Attachment 3

Model Description

Attachment 3

CostQuest Associates (CQA)
Economic Research & Analysis

Coalition Implementation of CostQuest Associates Broadband Analysis Tool (CQBAT)
July 29, 2011

CostQuest Associates (CQA) Economic Research & Analysis

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Executive Summary

CostQuest has developed and populated, with the help of a broad wireline coalition (the "CQBAT Coalition" or "Coalition"), the CostQuest Broadband Analysis Tool ("CQBAT") to allow calculation, on an individual Census Block basis, of (1) the forward-looking cost of deploying and operating broadband services and (2) universal service support levels required to support these broadband services.

The CQBAT – which is consistent with the FCC's Broadband Assessment Model ("BAM") – offers a detailed assessment of the economics of both deploying and maintaining broadband service. It acknowledges and accommodates the substantial diversity across geography and business needs, and among consumers. The underlying database, which is several hundred gigabytes in size, is among the largest, most granular, and robust broadband databases ever assembled on a consistent, national scale.

Baseline conditions in different regions of the country are addressed with substantial granularity. The CQBAT profiles 8.2 million Census Blocks using unique/relevant demographic, geographic, and communications infrastructure detail (such as population, housing counts, road density, business counts). The model further captures a view of existing cable broadband coverage (and coverage gaps) through use of the National Broadband Map, which was produced by the National Telecommunications & Information Administration ("NTIA"), and additional, granular data from third-party vendors.

The CQBAT assessment of cost-effective and efficient broadband network is similarly rigorous. The model replicates real-world engineering practices to "build" (model) network deployments, including the consideration of network component exhaust points that drive network costs through time as demand and use expand. Each deployment is scaled to reflect the realities on the ground at the Census Block level, as well as achieve the selected broadband speed outcome.

With respect to operating expenditures, the model uses real-world cost factors built by a careful examination of available operating cost information specific to wireline technology. The model also considers unique factors, such as company size, customer density, terrain, and technology deployed in estimating operating costs.

The CQBAT concludes with the computation of an estimated economic support level required for specific Census Blocks in the country. This computation is based on modeled (technology-specific) network build outs and the resulting capital-related costs and operating costs compared to a benchmark level. The model includes the capability to cap support levels and exclude extremely high-cost areas.

The documentation that follows provides insight into how the model is designed, how it works, and the inputs, toggles, and parameters used to produce the results shown in the CostQuest Broadband Assessment Tool – Model Scenarios (Attachment 2).

1.0 - Benefits of CQBAT

CQBAT allows policymakers to examine potential support approaches with what economists like to refer to as an “all else equal” approach. That is, it allows one to examine how terrain, density, service area demographics, and other objective factors impact costs while holding the impact of other factors equal.

CQBAT provides assistance for choices regarding universal service support, such as:

- Appropriate benchmark level,
- Identification of high-cost areas for targeting purposes, and
- Impact of support caps.

In addition to these key metrics, CQBAT can help one understand

- Technology choices,
- Engineering choices (copper distance, bandwidth changes, etc.),
- Geographic choices (even down to the Census Block), and
- Service choices

Overall, the CQBAT is an instrument that evaluates where (in what areas) broadband support is necessary and in what amount within the parameters of the tool – i.e., the underlying assumptions discussed herein and the input data that were used.

2.0 - CQBAT Introduction

The two primary CQBAT Modules (and the underlying modeling processes) are discussed in this section. Where relevant the discussion will touch on the *purpose* (the fundamental goal of the component), the *strategy* (the high-level logic, data development, and computational strategy employed), and relevant *inputs* and *outputs*. As additional context for the material that follows, it is important to understand the nature of design criteria and simplifying assumptions that underpin the logic. Appendix 1 defines terms used in the text below.

2.1 - High-Level Design Principles

Three broad principles guided our approach to determining the most efficient network configuration to achieve a designated speed:

2.1.a - Economically efficient, forward-looking network engineering

First, a key principle is that the modeled network must be both cost-effective and efficient and designed to achieve a desired standard of speed / reliability. Accomplishing this objective includes the consideration of issues such as the following: whether we are building a Greenfield network; what measure of population density should be used within the market area; what terrain characteristics impact costs; and whether and how to incorporate the size and technology-type of firm providing broadband services.

2.1.b - Reflective of prudent business practices

Second, another important principle is that the modeling of economic costs assumes business decisions are made in a prudent manner consistent with choices that would be made by a viable company facing at least the potential for market competition, even in areas where that competition may not currently exist. Key to abiding by this principle is the model's adherence to contemporary engineering practices.

2.1.c - Consistency with known public policy decisions

Third, a final important principle is that the modeling of broadband network economic costs must consider (and fit with) the foreseeable public policy and regulatory environment. For example, federal and state universal service policies can selectively influence costs (both operating expenditures and capital expenditures) for individual companies, as well as economic choices among alternative network technology options for individual telecommunication companies. Public policy choices to provide grants, loans, tax incentives, technical assistance, regulatory flexibility, and other mechanisms to encourage expanded utilization of broadband communications can change the demand-side revenue equation for supplying telecommunications companies. Inconsistency among state telecommunications regulatory and policy frameworks in areas, such as rate-of-return regulation and carrier of last resort obligations, can influence operating expenditures and investment choices selectively in different geographies.

With consideration of these three broad principles, the logic-block specific sections that follow include an inventory (and brief discussion) of the design parameters identified as important to the CQBAT model. These design parameters framed the modeling approach and process.

2.2 - High-Level Assumptions

The logic that underlies the operation of the CQBAT also incorporates simplifying assumptions that fall into at least two general categories:

2.2.a - Assumptions necessary to address data limitations

Granular data to support the development and analytical implementation of the CQBAT have been assembled. The data sources are documented in relevant Appendix material. However, the modeling of real-world wireline broadband costs and revenues is complex, making it necessary to formulate and employ assumptions to accommodate data limitations. For example, costs are projected over a defined time period. Precise data on future costs and demand does not exist. While a combination of statistical estimation approaches and expert industry knowledge are incorporated into those projections, it is generally necessary to assume that the fundamental industry and policy structure will continue into the future

2.2.b - Assumptions necessary for practical modeling

Additional assumptions are required to reduce real-world complexities to a level that can be handled for practical model development. For example, the actual level of sharing of buried plant in a Greenfield build could vary substantially across geographic areas. However, for practical modeling considerations, it is necessary to adopt assumptions for buried plant consistent with what has been generally accepted and tested against real-world data. Without assumptions of this type, the development of the CQBAT would be impracticable.

The more significant assumptions are outlined below.

2.3 - Strengths and Limitations

Through the model design and development process certain strengths and limitations emerged with respect to the approach (and the underlying available information). These strengths and limitations are summarized below. Notably the precision of model outcomes will be impacted by the quality of available input data. In general, these limitations will have a more significant impact on the precision of derived results for a small area (such as Census Block) than for larger areas, such as wire centers, counties, states, or the nation.

