are appropriately shared by the different clusters that lie along a given feeder route. Each cluster is served by either copper feeder cable or a DLC system running over fiber optics cable. The model selects the appropriate feeder technology based on a set of criteria that, among

[5] It is easy to show mathematically that assuming right-angle, rather than straight-line, routing adds approximately 27% to the route mileage.

other considerations, includes 1) ensuring that the longest copper loop carrying analog signals in the cluster does not exceed a user-adjustable maximum distance;[6] and 2) determining which feeder selection minimizes the life cycle cost of the feeder plant. Each feeder route is augmented by sufficient additional fiber cables, or additional strands in the fiber cables that may already be present in conjunction with DLC feeder systems, to support the fiber-based broadband services that are located in clusters served by that route.

If the distance from the wire center to the customer location in a cluster that is the greatest route distance from the wire center exceeds the maximum analog copper loop distance, the main cluster is divided into two or more sub-clusters, and fiber feeder is extended to terminals and Serving Area Interfaces located in each of the sub-clusters. Fiber optic cables also extend from the feeder termination in each main cluster to the remote clusters associated with that main cluster.

In summary, HM 5.3 configures a feeder network to reach actual clusters of customers, a distribution network that is based on the actual extent of those clusters, and sufficient capacity in both to meet the demand for narrowband, wideband, and broadband services. What this means is that HM 5.3 provides an accurate estimate of the required amount of outside plant, based on actual customer locations throughout Verizon California's serving area.

After proceeding in this fashion, the model determines the amount and capacity of NIDs, drops, distribution and feeder cables, support structures (poles, conduit, and trenching), SAIs, and DLC electronics that are required to serve all the clusters in the database. It then determines the loop investment by multiplying the amounts of each component by the respective prices of those components. The investments are available to the expense module that converts the investments into appropriate unit costs for the different loop rate elements.

C. Customer Location and Clustering in HM 5.3

Section 5.2 of Exhibit RAM-4 describes the process of determining the locations of residential and business customers in detail. Sections 5.1 is also useful in understanding how residential and business line counts are determined by wire center. Briefly, HM 5.3 utilizes the most precise customer address or geocoded location data that are available – either the ILEC's own customer address databases, if available in a usable form, or data extracted from information available from the U.S. Census Bureau files and commercial customer location database providers.

The model distributes locations for which no geocoding information is available uniformly along the roads that lie on and within the boundaries of the census block. The road information is determined from the U. S. Census Bureau's Topologically Integrated Geographic Encoding and Referencing ("TIGER") files. Roads where customers are unlikely to be located have been eliminated from consideration. This includes, for instance, limited access highway segments, road segments that are in tunnels or underpasses, vehicular trails and roads passable only by four-wheel-drive vehicles; and private driveways and roads.

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6 The "analog copper distance" refers to the distance over which analog telephone signals are transmitted on copper cables, as opposed to signals transmitted in digital form on copper or fiber cables.

Sections 5.3 of Exhibit RAM-4 describe the process of grouping, or "clustering," customer locations in order to identify subsets of the customer locations that are close enough together to be efficiently engineered as a single telephone plant serving area. Customer locations must meet the following criteria to be considered members of a particular cluster:

- No point in a cluster may be more than 17,000 feet distant (based on right angle routing) from the cluster's centroid;
- Clusters are targeted not to exceed 6,452 line equivalents in size;[7] and
- No point in a cluster may be farther than two miles from its nearest neighbor in the cluster.[8]

TNS classifies the clusters it identifies as "main clusters" if they have 20 or more POTS (basic telephone) lines, and "outlier" clusters if they have fewer than 20 lines. Clusters with one or more high-capacity services, however, are automatically classified as main clusters.

Once main clusters are identified in this fashion, the clustering algorithm calculates and records a rectangle with the following properties: (1) its centroid is located at the same point as the centroid of the convex polygon that defines the cluster;[9] (2) its aspect ratio and orientation[10] are determined from the minimum "bounding" rectangle of the convex polygon, meaning the polygon is completely contained within it; and (3) its area is the same as the area of the original cluster. Thus, customers belonging to main clusters end up within the confines of a "rectangularized" cluster shape that allows the model to estimate the type and amount of outside plant required to serve each cluster. The information about each cluster resulting from this process is contained in the cluster record that was described in Section B of this exhibit.

D. Summary of the Methodology Used to Develop Switch Investments

As has been described earlier in this Exhibit, specific customer locations and types (*e.g.*, residence versus business customers) are assigned to the ILECs' current wire centers using the existing boundaries of those wire centers. These customer locations are aggregated to identify the number of residential, business, and public POTS lines (as well as non-switched services, but those are not involved in the switch calculations) homed each wire center. The ILEC's traffic

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7 This number results from 80% utilization of an 8,064 controlled environment vault. It is a <u>target</u> maximum size, but the final count of lines in a cluster may exceed this many lines if a single-location building, such as a large downtown office building, has more than that number of lines. If this occurs, the model adds sufficient remote terminals and SAIs to serve the actual line count, taking excess capacity into account.

