Federal Communications Commission

Broadband Assessment Model

(BAM)

Model Documentation

[Provided by CostQuest Associates, updated March 2010]

Contents

Quick Tour

The recognition that broadband access to the Internet is a critical driver to economic development, shared opportunity and a desired quality of life across our nation is pretty much a given today. An understanding of where broadband exists – and more importantly, where it does not exist – is still emerging. There are a number of state broadband mapping initiatives underway and, in time, these efforts will bring more clarity to the problem – and the opportunity. In advance of that however, pursuant to defining Congressional action, national policies must be explored and new directions established consistent with emerging national priorities. As a result, there is an immediate need for an actionable understanding of where broadband access is lacking across the country – what it will take to fill the access gaps and what the likely economic outcomes of such a broadband augmentation might be. This is the mission of the Broadband Assessment Model (BAM).

- Where (specifically – at a Census Block level) is broadband access lacking across the entire country?
- What contemporary technologies are available and appropriate to efficiently fill those gaps?
- What new network facilities will need to be built to provide sustainable/affordable access?
- What will it cost to deploy those networks?
- What will it cost to operate those networks?
- What revenue will accrue from the new customers on these new networks?
- Will the resulting business opportunities make economic sense?

…these are the questions the Broadband Assessment Model (BAM) is being asked to help resolve.

Diversity abounds. We are a large and very diverse nation. Our diversity exists across our populations (e.g., urban vs. rural) and across our geographies (e.g., terrain, degree of rurality, etc.). On top of that, the various commercial interests available to serve the consumer's broadband need have a wide array of viable technologies at their disposal. Contemporary technologies range from longstanding wireline solutions (e.g., xDSL and fiber) to a range of cable based solutions (e.g., DOCSIS 2.0 or DOCSIS 3.0) to a number of emerging wireless/mobility solutions (e.g., wireless 4G technologies). All of this diversity can and will impact the cost to deploy and operate new broadband networks. And all of this diversity can and will impact the revenue that might be anticipated from such deployments. These are important issues for the companies that provide broadband access. These are important issues for the nation's policy considerations. Specifically, what public policy actions ranging from grant funding to regulatory changes to public/private partnerships will result in cost effective, responsive and sustainable attainment of the nation's broadband goals? And hence these are important issues for the nation's citizens and business interests. The BAM is built to acknowledge and accommodate the substantial diversity across geography, business needs, and among consumers. Specifically:

- ➢ The model baseline includes 8.2 million Census Blocks – each profiled using unique/relevant demographic, geographic and communications infrastructure detail (such as population, housing counts, road density, business counts, etc) – detail that is vital to accurately modeling cost effective, sustainable and efficient broadband augmentations appropriate in different regions of the country.

- The model builds a view of existing broadband coverage (and hence, coverage gaps) through an exhaustive analysis of technology-specific data including wireless and cable system deployments and sampled wireline (xDSL) broadband coverage that is extended to a national view by way of multiple speed-dependant statistical models.

- The model incorporates six relevant technology opportunities – including a variety of 'fiber to the [x]" alternatives designed to extend fiber transmission benefits (e.g., speed) deeper and deeper into the network. The service capability of the different technologies is also considered later in the model when revenues are determined.

- 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 also scaled to reflect the realities on the ground at the Census Block level as well as meeting the selected broadband speed outcome.

- The model uses real world operating cost factors built by a careful examination of available operating cost information specific to each technology (e.g., wireline vs. wireless vs. cable). The model also considers unique factors such as company size, customer density, terrain and of course, technology deployed in estimating operating costs.

- The model determines likely revenues by application of a well informed average revenue per user (ARPU) function (provided by the FCC broadband team) and associated take rates and related impacts unique to the Census Block for which new broadband service is being deployed. The estimated average revenue per user and associated take rates incorporate the realities of differing capabilities including voice, video, data and bundled offerings enabled by the alternative broadband technology options.

- The model concludes with the computation of an estimated economic contribution margin for each unserved Census Block in the country based on modeled (technology specific) network augmentations and the resulting incremental capital related costs, operating costs and associated incremental revenue.

The underlying data base is among the largest, most granular and robust ever assembled on a consistent national scale. The underlying database is several hundred GB in size and 1-8 hours processing time is required to run a single scenario for the entire country (e.g., a selected broadband speed for a selected technology solution for a selected study period, etc.).

The documentation that follows provides more insight into how the model is designed / how it works – and why.

For the reader's benefit, we have provided a glossary of terms used in this document as BAM Attachment 1.

Background / Context

The purpose of this material is to document the Broadband Assessment Model (BAM). As a backdrop to this material it is important to establish a clear context for this work.

In the American Recovery and Reinvestment Act of 2009 – known as the stimulus package – Congress charged the Federal Communications Commission (FCC) with creating a national broadband plan (the Plan). In April 2009 the FCC began work on a national broadband plan designed to ensure that every American has access to broadband capability. Targeted for delivery to Congress in 1Q 2010, the goal of the Plan is to provide a roadmap toward achieving the goal of ensuring that all Americans reap the benefits of broadband. The Recovery Act requires the Plan to explore several key elements of broadband deployment and use including:

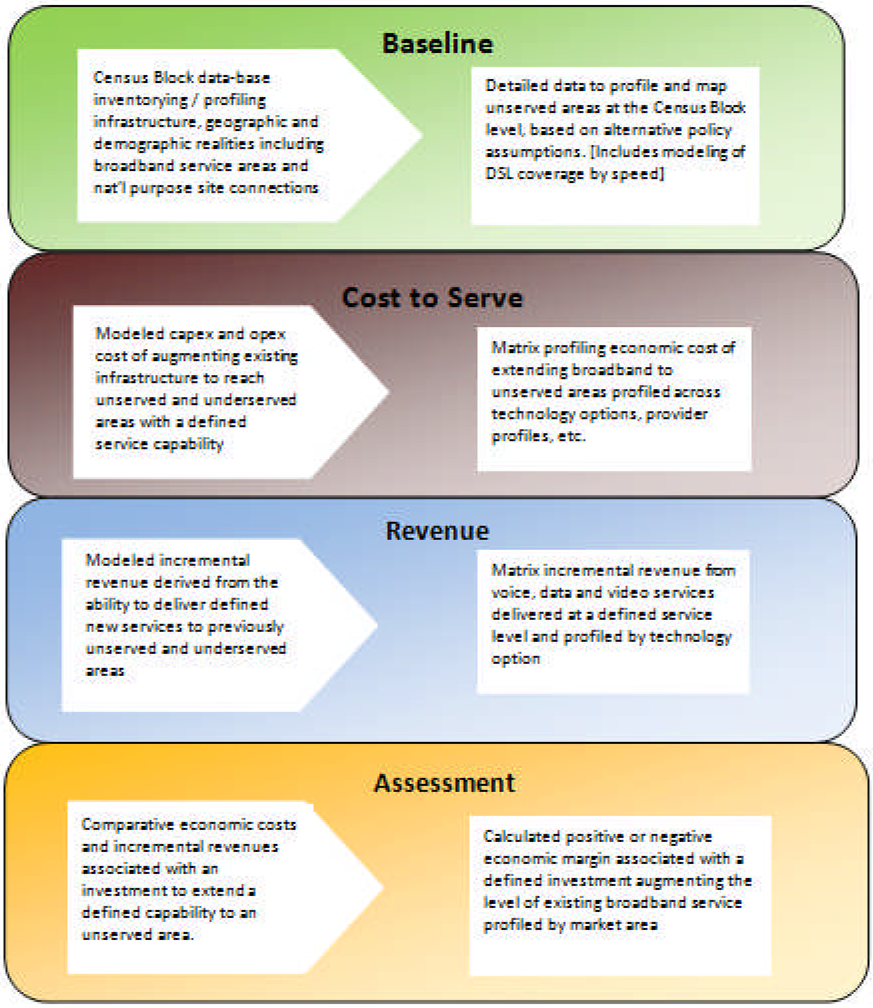
- The most effective and efficient ways (e.g., technology alternatives) to ensure broadband access is available to all Americans.
- Strategies for achieving affordability and maximum utilization of broadband infrastructure and services.
- Evaluation of the status of broadband deployment, including the progress of related grant programs.
- How to use broadband to advance consumer welfare, civic participation, public safety and homeland security, community development, health care delivery, energy independence and efficiency, education, worker training, private sector investment, entrepreneurial activity, job creation, and economic growth, and other national purposes.

As an element of their work to craft the Plan, the FCC commissioned the assembly of relevant data and the development of an economic model to (1) establish the baseline of current broadband deployment in all geographic regions of the nation and (2) determine the "forward looking" economics of supplying broadband capacity to currently unserved areas. **This material provides documentation on the resulting Broadband Assessment Model (BAM)** which was developed by CostQuest Associates (and their modeling team) under the direction of FCC staff. Consistent with the directive Statement of Work, the model is designed, built and executed at a sufficiently granular level, both geographically (e.g., at the Census Block level) and economically (e.g., to account for scale benefits and the coarseness of actual capital investment), to ensure sufficient precision of results to accurately identify incremental economic costs and incremental revenues associated with broadband augmentation within sub-state economic regions.

The primary purpose of the BAM is to support federal agency and congressional policy considerations relevant to the deployment and adoption of broadband across the nation[i]. To fulfill this purpose the model is designed to (a) approximate the size of the national broadband challenge under different scenarios of speed, degree of national coverage desired and relevant perspectives on competition and (b) develop an estimate of the financial implications (costs and revenues) associated with providing broadband to areas presently not served by adequate broadband speed and capacity required to fulfill national purposes.

High Level Overview

The BAM modeling processes are organized around four integrated modules; Baseline, Cost to Serve, Revenue, and Assessment. Associated with each module is an underlying input data set and specific model architectural design parameters that are applicable to the implementation of one or more technical estimation modules. A thumbnail sketch of each of the four "Modules" and the intended output is described below.



Module 1 – Baseline

The Baseline Modules identify and characterize broadband services by Census Block. (Census Blocks are pre-established contiguous regions comprising about 35 inhabitants on average.) Services are characterized by download speed and type of technology used. Cable and wireless broadband service data are obtained from published sources (see BAM Attachment 2). No comparable national coverage data source for wireline telecommunications (*i.e.*, xDSL) exists. Consequently, it was necessary to estimate broadband coverage availability and speed in each Census Block using statistical methods.

The statistical method employed utilized the best available data on xDSL availability for a subset of the country (the dependent variable), in combination with data that would be generically available for the entire country (the independent variables). Census Block level data on xDSL availability were obtained for Alabama, Pennsylvania and Minnesota.

Independent variables were selected by identifying variables found to be significantly related to broadband availability in published (primarily peer-reviewed) studies and by incorporating additional variables suggested by economic or statistical theory. Collectively these variables provide information about demographics, wireline infrastructure, and business activity. They are available at differing geographic levels of aggregation, including Census Blocks, Census Block groups, Census tracts, and wire centers. The Census units are nested (blocks within block groups within tracts), making it possible to relate data at one level to data at another level. However, wire center boundaries do not ordinarily conform to the Census division of geography. Therefore, the level of statistical analysis was chosen to be the *intersection* of blocks and wire centers, termed “fragments” for this work. To provide results for individual blocks, xDSL (at any given speed) is deemed available within a block if it is estimated to be available at that speed at any point within the block’s fragments.

Due to the nature of the data, the statistical modeling predicts the presence or absence of DSL at predetermined speed thresholds. The method used is logistic regression. Its output is subsequently fine-tuned to minimize the numbers of expected prediction errors. When combined with the cable (Media Prints Cable Block Group Boundaries) and wireless coverage data (American Roamer, Advanced Services), the result is a geographic profile of served and unserved Census Blocks throughout the entire nation together with numerous demographic, business and infrastructure attributes of these blocks and their surrounding areas (block groups, tracts, and wire centers).

Module 2 – Cost to Serve

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

This section of the model begins with contemporary topology-specific augmentation networks being ‘built’ (modeled using output from CostQuest’s industry recognized CostPro platform) according to real world engineering rules, constraints and key characteristics of the three modeled technologies (i.e., copper wireline, wireless and fiber). Designed network solutions were developed for contiguous unserved areas and where appropriate, these augmentation network costs are applied using allocation methods to the Census Block level. For each modeled technology several alternative topologies are built in this process (e.g., FTTn and FTTp in the telco sector, FTTp in cable, etc.) An estimated incremental capital expenditures (‘capex’) required to meet a discrete speed 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 augmentation areas are estimated for each of the three technologies – based on certain user defined criteria (e.g., company size) and based on certain census-block specific profile data (e.g., terrain, available fiber).