Strengths
Granularity of Data • Detailed data on broadband infrastructure (by technology), factors impacting capital and operating expenditures (e.g., terrain, company size), and service locations (e.g., housing units) are developed at the Census Block level. This granularity helps ensure that results reflect the nation's diversity. **Consistency with real-world engineering standards** • For terrestrial wireline technology, network inputs and the underlying logic used are based on a consortium of current broadband provider information and are consistent with prior data that have been tested and confirmed in numerous federal and state regulatory proceedings.
Limitations
Availability of Data • National data to pinpoint the precise location of both business and residential customers do not exist (and currently are not economically feasible to obtain). As such, service location data must be estimated using a combination of secondary data sources. • Current information available on cable broadband deployment has some known issues in regard to the extent of coverage and the reported speed. • Infrastructure data (e.g., wire center locations and service area boundaries) are based on third-party sources. **Limitations in Predicting the Future** • Future uncertainties exist in both broadband technology and customer service demand, creating challenges in forecasting broadband cost of providing services in outlying years.

2.4 - CQBAT Architecture and Logic

The CQBAT modeling processes are organized around two integrated modules: (1) Cost to Serve Module and (2) Support Module. Associated with each module is an underlying input data set and architectural design parameters that are applicable to the implementation of these main modules.

A depiction of the overall model is as follows:

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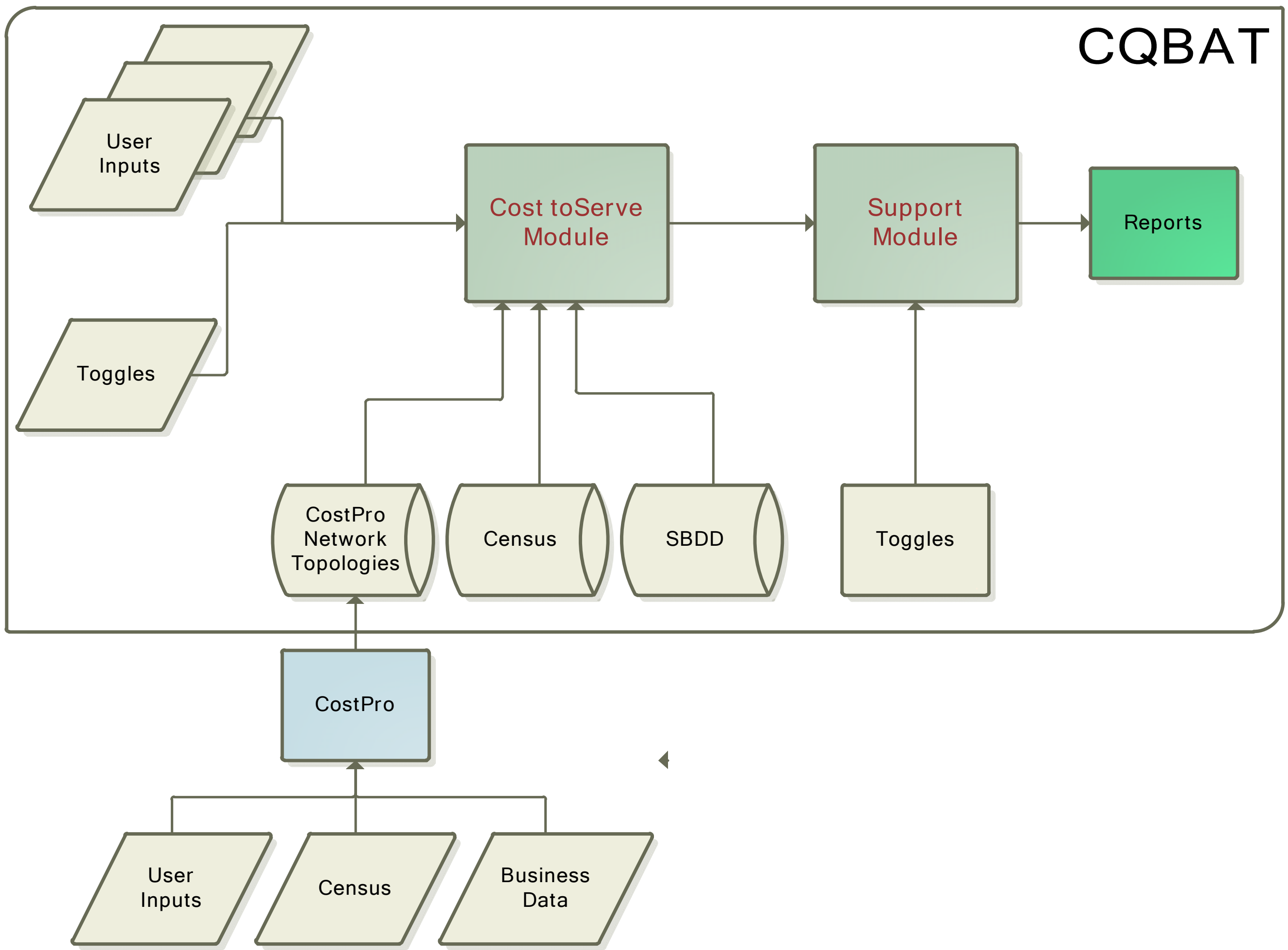

The “Cost to Serve Module” is a systematized collection of mathematical procedures that takes as inputs geographic and non-geographic data and then produces an estimate of the cost of providing a broadband service. As such, it provides unitized measure of costs for comparisons.

The “Support Module” contains a mathematical procedure that takes cost data as an input and produces a universal service support amount.

3.0 - Cost to Serve Module

3.1 - Overview

Based on relevant demographic, geographic, and infrastructure characteristics associated with each identified service area and coverage requirements defined by a set of assumptions (outlined below), estimated build-out investments and operating costs are developed for each Census Block.

This section of the model begins with contemporary topology-specific networks being "built" (modeled using output from CostQuest's industry recognized CostPro platform), according to real-world engineering rules, constraints, and key characteristics of modeled technologies. Designed network solutions were developed for contiguous service areas (e.g., wire centers), and where appropriate, these network costs are driven to the Census Block level based upon cost-causative drivers.

For wireline technology several alternative broadband topologies are available (e.g., Fiber to the Premise, Fiber to the Node, and Fiber to the DSLAM). The Coalition focused on a topology with a subscriber loop of up to 12,000 feet of copper and fiber to the DSLAM. An estimated capital expenditure ("capex") level required to meet a discrete broadband standard set by the user for a model run is developed within this Module. In a corresponding component of work within this Module, operating costs ("opex") for service areas are estimated based on certain user-defined criteria (e.g., company size) and certain Census Block-specific profile data (e.g., terrain, density).

The Cost to Serve Module considered both capital expenditures ("Capex Sub-Module") and operating expenditures ("Opex Sub-Module"). Where relevant, the following discussion of the module will explain in greater detail the purpose (the fundamental goal of the component), the strategy (the high level logic, data development, and computational strategy employed), and relevant inputs and outputs. As context for the material that follows, this section also describes the nature of design criteria and simplifying assumptions that underpin the logic.

3.2 Capex Sub-Module

3.2.a - Build Assumptions and Attributes

Key to any economic cost model approach is defining the key architectural assumptions and design criteria used to construct the network.