8 Strictly speaking, this is not a plant engineering criterion, it is a mechanism that makes the clustering process more efficient.

9 A convex polygon is one whose internal angles are less than 180 degrees, meaning that it "bulges outward" at each of its vertices.

10 The orientation of the rectangles is defined relative to the "V-H" rectangular coordinate system that is widely utilized in the U.S. telephone industry to locate wire centers, billing rate centers, and the like.

data reported in ARMIS,[11] combined with information on the number of call attempts per busy hour by residential and business customers taken from Telcordia's LSSGR,[12] are used to estimate the number of busy-hour call attempts and the busy-hour switched minutes of use.

With this information, the model tests the required switch capacity in each wire center against three different constraints:

- the number of lines in the wire center versus a user-adjustable maximum switch size of 120,000 lines;
- the number of busy-hour call attempts, suitably adjusted by a user-adjustable processor feature loading multiplier, versus a user-adjustable maximum switch processor capacity of up to 1,200,000 call attempts, depending on the switch line size; and
- the busy-hour traffic, expressed in CCS, versus a user-adjustable maximum switch traffic capacity of up to 2,400,000 CCS, depending on the switch line size.

The HM 5.3 Inputs Portfolio provides the rationale for each of the capacity limits expressed in these three tests. If any of the limits are exceeded in a given wire center, then the model will equip the wire center with two or more equal-sized switches to meet the constraints.[13]

The model then estimates the switch investment in each wire center using the equation

Switch investment = $A + B * L$, where A and B are constants, and L = line size.

The values of A and B are user-adjustable. If switch purchase data are available from the incumbent being studied, those data form the basis for determining the switch price parameters. Otherwise, the values are taken from the FCC's determination of switch investment presented in its Inputs Order.[14] To the switch investment are added appropriate investments for switch engineering, the wire center land and buildings, distributing frames, and power. These are user-adjustable; and if FCC switch prices are used, the default values for switch engineering, distributing frames, and power systems are set to zero because the FCC-specified switch investments include them.

Section 10.3.3 provides a detailed description of the process of estimating tandem switch investments. The model identifies a set of tandem switches and the local switches that home on

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[11] Automated Record Management Information System ("ARMIS"), a process by which data from all Tier 1 telephone companies with annual revenues of at least $117 million in revenues from regulated services is reported to, and published by, the FCC.

[12] Telcordia Technologies, Inc., LATA Switching Systems Generic Requirements: Traffic Capacity and Environment, GR-517-CORE, Issue 1, December, 1998, composite numbers taken from Tables 6-3 – 6-5. The LSSGR provides a detailed (multi-volume) description of recommended attributes of switches to be purchased by local exchange companies.

[13] While the model tests all three criteria, in reality it is essentially only switch line capacity that ever causes the model to require a second switch in a given location.

[14] In the Matter of Federal-State Joint Board on Universal Service, CC Docket 96-45, and Forward Looking Mechanism for High Cost Support for Non-rural LECs, CC Docket 97-160, Tenth Report and Order, Released November 2, 1999.

each. Based on the amount of interoffice traffic generated by each local switch, and input values for the fractions of interoffice traffic of three types (local, intraLATA toll, and interLATA) that are routed via tandem switches, the model determines the capacity of each tandem switch. Using the calculated tandem switch capacities and user inputs for the investments in tandem switches (as a function of tandem switch capacity), the model's switching and interoffice module calculates the total tandem switch investment. The expense module then converts the investment into total yearly tandem costs, and divides by the estimated tandem switch minutes of use to yield a cost per minute of use.

E. Mechanism for Setting Expense to Investment Ratios in HM 5.3.

For each category of plant, HM 5.3 calculates default expense to investment ("E/I") ratios from the expense and investment amounts entered in the "ARMIS Inputs" Worksheet of the Expense Module for each plant category. The Model also allows the user to set different alternative E/I ratios that override the default calculations. This may happen, for instance, because an ILE-specific study of E/I relationships has been performed or because the user elects to use the E/I values determined to be appropriate by the FCC in its Inputs Order.

To change the E/I ratios used by the Joint Commentors, a user may enter an alternative value for one or more of the plant categories in Column H of the Actuals worksheet in the output of the model,[15] and depress the F9 key to recalculate results. Where the Model's sponsors have determined appropriate values to use, the submitted model typically has those values coded into appropriate cells of the Actuals worksheet, but the user may still reset those values and recalculate results.

[15] Individual values of the E/I values for fiber and copper cable associated with each type of outside plant structure – aerial, buried, and underground – can be set in Columns I and J of Rows 44-46 of the Actuals Worksheet.