Module 3 – Demand and Revenues

Associated with each choice of augmentation investment is a set of corresponding incremental revenues. The third BAM element estimates incremental demand and revenues associated with data, voice and video services delivered over the modeled technology. Revenue received as a result of a network augmentation is a function of the average revenue per user (ARPU) and estimated market penetration (i.e., take rates) for broadband services. Take rates as well as potential revenues vary with customer characteristics (e.g., Income, education, or age) and the product capabilities (e.g., voice, video, data or bundled services) enabled by the technology applied. Take rates and the resulting ARPU are developed and output in the third model component at the Census Block level to correspond with the cost of service estimates developed under comparable assumptions Module 2.

Module 4 – Assessment

Outputs developed from the preceding Modules are brought together in the final model phase. In this final Module, the incremental cost of an infrastructure augmentation is rolled up (into a chosen ‘market area’) to form a total incremental cost of augmenting infrastructure to a defined speed. Each such augmentation is developed using the least cost technology available with the capability to meet the required broadband speed and product capabilities within the market area. Similarly, with corresponding assumptions of technology and market area, an estimate of total incremental revenues associated with each broadband infrastructure augmentation is developed. Costs and revenues of each market area augmentation are profiled over a user-defined period. Both the resulting cost and revenue streams are “levelized” to provide comparable fixed annual values estimated at the appropriate geographic area for defined model horizon. The resulting levelized cost compared with the levelized revenue will produce a positive or negative economic contribution margin associated with the delivery of broadband service in a currently unserved area. The economic contribution margin for a specific area can be either zero, positive or negative depending on the incremental cost of deploying the augmented network relative to the potential incremental revenues to be gained from that augmentation.

Technical Architecture

As noted in the introductory section, within each of the four broad modules there is at least one key analysis module.

Module One: Establish <u>baseline</u> view of unserved areas by Census Block:

GIS Module	…to compile and develop relevant data related to unserved areas to be used in downstream modules in determining broadband augmentation revenues and costs.
Wireline Coverage Module	…to predict xDSL broadband coverage (by speed) based on a robust statistical analysis of available xDSL data and other relevant information.

Module Two: Model network and determine <u>costs to serve</u>

Investment Module	…to develop / design a set of augmentation network topologies (and related capex costs) for each of alternative technologies (e.g., telco, wireless and cable) for the delivery of broadband to unserved areas and to allocate such costs to unserved Census Blocks.
Operational Cost Module	…to estimate operating costs (opex…and related cost drivers) for various provider types and sizes and Census Block profiles across the different technologies relevant to the provisioning of broadband in unserved areas

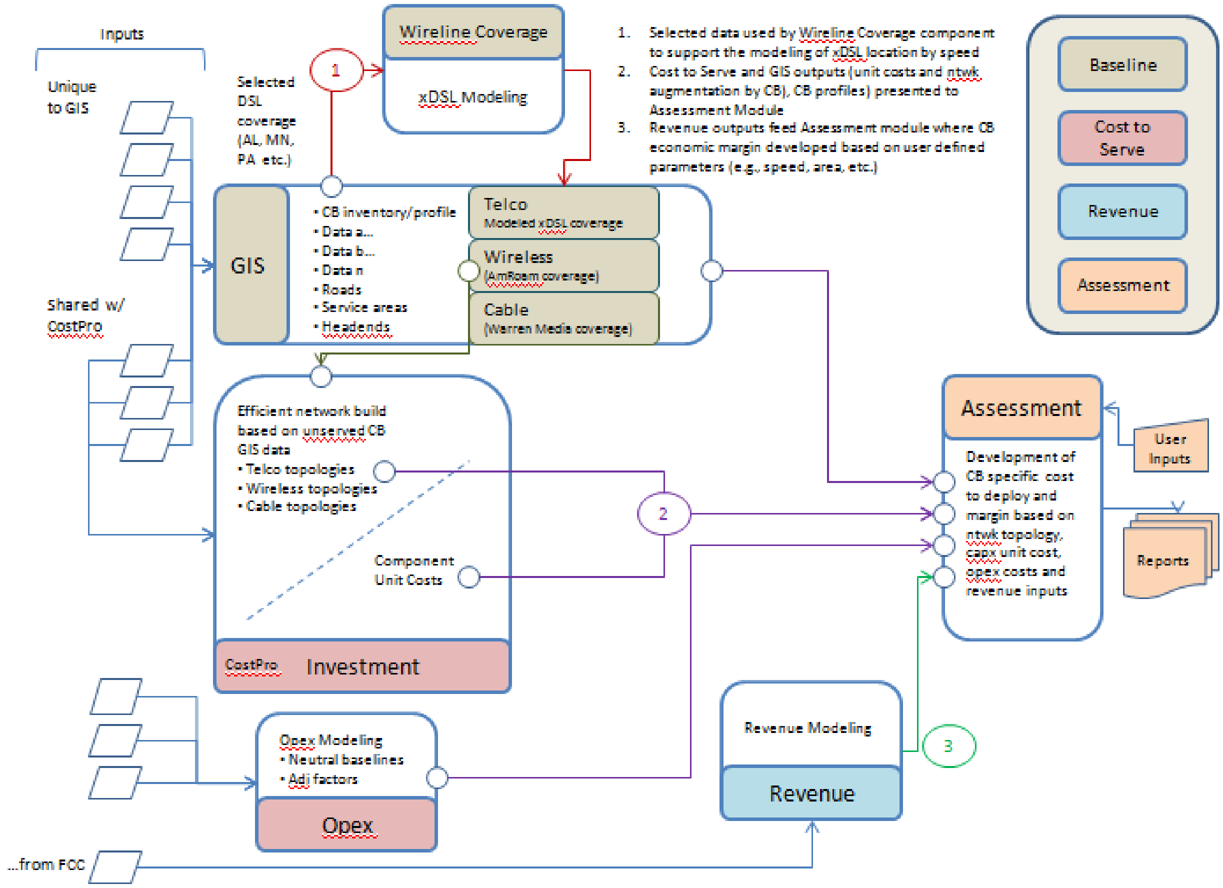
Module Three: Determine demand and <u>revenue</u>

Demand and Revenue Module	…to determine estimated demand and revenue characteristics in augmentation areas based on assumptions regarding ARPU, take rates and penetration (developed by related initiatives within the FCC)

Module Four: Develop <u>assessment</u> of economic margin

Assessment Module	…to integrate inputs from all upstream modules relevant to user electives (e.g., by technology, by size of provider, etc.) and compute an economic margin using estimates of revenue, capex and opex for broadband augmentation in unserved areas.