The following table summarizes key assumptions and design attributes:

Category	Assumptions
Overall Design	Scorched node
	Forward looking
	New network built to all locations
	All service locations have access to broadband
	Contemporary / real-world wireline systems engineering standards are to be used for the modeling of broadband networks. More specifically, the use of industry standard engineering practices for wireline deployments are to be used.
	The model employs long-standing capacity costing techniques to estimate economically rational deployment investments reflecting real-world engineering capacity exhaust dynamics.
	Network build out will be based on deployment from known/existing LEC central offices.
	The current service provider will continue to supply the service area.
	Smaller companies have the opportunity to join purchasing agreements

	with other small companies, reducing scale economies.
Coverage	Cable broadband coverage based on NTIA's National Broadband Map
	Wireline broadband coverage based on NTIA's National Broadband Map
Network	IP-based network
	Focus on cost of data "Pipe"
	No Video gear (including Set Top Boxes) installed
	No Voice Gateway installed
	Network is built to a steady state, and results represent a steady state valuation.
	Plant mix will be specific to each state.
	Structure apportionment and fiber will be based on active terminations, and copper will be based on pairs or active terminations.
	The build should include special service terminations required by businesses.
	The supported model ends at the fiber termination on the cloud.

3.2.b – Service Location Data

Regulated wireline carriers often have an obligation to provision new service within a short period of time. Significant components of wireline networks are engineered to meet residential and business service demand within an area in recognition of this requirement. That is, wireline networks are typically built and sized to serve all locations. Service location data are, therefore, key drivers of the network build, and a reasonable service location data set must be created.

For CQBAT, the following provides an overview of the creation of a service location data set.

- For residential data, Census Block-based estimates were used (see Appendix 2 for details). Using CostPro, these residential data were then randomly placed along the roads in a Census Block, to arrive at an unbiased estimate of residential locations to drive the network build.
    - The services assumed at each household are described below.
- For business data, a multi-step process was used.
    - A count of business locations by Census Block was obtained from Geolytics (see Appendix 2 for details)
    - To estimate the type and size of the firms, business data from the Economic Census (2007) were utilized (http://www.census.gov/econ/census07/). These data were provided at the ZIP Code level and include the firm type (North American Industry Classification System NAICS code) and size (number of employees) distribution within each ZIP Code.
    - ZIP Code boundaries were overlaid on top of Census Block boundaries to create an association between Census Blocks and ZIP Codes.
    - The Economic Census business data were allocated into Census Blocks based on the prevalence of ZIP data points
    - Within each Census Block, the Economic Census count of firms was then compared to the Geolytics count of firms. The differences in firm counts were assumed to be Single Office or Home Office ("SoHo") business locations, and each was assigned a fictitious NAICS and an employee count less than 4.
    - Once all the firms' locations in Census Block were classified by type and size, the firm points were randomly assigned to eligible road segments within the blocks. The business firm points were placed at random locations along their assigned road segments.
    - As a final step, wireless towers were added to the business demand point data set.
    - The services assigned to each firm or tower are described in 3.2.d.2

3.2.c - Network Architecture

With the service location data in hand, CQBAT models expected outcomes in terms of broadband coverage and related financial requirements (i.e., capex and opex) for contemporary wireline broadband deployments.

The schematic that follows (Figure 1) reflects the fundamental technology architecture (topology) assumed within the CQBAT. Nodes (e.g., Node 0 thru Node 4) are used to help bridge the understanding of functionality through the selected topology. The “nodes” are significant in that they represent the way in which costs are assigned / aggregated.

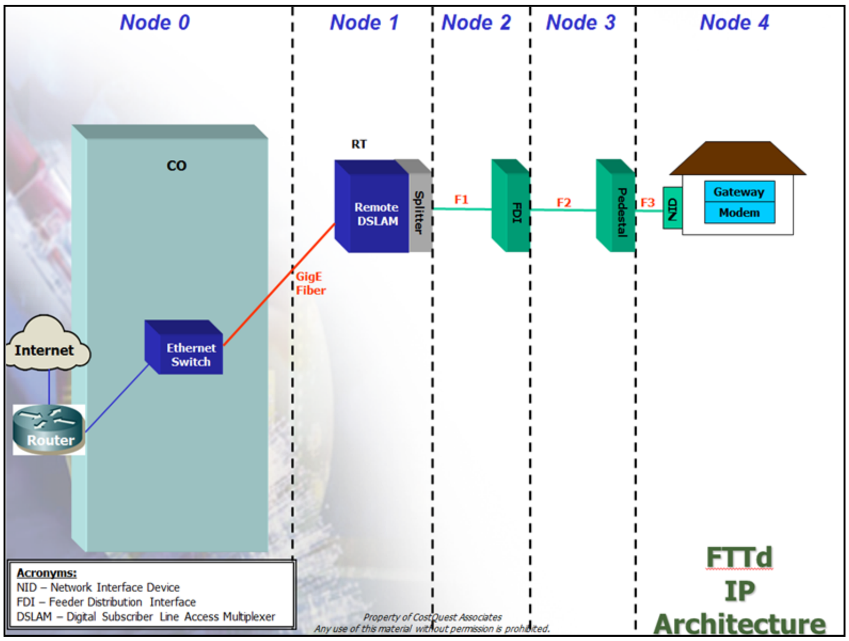

Figure 1 - Fiber to the DSLAM with up to 12,000 ft. of copper cable. (FTTd)

3.2.d – Network Component Development

The Capex Sub-Module employs a granular approach, the use of spatial analysis, and a set of defined real-world engineering rules as the approach to modeling the network design. The resulting costing takes into account service locations; efficient road pathing; traffic demanded at or traversing a network node; sizing and sharing of network components resulting from all traffic; and capacity and component exhaustion. Output unit costs, which were developed using a classic Capacity Costing technique, address all necessary plant, structure, and electronics to support the designed network. The modeled network design also is grounded in actual central office location data (where available).

The broadband network is broken into two key components: loop and middle mile. First, the loop portion captures the routing of network facilities from the service location up to a serving central office. This routing captures both the “last mile” (facilities from the customer to the serving Feeder Distribution Interface)(FDI) and the “second mile” (facilities from the FDI to the central office). Second, the middle mile captures what one might typically refer to as the interoffice network transport. It captures the routing from the End Office up to the point at which traffic is passed to “the cloud.” For this effort, the connection to the cloud occurs at a tandem location within a LATA.

The following discussion provides an overview of how the two key portions of the broadband network are developed.

3.2.d.1 - The Loop

Rather than rebuild the logic captured in CostQuest's industry recognized CostPro Economic Network model platform, CQBAT accepts as inputs key files produced by runs of CostPro. These files include the distribution (last mile) and feeder topologies (second mile) of the wireline network. The workings of CostPro are described in attachments to the National Broadband Plan.[1]

At a high level, CostPro is a "spatial" model in that it identifies where customers are located and "lays" cable along the roads of a service area. For example, a cable path can literally be traced from each customer's premises to the serving central office, a path that follows the actual roads in the area.

From the output of CostPro, a network topology is built that captures the equipment and facilities required for delivery of broadband services to an entire service area. Within the CQBAT capex logic, the network topologies are combined with equipment prices, labor rates, contractor costs, and key engineering parameters to arrive at the investments required.