In terms of data flows an overview of the model is provided below. Attachment 3 provides a more detailed view of data relationships within the model. As noted earlier, see also Appendix 2 for an overview of model inputs/data sources.



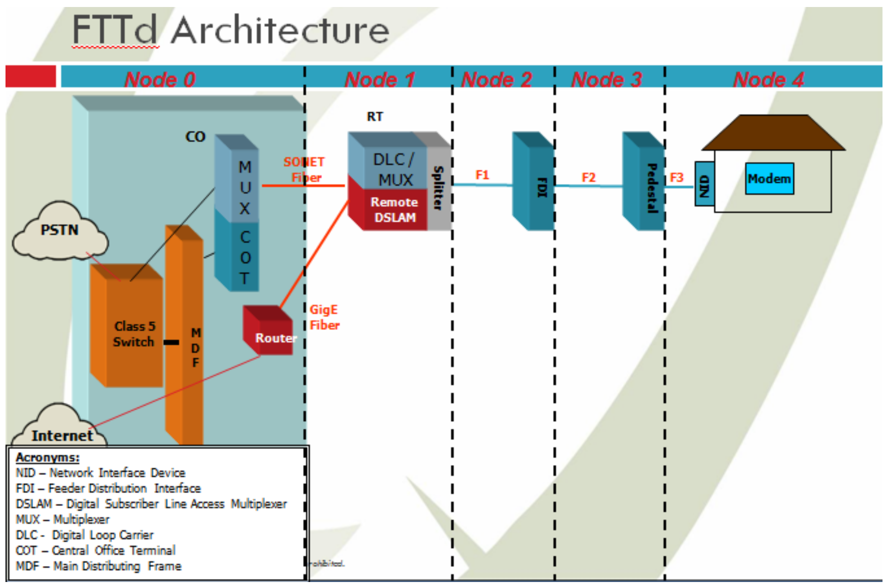
Inputs
Unique to GIS
Shared w/ CostPro
...from FCC
Selected DSL coverage (AL, MN, PA etc.)
1
Wireline Coverage
xDSL Modeling
1. Selected data used by Wireline Coverage component to support the modeling of xDSL location by speed
2. Cost to Serve and GIS outputs (unit costs and ntwk augmentation by CB), CB profiles) presented to Assessment Module
3. Revenue outputs feed Assessment module where CB economic margin developed based on user defined parameters (e.g., speed, area, etc.)
Baseline
Cost to Serve
Revenue
Assessment
GIS
• CB inventory/profile
• Data a...
• Data b...
• Data n
• Roads
• Service areas
• Headends
Telco
Modeled xDSL coverage
Wireless
(AmRoam coverage)
Cable
(Warren Media coverage)
Efficient network build based on unserved CB GIS data
• Telco topologies
• Wireless topologies
• Cable topologies
Component Unit Costs
CostPro
Investment
2
Assessment
Development of CB specific cost to deploy and margin based on ntwk topology, capx unit cost, opex costs and revenue inputs
User Inputs
Reports
Opex Modeling
• Neutral baselines
• Adj factors
Opex
Revenue Modeling
Revenue
3

Network Architectures

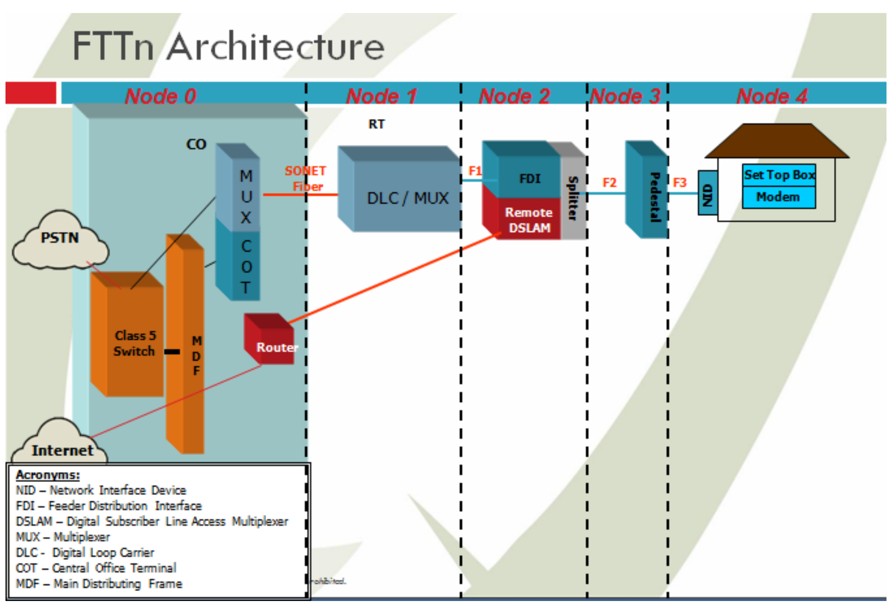
The BAM is designed to model expected outcomes in terms of broadband coverage and related financial expectations (i.e., revenue, capex, opex and economic contribution margin) for contemporary wireline, wireless or cable deployments to fill broadband gaps in unserved areas.

To understand model outputs it is crucial to understand the underlying technologies and their contemporary deployment alternatives. The schematics that follow reflect the fundamental technology architectures (topologies) assumed within the BAM. Nodes (e.g., Node 0 thru Node 4) are used to help bridge the understanding of functionality across differing technologies. The “nodes” are significant in that they represent the way in which costs are assigned / aggregated to enable neutral comparisons across technologies.

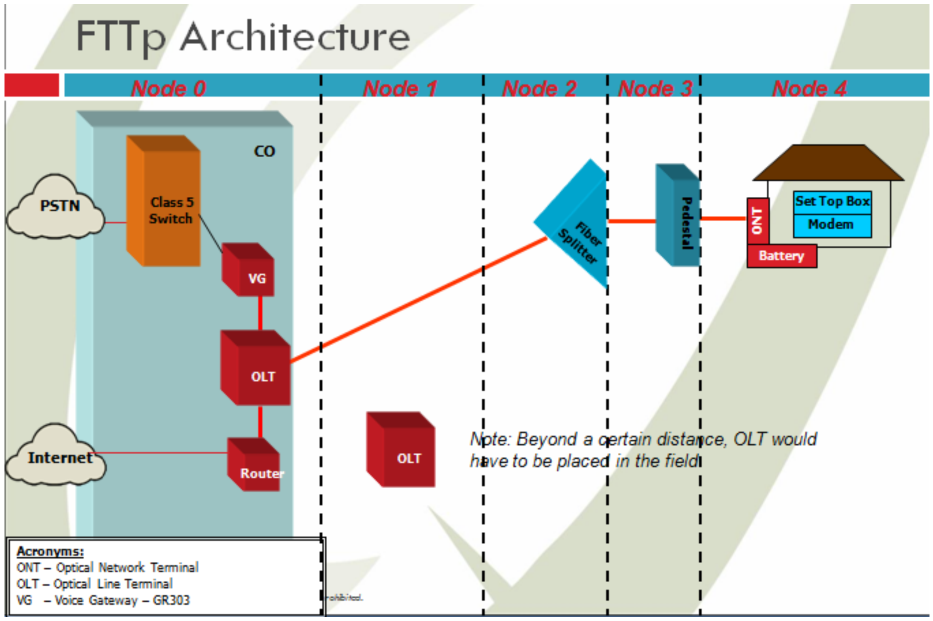
Relevant landline/telco ‘fiber to the…” alternatives include fiber to the DLC



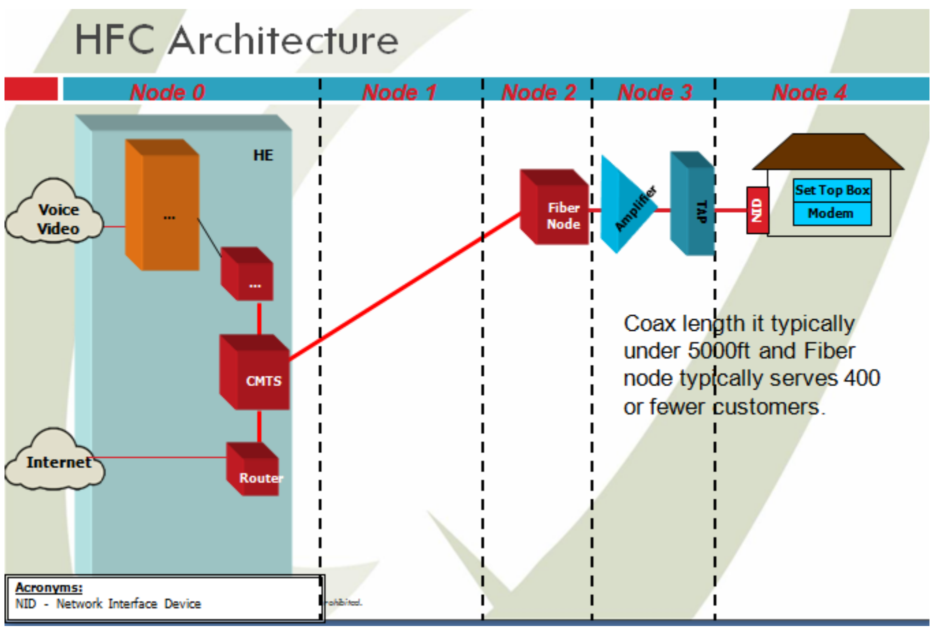
Fiber to the node



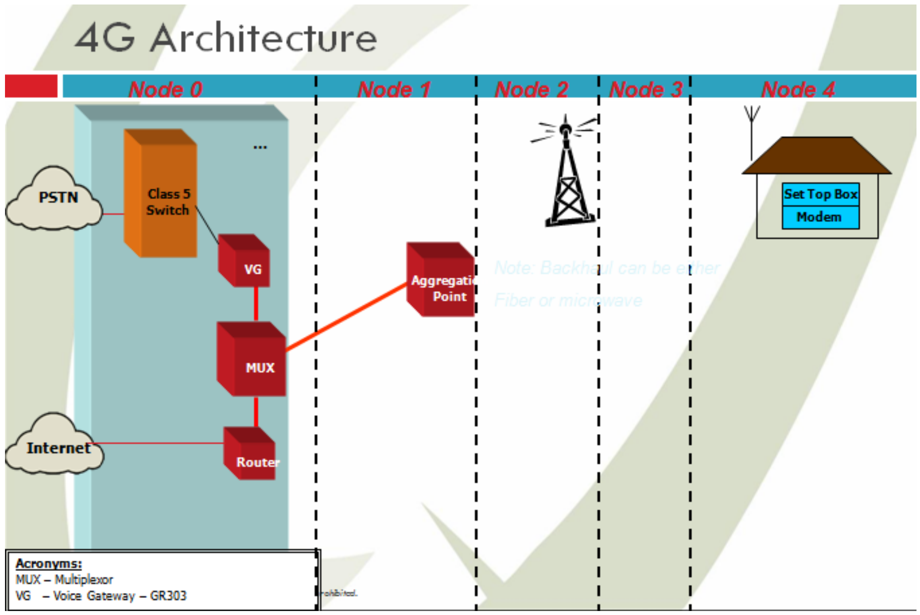
For the converged cable and telco sector, Fiber to the premises



In the cable sector the HFC architecture [future use], will be as follows:



And in the wireless / mobility sector the 4G architecture is as follows:



BAM Design and Logic

The four primary model 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.

Design Parameters

Determining the most efficient network configuration to augment infrastructure in unserved areas to achieve a designated speed requires consideration of certain design criteria (e.g., the development of specific design parameters) consistent with three broad principles:

Economically efficient forward-looking network engineering

A key principle is that the modeled augmentation network must be both cost effective and efficient and designed to achieve a desired standard of speed / reliability. Accomplishing this includes the consideration of issues such as if the build is in a *greenfield* or *brownfield* area; population density within the market area; terrain characteristics; available infrastructure in adjacent areas, size and technology-type of firm providing telecommunications as well as assumptions about the use of existing broadband capable network elements (e.g., an existing fiber node as a point to aggregate the transport of newly deployed services to a network core).