The Capex Sub-Module uses the topology as the basis for a logical economic scorched node build given the technical parameters.

3.2.d.2 - CostPro Network Assignment

As noted above, CostPro was populated with data that incorporate various types of business locations in addition to Census-based residential locations. Based on this road-located service location data set, CostPro then created the network topology required by customers and their associated service requirements.

The following outlines what services were provisioned for each customer type:

- Residential
  - Broadband pipe
- Business
  - Technology-Oriented Business - (NAICS code > 50000)
    - Employee count < 10
      - Broadband pipe
    - Employee count > 10
      - Dedicated fiber service
  - All Other Business – (NAICS code < 50000)
    - Employee count < 10
      - Broadband pipe
    - Employee count between 10 and 50
      - Broadband Pipe
      - Non-broadband copper services
    - Employee count > 50
      - Dedicated fiber service
  - Wireless Towers
    - Dedicated fiber service

Once the network topology was designed, the network facilities associated with the build out were associated with each service (broadband pipe, dedicated fiber) either based upon cost-causative drivers or through an appropriate attribution and pushed to the subscribers in the Census Block. Only the facilities (or portions thereof) associated with the broadband services were extracted from the CostPro results and pulled into CQBAT. As such, the network topologies capture the full build of a broadband provider, and through appropriate economic rationale, only the portion of the network build associated with broadband was captured in the CQBAT results.

[1] Documentation of CostPro, which was used in the FCC's BAM, can be found at http://download.broadband.gov/plan/fcc-omnibus-broadband-initiative-(obi)-working-reports-series-technical-paper-broadband-assessment-model-attachments.zip.

3.2.d.3 - Middle Mile

Middle mile connects central offices with "the cloud" (Internet gateways) via connection to point of interconnection at a tandem within the LATA. Efficient high-capacity Ethernet routes are created to move traffic from these central offices to the location of existing access tandems.

The material that follows provides information on how middle mile costs are developed within CQBAT.

The approach used to determine middle mile equipment required – and then to compute the related investment costs – is centered in the spatial relationship between the central office and the nearest access to a Tier 3 Internet gateway. A surrogate for such access is assumed to be on a regional access tandem ring within the LATA.

This approach starts with obtaining the location of each central office – also referred to as Point of Interconnection ("POIs"), Common Language Location Identifier ("CLLI"), and/or Node0 – from the TeleAtlas wire center boundary database. The result of this approach aligns the central office/Node0 locations used in the underlying CostPro model to middle mile investment calculations.

Regional tandem ("RT") locations (and the relevant feature groups deployed) are obtained from the LERG database. Each tandem identified as providing Feature Group D access in LERG 9 is designated an RT. As with COs, a latitude and longitude is identified for each RT.

The underlying logic (and the process) of developing middle mile investment requirements are grounded in the assumption that the Internet Gateway peering point is located on the RT ring – meaning that if the modeled design ensures each central office is connected to an RT ring, the corresponding Node0 customers all have access to the Internet.

Given this baseline data on central office and RT locations and working under the assumption outlined above, the middle mile processing logic proceeds as follows:

- The Middle Mile process is run state by state. All CLLIs in a state are homed to a RT in that same state. The RT location is assumed to be where the Internet Gateway is located.
- Within a state, each CLLI location is assigned to its nearest RT (parent RT) to create the initial spatial relation of Central Office locations to RT locations.
- CLLI locations are then routed to other CLLI locations with the same RT parent using a spanning tree approach based on the shortest distance routing back to their parent RT location.
- For cases where multiple RTs exist within a LATA, all the RTs within the same LATA are routed together in a ring. To ensure an efficient design the shortest ring distance is used. The shortest ring is chosen by starting at each RT point and examining the ring route distances. After stepping through each potential ring route, the shortest ring distance is then used for further computations.

With this information in hand, the CQBAT develops middle mile costs with the following steps:

1) The distance of the RT rings is attributed to each CLLI on the ring in proportion to the number of service locations at each CLLI as compared to the total service locations for all the CLLIs attached to the RT Ring.
2) The distance from the CLLI back to the RT is attributed much in the same way as the routing to DSLAMS is attributed. That is, CQBAT attributes each route based on the cumulative service locations that can use the route.
3) For electronics, CQBAT places an Ethernet switch in each CLLI. This Ethernet switch is connected to a router that may serve one CLLI or multiple (based on demand). If the distance to the RT exceeds a user-specified distance, a regeneration unit is placed to extend the distance. This router/regenerator is then assumed to be the last piece of costed equipment in the broadband costs that are developed.

4) For the fiber placement, CQBAT assumes a percentage of conduit and poles are included in the Loop plant. As such, only an increment of these costs is assumed to be incurred on the routes. All costs are incorporated for fiber and trenching related to the portion of the route that is assumed buried.
5) For the route-related costs, CQBAT assigns only a portion to the broadband network (current value set at ½) based on the assumption that the transport network is built for multiple purposes (CQBAT broadband services and leased dedicated data services)
6) Finally, CQBAT apportions the middle mile cost out to each Census Block (the basic unit of geography in CQBAT) based on the proportion of service locations in the Census Block (as compared to the total service locations in the wire center/CLLI serving area).

3.2.d.4 - Capex Accuracy

It is important to note that variances in capex accuracy (somewhat driven by the quality of service location data) at the Census Block level will tend to be mitigated as the model results are viewed at larger area aggregations. Examples of design logic intended to improve the accuracy of capex estimates at the small region level include, but are not limited, to the following:

- Terrain: The Capex Sub-Module is sensitive to terrain characteristics faced in wireline construction via the use of a variable factor.
- Density: The Capex Sub-Module is sensitive to aggregate density of a Census Block through multiple factors, including user quantity driven wireline costs and scaled backhaul (second and middle mile) costs based on aggregated demand in a given serving area.

3.3 – Opex Sub-Module

3.3.a - Introduction:

The CQBAT Opex Sub-Module is designed to estimate wireline telecommunication operating expenses in provisioning broadband in service areas by company size (i.e., Large, Medium, Small, Extra Small, and Extra-Extra Small) and by density (i.e., Demographic, Geographic, and Terrain). The CQBAT Opex Sub-Module is designed to be applied to Census Block profiles with consideration of coverage requirements defined by a set of user assumptions and investments.

The CQBAT opex cost profiles are presented within a hierarchy of costs referred to as the CostFACE. From the highest level in the hierarchy down, the CostFACE is comprised of the following:

F – Cost **F**AMILY (e.g., Network vs. Customer Operations vs. General and Administrative)

A – Cost **A**REA (e.g., Plant Specific vs. Plant Non-Specific)

C – Cost **C**ENTER (e.g., Cable & Wire vs. Circuit Equipment vs. Switching)

E – Cost **E**LEMENT (e.g., Copper Aerial vs. Fiber Aerial vs. Copper Buried vs. Fiber Buried)

The purpose of the CostFACE is to facilitate organizing and aligning costs with relevant cost drivers (e.g., associated capex investment and subscribers).

The model input is rendered in a set of static tables made available to CQBAT for purposes of aligning the selected operating costs to the selected provider type, size, and density requirements based on cost drivers, such as investment or active service locations.

To provide estimated operating expense for the difference in operating characteristics noted above, relevant provider data available within the public domain were gathered and analyzed to develop a set of neutral baseline cost profiles and a corresponding set of factors or cost functions designed to adjust the baseline views by provider size and density. These publicly available values were then compared to proprietary data provided by Coalition members to test for reasonableness.

The steps in the operational cost development process vary by provider size, but are summarized generally below:

- Research and gather operating expense data;
- Segmentation of data to uniform expense lines;
- Analysis of data;
- Identification of appropriate CQBAT Opex Sub-Module cost drivers based on best “available” data;
- Development of baseline opex detail;
- Development of factors for size and density adjustments;
- Development of property tax location adjustments; and
- Validation and revalidation of results.

3.3.b - Assumptions

While the process noted above provides results within an acceptable range for the designed purpose of the sub-module, consideration was given to certain assumptions and existing limitations that constrained the absolute predictability of the Opex Sub-Module, as listed below:

a) Industry reported financial data are reasonably accurate and sufficiently segregated to develop opex drivers to model operating expenses at geographic granular levels (i.e., Census Blocks);
b) Varying formats and expense-detail levels of publically available financial data can be reconciled to provide unitized detail;
c) Compilation of publicly available information can be analyzed using regression equations and other acceptable analysis supported with industry information to derive valid baseline opex detail;
d) Resulting unitized baseline expense detail can be modeled against CQBAT forward-looking cost drivers to approximate reasonable estimates of opex for a selected provider, size, and density characteristics;
e) Historic financial data comprised of mixed technological generations can be adjusted to reasonably predict the operating expense of deployed new technology; and
f) Validation of varying types of expense detail against sufficient industry- or company-specific data will produce acceptable variance metrics.

3.3.c - Sources of Information

The following information sources are publicly available through free media or by subscription and were the primary sources from which the opex data were derived, analyzed, and tested:

- FCC ARMIS Data;
- NECA Data;
- Thomson Reuters Checkpoint, RIA. (2011);
- Wolters Kluwer, CCH. (2011);
- Various comments filed with the FCC regarding the National Broadband Plan;
- Public Financial Statements;
- Standard & Poor’s Industry Surveys: Telecommunications: Wireline, April 2011;
- Business Monitor International, United States Telecommunications Report, Q1 2011;
- Morgan Stanley, The Mobile Internet Report, December 15, 2009;
- R.S. Means, Building Construction Cost Data 69th Annual Edition (Massachusetts: R.S. Means Company, Inc. 2010);
- Marshall & Swift, Marshall Valuation Services (U.S.A.: Marshall & Swift/Boeckh, LLC, 2010); and
- Other related industry analysis, research, and publically available information.

We also relied on and/or considered certain proprietary information, including data provided by the CQBAT Coalition members.

3.3.d - Development of Opex Factors

Below is an overview of the methodology used to develop the CQBAT Opex Sub-Module factors and related adjustment factors for the following FACE elements:

- Network Operation Expense
  - o Plant Specific
    - Outside Plant Cable by Cable Type
    - Poles
    - Conduit
    - Circuit / Transport
  - o Plant Non-Specific
    - Network Operating Expense
    - General Support and Network Support
- General and Administrative
- Selling and Marketing
- Bad Debt

3.3.d.1 - Network-Operations Expense Factors

To estimate the CQBAT Network Operations Expenses, the relationship between capital investment and ongoing cost to operate and maintain the plant was determined. For this determination, we relied primarily on five years of NECA data (2006-2010), supplemented with financial data provided by the CQBAT Coalition company members. These NECA data report operating expenses, Investment by Plant Type in Service ("IPTS"), and Total Plant in Service (TPIS) amounts for companies across CO Transmission and Circuit Equipment, and Cable & Wire accounts. These data were further categorized with a size variable by classifying the parent company as follows:

- ➢ Large Company: Greater than 1,000,000 loops nationwide
- ➢ Medium Company: Between 100,000 & 1 million loops nationwide
- ➢ Small Company ("Small): Between 4,000 & 100,000 loops nationwide
- ➢ Extra-Small ("X-Small"): Between 1,000 & 4,000 loops nationwide
- ➢ Extra-Extra-Small (("XX-Small"): Less than 1,000 loops nationwide

The NECA rural classification was overlaid on the company size data. Furthermore, the cable and wire accounts were further broken out into Aerial Cable, Buried Cable, Conduit, Poles, and Underground Cable using industry data percentages of distribution plant (e.g., Opex & Plant Investment). Finally, the data were unitized on a per-loop basis to improve the accuracy of the results and facilitate the validation/testing of the results by company size and density.

Two analyses were considered to develop the set of baseline CQBAT Opex Sub-Module factors for each company size by density (e.g., rural, suburban,[2] and urban): (1) Regression analysis to develop opex regression coefficients; and (2) Data analysis to develop the average Opex / IPTS factors. Based on the results of the regression (e.g., Multiple R (R2)), we concluded the weighted average Opex / IPTS factors were more appropriate.

To develop the Opex / IPTS factors we relied on NECA data (2006-2010), segregated by company size and density. An analysis of the network operating expenses and investments on a per loop basis resulted in annual operating expense per loop factors by company size and density. These results were then adjusted from a historical cost basis to a contemporary topology-specific network build on a forward-looking cost ("FLC") basis, resulting in the baseline CQBAT Opex Sub-Module factors.

From these data, a baseline view was extracted from the data based on the cost drivers noted in the Cost Face format illustrated above, and factors were derived to adjust for size, density, location, and property taxes. In addition, cable CQBAT Opex Sub-Module factors were further segregated between metallic and non-metallic to account for the significant operating differences between the two types of cable.

[2] For the Suburban companies, and given the limitations of the data, the CQBAT Opex Sub-Module factor was determined to be equivalent to the corresponding Urban CQBAT Opex Sub-Module factor.

3.3.d.2 - General and Administrative Operating Expense

To calculate the CQBAT General and Administrative ("G&A") Opex sub-module factors, a regression analysis was employed using five years (2006 - 2010) of NECA G&A Opex (dependent variable) and TPIS (independent variable) data segregated by company size to determine the relationship between total plant investment and G&A operating expenses. Using the same NECA data unitized on a per loop basis, Forward-Looking Cost G&A Opex Component factors per loop were developed by company size and by density. Comparing the contemporary G&A Opex Component factors to the regression resulted in FLC to historical G&A adjustment factors by company size and by density to be determined. Applying these adjustment factors to the regression coefficients resulted in the CQBAT G&A Opex Component factors by company size by density. The Large Company baseline results were validated then by comparing them G&A operating expense data provided by the Coalition companies.

3.3.d.3 - Customer Operations Marketing & Service Operating Expenses

To determine the CQBAT customer selling and marketing ("S&M") Opex Sub-Module factor, we relied on publicly available ARMIS data and CQBAT Coalition company data. Based on the CQBAT Coalition company data, S&M costs were estimated to be 12.8 percent of revenue. A review of the latest ARMIS data available for large incumbent local exchange carriers ("ILECs") (2007) and mid-sized ILECs (2010) indicates S&M operating expenses are 12.97 percent of revenue.