Reflective of prudent business practices

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 exist in reality. Key to this is the model's adherence to contemporary engineering practices.

Consistency with known public policy decisions

And a final important principle is that the modeling of broadband network economic costs and incremental revenues must also consider (and fit with) the foreseeable public policy and regulatory environment. For example, federal and state universal service policies can selectively influence costs (both opex and capex) 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 within anchor institutions such as schools, universities, or hospitals 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, carrier of last resort obligations, parity of access rates and so forth can influence OPEX 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 BAM model. These design parameters served to frame the modeling approach and process.

Assumptions

The logic which underlies the operation of the BAM also incorporates certain simplifying assumptions. Simplifying assumptions fall into at least two general categories:

Assumptions necessary to address data limitations

The best available data to support the development and analytical implementation of the BAM has been assembled. The data sources are documented in relevant Appendix material. However, the modeling of real world telecommunications costs and revenues is complex making it necessary to formulate and employ assumptions to accommodate data limitations. For example, both costs and revenues are projected over a user defined time period. Precise data on future costs and revenues 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.

Assumptions necessary for practical modeling

A second category of assumptions are those 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 brownfield augmentation could vary substantially across geographic areas. However, for practical modeling considerations, it is necessary to adopt assumptions on buried plant consistent with what has been generally accepted in regulatory proceedings and tested against real world data. Without assumptions of this type, the development of the BAM would be impracticable.

The more significant assumptions associated with each Module are outlined below. As an additional introduction to that Module specific discussion it is helpful to understand the underlying strengths and weaknesses/challenges within the overall model. The model assumptions make transparent limitations which should be considered in utilizing modeled outcomes. 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 at the small area (such as census tract) than will be the case for larger areas such as larger market area, the state or nation.

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. Additional insights into module-specific strengths and weaknesses are addressed in the relevant sections that follow.

Strengths
Granularity of Data • Detailed data on telecom infrastructure (by technology), factors impacting capex and opex (e.g. terrain, company size) and customer data (e.g. number of households, anchor institutions) are developed at the Census Block level providing a level of assurance that results reflect the nation's diversity. • The application of granular data within the modeling process enables users to aggregate and scale inputs/outputs to explore costs and revenues for different geographic boundaries (e.g. wire centers, counties, BEA regions, states, etc.) **Consistency with real world engineering standards** • For the terrestrial wireline technology, network inputs and the underlying logic used in the model have been tested and confirmed in numerous federal and state regulatory proceedings. • The engineered networks modeled for the wireless and cable technologies as well as cost data used for these technologies were compared with real-world company data and determined (thru validation processes) to be consistent with current practices. **Technology Neutrality** • The BAM model is inclusive of all major technologies (and related topologies) presently utilized and expected to be utilized in the near future for the delivery of relevant broadband services/speeds.
Limitations
Inconsistent and Limited Industry Data • Communications industry data for the three technologies (wireline, wireless and cable) is reported in different formats, for different overlapping geographic areas and at differing levels of detail by technology creating significant challenges in producing comparable results that are well aligned with model requirements. • Relevant benchmark company-specific data used to validate model inputs was substantially more available for wireline telecommunications companies than was the case for wireless and cable companies. **Availability of Customer Data** • National data does not exist to precisely pinpoint the location of both business and residential customers and must be estimated using a combination of secondary data sources. • Data is not readily available on the current type and volume of broadband services demanded by individual customers at the Census Block level and must be estimated using statistical methods and proxy data. **Limitations in Predicting the Future** Future uncertainties exist in both broadband technology and customer service demand creating challenges in forecasting broadband revenues and associated cost of providing services in outlying years.

Module One: Profile Census Blocks and Identify Unserved Areas

As noted above, in the initial Baseline Module of the BAM two key analysis modules (the GIS Module and the Wireline Coverage Module).

First, Census Blocks are inventoried and profiled with relevant demographic, geographic (e.g., boundaries) and communications infrastructure data. Demographic and communications infrastructure data included in the Census Block profile are selected to support downstream modeling of xDSL availability and investment / operating cost estimates. Much of the communications infrastructure data (e.g., tower locations, wire center boundaries, etc.) is shared with the Investment Model as discussed below.

Second, the model uses real-world xDSL deployment information and a series of logistic regression models to predict baseline xDSL coverage (by speed) across Census Blocks. Wireless coverage and cable coverage is developed in the GIS Module by reference to public information as outlined below.

A brief discussion of the two key processing modules in this Baseline Module is provided below:

GIS Module

Important design parameters

Important design parameters (i.e., guiding logic structure) for the GIS Module include:

	Design Parameter
1	Census Blocks are the primary unit of data collection and presentation thereby allowing for granular analysis of relevant information (e.g., infrastructure, demographic, and economic) that can then be rolled up into larger geo-political areas as desired.
2	The model must have the ability to relate Census Blocks (the default unit of measure) to wire centers and other geographic units relevant to the model logic and contemporary engineering practices.
3	Road networks are to be used as the basis to determine customer locations for purposes of understanding demand and the related costs to serve that demand. This approach best reflects where people live and how wireline networks are built.
4	National purpose sites are a targeted policy consideration for the National broadband plan and are to be included as a unique attribute of the GIS database. The baseline model view must consider the location and current broadband connection to national purpose sites across six categories (e.g., schools, libraries, healthcare sites, etc.).

Assumptions

Important assumptions for the GIS Module include:

	Assumption
1	Published data sources on wireless and cable infrastructure represent the best available baseline data at the Census Block level. As such public data sources represent a valid proxy for wireless and cable infrastructure data and resulting broadband coverage.
2	Values can be derived for data sources only available for geographic regions larger than a Census Block to be accurately attributed to individual Census Blocks within those larger geographic areas.

Scope and Purpose – GIS Module

The fundamental purpose of the GIS Module is to assemble data in an accessible form for use and analysis by other model processes (e.g., statistical estimation of wireline telecommunications (e.g., xDSL) coverage by Census Block, the separation of brownfield and greenfield scenarios, etc.). Said another way, a primary role of GIS is to develop and provide a rich dataset utilized as inputs to other modules as well as for statistical tests of assumptions and profiling of results. As noted, most GIS data are collected, uniformly attributed and/or compiled at Census Block level but are designed to be rolled up into larger geographic regions (market areas) for analysis and presentation as needed. In addition to collecting, normalizing and storing data the GIS Module derives certain data (e.g. Certain Census demographic data available for block groups is derived for the smaller Census Block geography). Beyond inventorying data required by downstream modules, a central goal of the GIS Module is to stage and/or preprocess data in a way that minimizes downstream run time within the Assessment Module.