3.3.d.4 - G&A Opex Property Tax Location Adjustment

Property taxes are typically a subset of the G&A operating expense. Property taxes, which are based on the value of the property owned by the taxpayer in the taxing jurisdiction as of a particular lien date, vary by state and, to some degree, by taxing authority within each state. As such, location-specific property tax indices to be applied to the G&A Opex Component factors were developed.

To develop the location-specific indices, total corporate operations expenses (G&A plus Executive & Planning) and the net plant in service, based on the NECA data, were summarized by state. We then developed the average property tax levy rates by state. Applying these levy rates to the net plant in service (e.g., proxy for the taxable property tax value) resulted in the implied property tax expense by state. Comparing these figures to the overall national weighted average property tax levy rate, property tax indices by state were developed. Applying these indices to the G&A operating expense adjusts for location-specific differences in property taxes.

3.3.d.5 - Validation

The accuracy of the CQBAT Network Opex Sub-Module factors was tested by applying them to the estimated CQBAT Capital Investment Module factors per loop and comparing the results to the NECA network operating expenses per loop by company size and by density. The Large Urban Companies returned a variance of 1.2 percent and the Medium Urban Companies return a variance of 2.7 percent. For the rural density, the variance for the Large Companies was 0.8 percent, Medium Companies were -3.2 percent, and the Small Companies 1.8 percent. The overall weighted average variance by density was 1.2 percent for Urban Companies and 0.5 percent for "Rural" Companies.

The CQBAT operating expenses per customer output by cost element also were reviewed for reasonableness, and we found that they adequately reflected differences in density, technology, and other factors. General and Administrative and Selling & Marketing expenses fell within a reasonable range in connection with the provisioning of broadband services. In addition, and throughout the entire process, we considered the feedback and analysis from the CQBAT Coalition as well as relied upon our industry experience.

3.4 - Cost to Serve Inputs

As noted above, CQBAT captures the capex, opex, and demand attributes in the model. All key inputs to and/or from the Capex and Opex Sub-Modules are captured or controlled by user input tables. The user then assembles the appropriate inputs into an "Input Collection" that then guides the processing of CQBAT.

Before we outline the user input tables, it is important to first understand what has been developed externally and loaded into databases within CQBAT:

- Current broadband coverage pulled from NTIA's National Broadband Map is captured in the CBMaster database.
- The network topology, as produced by CostPro, is captured in the CostPro databases (one for each state). These topology capture the size and type of plant required. These are then converted into investments (i.e., capex) applying costs for material and labor provided in user input tables. Included in these databases are topology tables for Distribution, Feeder, and Middle Mile.

What follows is an inventory of the User Inputs that control CQBAT at processing time:

- Annual Charge Factor (ACF)
    - This table captures the Annual Charge Factors that convert Investment into its monthly costs. The values loaded into CQBAT are produced by CostQuest's CapCost model. This model has been used in the Benchmark Cost Proxy Model ("BCPM") (universal service model) and by various telecommunications companies. The basis of the model is the economic determination of the depreciation, cost of money, and income taxes associated with various plant categories. The calculation incorporates industry standard procedures, such as Equal Life Group methods, inclusion of future net salvage, impact of deferred taxes, and mid-year conventions.
        - Key inputs into the derivation are lives of plant, assumed tax lives, survival curve shapes, cost of money, cost of debt, debt/equity split, and future net salvage
        - Inputs
            - Cost of Money set at 9 percent
            - Use Depreciation lives consistent with those prescribed by the FCC's Wireline Competition Bureau's latest general depreciation order – CC Docket No. 98-137
    - Used to convert Investment into monthly values of Depreciation (DEPR), Cost of Money (COM), and Income Taxes (TAX)
- Bandwidth
    - Provides the busy hour bandwidth
    - Used to size the appropriate network components
- Business Take
    - Set at 90 percent of service locations
    - Used to derive the demand for the business market
- Capex
    - Provides the material and installation costs for the plant build
    - Data were applied against the network topology data from CostPro to derive total build-out investment levels
    - Inputs capture technology, network node, network function, and plant sharing
    - Used to derive the total capex
- COSize Adjustment
    - Defaulted to 1 (no impact)
    - Provides the user the capability to adjust the assumed purchasing power of small, medium, and large providers
    - The inputs assume that all providers can achieve the same purchasing power (either as a result of their size or their ability to buy as a consortium)
    - Used to adjust up or down the capex costs in the model
- Opex
    - Discussed in the Opex Sub-Module above
    - Provides the estimated operation costs to run and maintain a broadband network.
    - Used to develop the operation costs
- PlantMix
    - Provides the estimated mix of cable by type: aerial, buried, and underground

- Used in drive to determine the type of cable required to serve a Census Block

- PTax
  - Sourced from property tax rates in each state
  - Provides the impact of property tax to various operating costs
  - Captured in the multiplier used for the operational element
  - Used to capture the impact of property tax in the operation costs
- RegionalCostAdjustment
  - Sourced from third party source - RSMeans
  - Provides the estimated difference in the cost to build and operate in each part of the county
  - Captures material and labor costs difference
  - Captured at the ZIP3 level
  - Used to drive differences in Capex and Opex costs due to labor and material cost differences across the country
  - Applied to All Capex and specific Opex components
- StateSalesTax
  - Sourced from appropriate tax rates in each state
  - Used in Capex derivation
- Residential TakeRate
  - Set at 90 percent of service locations
  - Used to derive the demand for the residential market

In addition to the User Inputs, there are a number of run-time toggles. The most significant are number of competitors and cable coverage. We assumed that in cable unserved areas there will be zero broadband competitors. With this assumption we established that the takerate would not be affected by satellite or alternative broadband services.

4.0 - Support Module

Once the Cost to Serve Module has run, a large amount of information is available for analysis and decision making. As described earlier, the Support Module takes the output from the Cost to Serve Module along with user-defined parameters to calculate a result representing universal service support specific to the user request. Put another way, the support module works as a sophisticated calculator on-top of the cost-to-serve information. The support module examines the granular cost information and calculates those areas requiring support given a specific set of parameters.

A few of the critical considerations in evaluating high-cost universal service support and included in the Support Module are:

> averaging criteria (targeting); benchmark above which support is eligible; federal portion of funding; monthly cap in the highest cost areas which may be better served by an alternative technology; monthly subscriber cap on funding; and an overall cap on total funding.

4.1 - Coalition Parameters

The following parameter elections were used in the Coalition solution to determine the support amount needed for each Census Block addressed by the CQBAT Support Module:

- States - All states were run.
- Total Max Funding - The variable was suppressed by using an arbitrarily large value.
- FCC Portion - Set to 100%.
- Monthly Support Funding Cap - The variable was suppressed by using an arbitrarily large value.
- Cable Unserved - Funding is only areas that lack cable broadband service.
- Geographic Level - The averaging of cost was performed at the Census Block level.
- Benchmark - A benchmark of $80 was used.
- Alternative Technology Threshold – Set to $176.

- Calculate Benchmark Testing - The comparison to the benchmark was performed at the Census Block level.

5.0 - CQBAT Results

The model is functional and capable of producing results. The following are some preliminary findings/summaries from the platform.

5.1 - Cost Chart

The following represents the average cost per service location across all potential broadband customers in the United States and captures the percentage of customers at each cost. This figure displays the classic “hockey stick” shape of costs (y-axis), showing that there is steady increase in cost until you reach approximately the 95th percentile (x-axis), where costs grow exponentially.

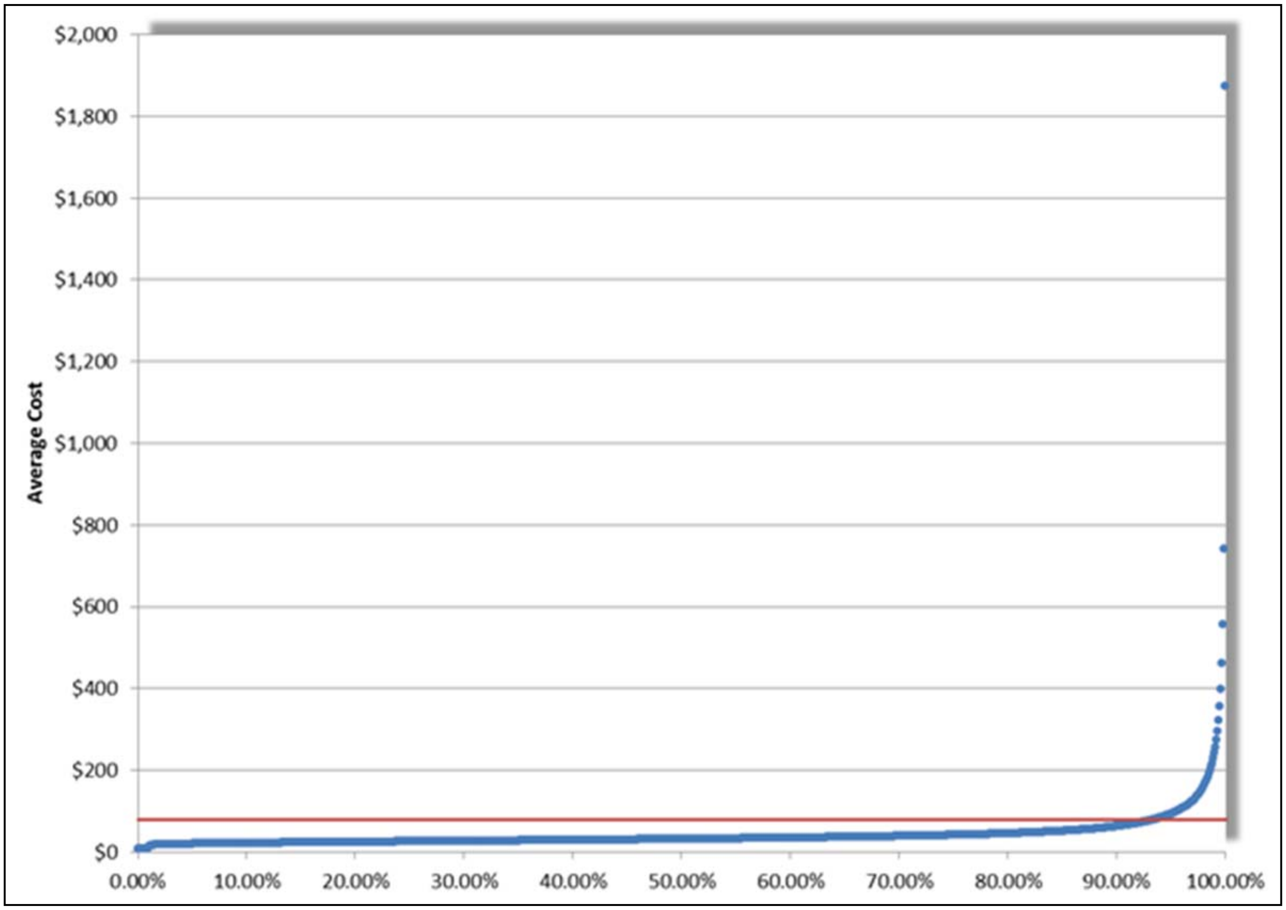

Figure 2 – Average Cost Per Service Location

5.2 – Implementation Results

Refer to the CostQuest Broadband Assessment Tool – Model Scenarios (Attachment 2) documentation for the Coalition solution results.

Appendices

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CQBAT Appendix 1 - Glossary

Across the modeled technologies (and the related operational environments) there are a number of terms that are vital to hold in common when working with CQBAT logic, inputs, and outputs. Key terms include the following:

Term/Phrase	Definition and Issues Relevant to CQBAT
ARPU	Average Revenue Per User – a measure / estimate of the average revenue from a subscriber relative to a defined unit of sale.
Broadband	Generally used to refer to a high data rate Internet access capability typically contrasted with dial-up access using a 56k modem.
Capacity Threshold	A threshold demand level based on total demand at an existing fiber-fed POI.
Capex	Capital expenditures representing the investments required to design and install communications facilities – including the related cost of money associated with capital investments.
Census Block	The smallest geographic unit used by the United States Census Bureau for tabulation of 100 -percent data (i.e., data collected from all houses, rather than a sample of houses). Within CQBAT, the Census Block is the most granular geography for which service availability is assessed.
FTTd	Fiber to the DSLAM. - a transmission system in which optical fiber is carried to a DSLAM which serves a relatively large area. The final connection to the service location is copper.
FTTh	Fiber to the home – a transmission system in which optical fiber is carried all the way to the service location.
FTTn	Fiber to the neighborhood (or node) – a hybrid transmission system involving optical fiber from the broadband provider network to a neighborhood node. The final connection to the service location can be twisted pair (copper), fiber, or coaxial cable.
GIS	Geographic Information System – computer applications involving the storage and manipulation of maps and related data in electronic format.
Greenfield	A term used to describe the situation where service is provided to an area where, to this point, there has been no such service.
IP	Internet Protocol – a protocol describing software used on the Internet that routes outgoing messages, recognizes incoming messages, and keeps track of address for different nodes.
Last Mile	This is the link between the customer (end user) and the service provider's network node. Also referred to as a local loop, this

	connection can be fiber, copper, wireless, or coaxial.
Latency	Refers to a short period of delay (usually measured in milliseconds) required for the conversion of analog and digital representations of the sound data.
Middle Mile	High High-capacity transport connections between a service provider's network core and its second and last mile network. In CQBAT the middle mile reaches the POI (which is a designated existing fiber location), with second and last mile network built to serve areas.
Opex	Operating expenses generally experienced by broadband providers, including network-related operating costs, sales and marketing costs, and a wide range of administrative costs (including bad debt).
POP	Point of Presence – a physical location that allows an interexchange company ("IXC") to connect to a local exchange company ("LEC") within a LATA.
POTS	Plain Old Telephone Service – the basic service supplying standard telephone single line service and access to the public switched telephone network.
QoS	Quality of Service – a measure of the quality of telephone service provided to a subscriber, which embraces a wide range of specific definitions depending on the type of service provided,
Scorched Node	A cost modeling approach wherein the central office, middle mile, and service locations are based upon current locations, but the construction of the network between the serving CO and customer is modeled using forward-looking algorithms.
Second Mile	Transport connections between the middle mile and last mile. In CQBAT the second mile is the transport between middle mile connection and network nodes (e.g., DSLAMs and ONT's) providing Last Mile customer connections.
Sharing Effect	Dealing with potential shared use of backhaul built by first carrier serving an unserved area.
xDSL	Digital Subscriber Line – a generic name for a family of digital lines being provided by CLECs and local telephone companies for high-speed data services, including broadband Internet access. [The "x" notation refers to an unspecified underlying technology (e.g., ADSL, VDSL, HDSL) and the attending speed realized.]