Key data points included within the GIS Module include available state mapping data (i.e., from AL, PA, andMN). These data are utilized for various validation tests and in the Wireline Coverage Module (described below) to estimate the presence of xDSL broadband by speed. In addition, a wide array of demographic, geographic and communications related infrastructure data relative to the Census Blocks that make up the states and territories included in scope for the FCC BAM is identified and brought into the GIS Module.

Primarily GIS outputs are tabular data rendered as static maps, data tables, graphic images, text or other data formats. Outputs are generally presented in the context of state databases. GIS outputs are designed to be responsive to needs of other modules – including Wireline Coverage Module needs as it relates to the modeling of DSL coverage.

As noted above, it is within the GIS Module that broadband coverage (or the lack thereof) is determined by Census Block. Due to differences in available data, broadband coverage is determined using different methodologies for the three different technologies being modeled.

1. Cable coverage is determined by Warren Media data[ii]
2. Wireless coverage is determined by American Roamer data[iii]
3. Telco coverage is determined (i.e., modeled) within the Wireline Coverage Module (see discussion below)

Unserved Census Block profiles are provided to / shared with the Investment Module for network design modeling and the development of required augmentation investment. This information includes plant placement information, road segment information, national purpose site location information, etc.

Wireline Coverage Module

Important design parameters

Important design parameters (i.e., guiding logic structure) for the Wireline Coverage Module include:

	Design Parameter
1	Statistical prediction models incorporating geographic, demographic, company characteristics, and other observed data are to be used to create a baseline wireline speed profile by Census Block.

2	Where possible, broadband speeds are derived from wireline attenuation-*versus*-distance curves.
3	Predicted speeds from the baseline model are profiled along road networks within Census Blocks to accommodate the network modeling approach and provide comparability with cable and wireless.

Assumptions

Important assumptions for the Wireline Coverage Module include:

	Assumption
1	Historical statistical relationships do not change in the future.
2	The assumed attenuation rates, types of xDSL service, line characteristics (such as gauge and conditioning), central office and DSLAM locations, and loop lengths (as estimated from road network distances) provide accurate estimates of xDSL speed.
3	Speeds reported at the Census Block level in states used in the logistic regression (PA, MN) are accurate.
4	Statistical relationships observed in the estimation states (used to develop the prediction equations) apply across the nation without substantial change.
5	The data used for prediction, which come from many different sources, relate to different geographic units (including Census Block groups and wire centers as well as Census Blocks), and were collected at different dates, accurately reflect conditions in Census Blocks.
6	The spatial correlation of prediction errors is weak and essentially nonexistent at distances characteristic of areas where summary information is developed (such as individual states).
7	Statistical results at the sub-Census Block level are valid for the entire Census Block[iv].

Scope and Purpose – Wireline Coverage Module

Wireline telecommunications (i.e., xDSL) coverage at discrete defined speeds is determined within the Wireline Coverage Module. Attachment 4 provides a discussion and summary of the modeling techniques applied to this determination. From a modeling flow perspective, relevant data available to the Wireline Coverage Module is assembled within the GIS Module. These data include geographic characteristics, demographics, geographic composition of the population (rural, urban, clustered, etc.), race and ethnic composition, linguistic composition, income and poverty, age profile, education profile, commuting profile, composition of the business market, telecommunications provider characteristics, local broadband competition, and telecommunications infrastructure. In turn, the Wireline Coverage Module employs a logistic regression methodology to predict xDSL broadband availability at selected engineered speeds in states where this information is not available. The output is a collection of formulae, all based on a common list of independent variables existing in the GIS data base, that forecast presence of DSL service in each Census Block at speeds equal to or exceeding specified values. Predicted values are compared to an adjustable numeric threshold in order to demarcate evidence for DSL service from evidence against its presence. For each DSL speed, the threshold is set to balance the expected numbers of households with false positive and false negative predictions. In this fashion, although predicted speeds in individual Census Blocks will sometimes be incorrect, on average the predicted availability will correctly indicate how many households are served and not served.

At this point in the BAM modeling process (i.e., after the Wireline Coverage Module is processed and fed back into the GIS Module) the number of served and unserved housing units can be determined. The model has, at this point, sufficient information to determine the unserved areas in the study area based on user defined broadband requirements. The 'size of the issue' can be stated in either demographic terms (population, households, etc.) or geographic terms (specific Census Blocks and/or related market areas). This is called the Baseline view. The baseline view does not include any estimated financial implications related to the provisioning of broadband to unserved areas. The financial implications of providing service are developed in Module Two.

Module Two: Determine Cost to Serve (Opex and Capex)

In this component of the BAM modeling process, the costs to deploy (capex) and operate (opex) broadband augmentation of the baseline wireline, cable and wireless networks are developed. With respect to capex, network required augmentation investments are determined for unserved areas based on (a) broadband speed requirements defined by the user, (b) real-world engineering rules for the relevant technology being modeled (i.e., wireline wireless or cable), (c) relevant Census Block characteristics (e.g., terrain, population, etc) and (d) other user-selected options (e.g., number of competitors, National Purpose Site assumptions, etc.). With respect to opex, costs to operate augmentation networks are developed through an analysis of available operating cost information from across the three technologies (wireline, wireless and cable). Key design parameters, assumptions as well as a description of the scope and purpose of each module are described below.