CQBAT Appendix 2 - Data Source and Model Application Summary

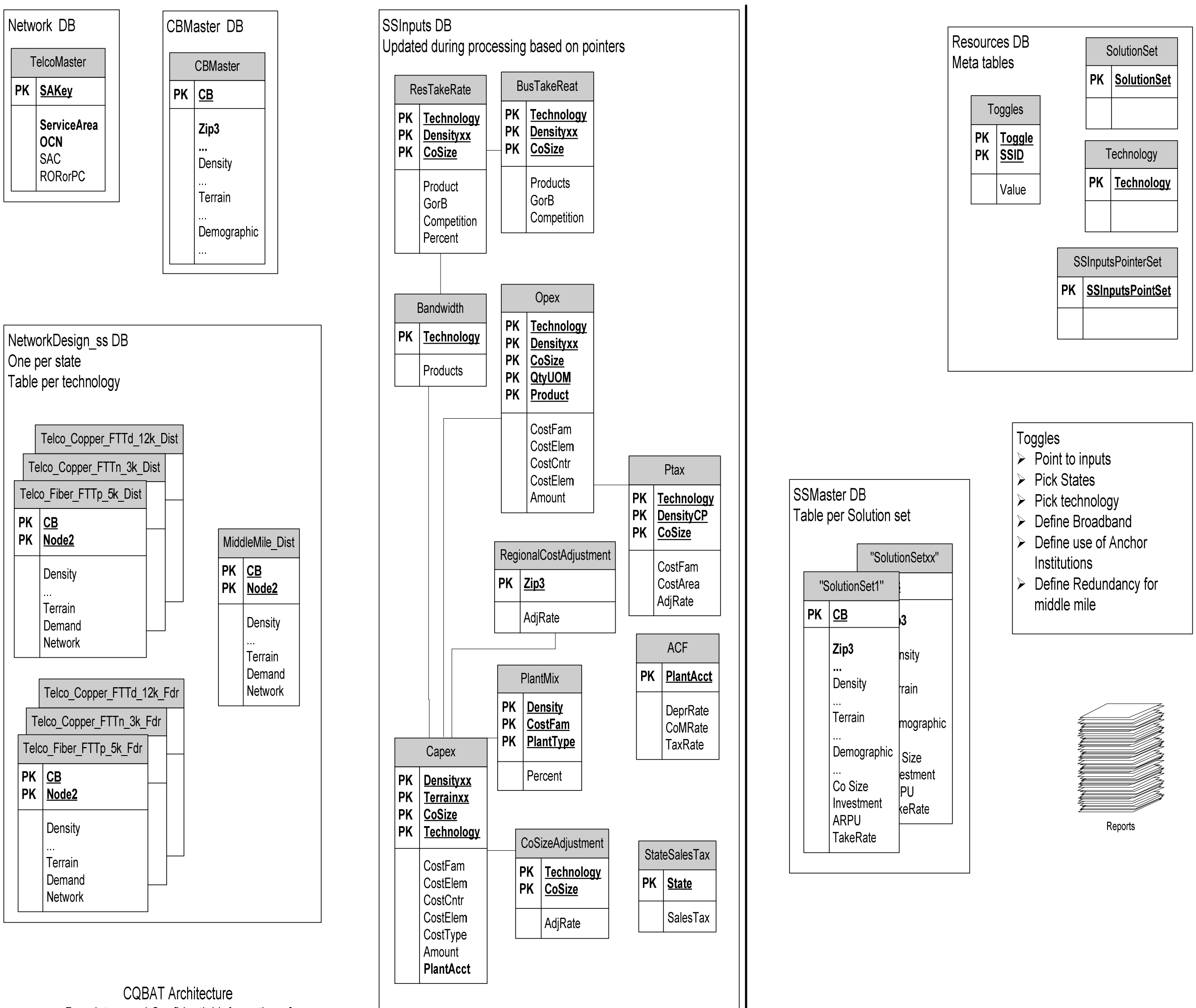
The table below provides a summary (inputs grouped by category) of the major data inputs to the CQBAT along with the underlying source for that data and a reference to where that data were used within the model.

Data Category	Model Variables	Data Source	Wireline Coverage	Capex	Opex
Census boundaries	Full Census Block; full Census Block Group; full Census Tract; full Census County; Census State	2009 TIGER	X	x	x
Wire center boundaries and switch locations	Wire center code; wire center area	TeleAtlas 2010	X	x	
Geographic characteristics	Land area; total road length; x and y coordinates by fragment	Tiger Roads 2009;	X	X	
Terrain	Terrain characteristics	USDA, NRCS-Statsgo	X	x	
Population size	Population by block; population density by block and road length	2010 Geolytics and 2000 Census	X	x	
Housing units	Occupied housing units; total housing units; total households by block	2010 Geolytics	X	x	
Provider size and organizational structure	Corporate ownership; size of parent company; number of wire centers operated by carrier	Coalition Members	X	x	x
Company opex financial data	A wide array of company-specific financial information (and underlying business volumes) from public and subscription service sources. Data centers on operating expense by category (e.g., maintenance, sales, interconnection, sales and marketing, G&A, bad debt, taxes, etc.).	See Appx. 4 for a comprehensive list of opex data sources			x
High capacity locations	High capacity locations will be used to represent high demand business points and will be used to improve business location points for sizing the network.	County Business Patterns http://www.census.gov/econ/cbp/	X	x	
Wireless tower location	Wireless tower locations will be used to represent locations requiring fiber service and will be used to supplement business and residential customer points for sizing the network.	Towersource (2008 extract)	X	x	
Wireless broadband service	Wireless provider broadband speed for wireless area coverage within a Census Block	National Broadband Map (as downloaded			

		on 3/22/11)			
Wireline broadband service	Telecommunications provider broadband speed for wireline area coverage within a Census Block	National Broadband Map (as downloaded on 3/22/11)			
Cable broadband service	Cable provider broadband speed for cable area coverage within a Census Block	National Broadband Map (as downloaded on 3/22/11)			

CQBAT Appendix 3 – Model Data Relationships

The schematic provides an overview of how data are organized and related within the model. While the figure should capture most of the design, there may be differences with the final model.



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Inputs for Solution Set Runs