Investment Module

Important design parameters

Important design parameters (i.e., guiding logic structure) for the Investment module include:

	Design Parameter
1	Contemporary / real-world wireline systems engineering standards are to be used for the modeling of augmentation networks. More specifically the use of industry standard engineering practices for landline deployments are to be used because they have been tested and confirmed against forward looking standards in a wide array of regulatory proceedings and field tests.
2	The model employs long standing capacity costing techniques to estimate economically rational augmentation investments reflecting real world engineering capacity exhaust dynamics.
3	The cost of material and equipment used to serve multiple customers will be assigned to Census Blocks based on customer locations, their distribution along networks and service demand
4	FTTn augmentation will be used, based on a deployment from known LEC COs. Unserved areas are augmented with FTTn deployment using xDSL assuming placement of DSLAMS served by fiber to deliver xDSL loop lengths of 15kft, 12kft, 5kft and 3kft from known LEC CO locations.
5	FTTp augmentation will be used in deployment from known/existing LEC COs and for currently unserved cable areas. Unserved telco areas will be augmented with FTTp deployment from known/existing LEC COs. Unserved cable areas will be built assuming all new plant placement with FTTp deployment from known/existing estimated headend locations.
6	Reflective of contemporary technology deployment activities in the industry, the model will augment fixed wireless networks at a 4G capability.
7	A grid system comprised of hexagonal tessellations (HT cells) will be used to systematically locate wireless base stations for deployment of 4G capability in augmented and unserved areas.

8	The model will associate 4G coverage sites in unserved areas with the nearest fiber point of interconnection (assumed to be a fiber equipped LEC CO) node thereby utilizing nearest existing fiber fed central offices to provide wireless backhaul.
9	The model will use a microwave and/or fiber for cost efficient backhaul associated with each wireless base station in unserved Census Blocks.
10	Consistent with contemporary engineering practices, fiber backhaul from wireless base stations is developed using a single fiber Ethernet link.
11	To recognize limitations on microwave backhaul, the model will consider factors such as customers, distance, number of hops and hub-link capacity in assessing when to deploy fiber based backhaul.
12	The model will use, to the extent possible, FTTp cable network engineering standards and logic. Further, the model is to assume DOCSIS 2 cable networks will migrate to DOCSIS 3 on the same footprint.

Assumptions

Important assumptions include:

	Assumption
1	The current (technology-specific) service provider (including the dominant wireless provider) will supply the augmentation area.
2	Smaller companies have opportunity to join purchasing agreement with other small companies reducing scale economies.
3	All costs associated with the construction of an HT cell in an unserved area will be allocated to the unserved area even when that cell that extends into an already served Census Block.
4	If an existing tower falls within the footprint of a HT cell, that HT cell will be assumed to be augmented using the existing tower as a base to deploy 4G capability.
5	A range of selectable HT Cell radii deployment scenarios will provide for attenuation performance based on demand, density and speed characteristics.

Scope and Purpose – Investment Module

The Investment Module employs a granular approach, the use of spatial analysis and a set of defined 'real world' engineering rules as the approach to modeling network design. The resulting bottom-up costing takes into account minimum transport 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 developed using a classic Capacity Costing technique include all necessary plant, structure and electronics to support the designed network. The modeled network design is also grounded in actual network infrastructure location data (where available).

Rather than rebuild the logic captured in CostQuest's industry recognized CostPro Economic Network model platform, BAM accepts as inputs key input files produced by runs of CostPro. These files include the distribution and feeder topologies of the wireline network, the wireless network, and the middle mile network. To understand the workings of these models, the reader is encouraged to read the model overviews provided in the attachments. Attachment 5 provides an overview of CostProLoop which provides the basic network topology for the wireline based broadband network.   Attachment 6 provides an overview of CostProWireless which provides the basic network topology for the wireless based broadband network. Attachment 7 provides an overview of the development of the middle mile network.

As an overview of the process and as noted above, the Investment Module is a 'spatial' model in that it estimates where customers are located and 'lays' cable and/or positions tower sites along the roads of an augmentation area. For example, a cable path can literally be traced from each customer's premises to the serving central office or headend; a path that follows the actual roads in the area. (See CostProLoop material for further information and illustrations.)

The purpose of the Investment Module is to estimate incremental deployment investment (capex) required for delivery of broadband services to unserved areas. Deployment investments are derived for each of the three alternative technologies considered (cable, telco and wireless). As summarized above, the Investment module models logical economic network augmentation costs for an existing footprint and/or an extension of network facilities where there is no current network.

The model incorporates middle mile costs as shared costs based on customer distribution across Census Blocks. Central offices or headends are assumed to be the first point of interconnection between network build for unserved areas and existing fiber transport networks (available to any carrier deploying broadband service to an unserved area). Efficient high capacity Ethernet (10GbE) routes are created to move traffic from these central offices to the location of existing access tandems. Existing access tandems are placed on a DWDM ring that incorporates access to the 'cloud' (Tier 3 Internet gateways).

Augmentation requirements (i.e., physical plant requirements) are developed for a number of topologies including but not limited to the following. See the Technology Selection options listed in the Assessment Module for a complete list.

- Telephony based wireline enhancing existing copper network infrastructure with fiber and DSL equipment to deliver broadband services (Fiber to the Node or FTTn)

- Telephony and cable based wireline enhancing existing network infrastructure or building new network infrastructure with fiber to deliver broadband services (Fiber to the Premise or FTTp)

- 3G based wireless enhancing existing network infrastructure or building new network infrastructure with 4G LTE to deliver broadband services.

- Wireless building new network infrastructure with 4G to deliver broadband services

The Investment Module uses these and other deployment scenarios as the basis for a logical economic network augmentation (existing network footprint) or extension (where no network footprint exists) given the technical parameters for each deployment. The BAM refers to this in terms of a greenfield or brownfield deployment scenario.

From a more specific capex (network costing perspective) the greenfield vs. brownfield differences are illustrated below.

- In a wireless brownfield augmentation existing towers are used while in a greenfield augmentation there is a full site setup.

- In a telco brownfield augmentation the fiber to the DSLAM and fiber are incremented while in a greenfield augmentation the copper distribution, the NID, and the Drop are all considered new deployment.

It is important to note that when augmentation is noted, the model assumes that certain assets are available for use. Key assumptions for augmentation include:

- For wireline service in existing served areas, distribution copper is assumed to exist and is available for FTTn and FTTd builds

- For all brownfield builds, poles and conduit are assumed to exist and can be used by the augmentation provider. BAM does not assign additional cost for conduit / pole attachments. The same for middle mile.

- For 4g builds, if towers and/or coverage exist in an area, the model assumes the tower can be used. Operationally, if the tower exists, the model includes a lease payment as an expense.

Similarly, the network module design parameters impact the Census Block specific predictive accuracy as outlined below. However it is important to note that variances in accuracy at the Census Block level will tend to be mitigated as the model is applied to larger aggregations of unserved area Census Blocks (e.g., in to market areas). Examples of investment module design logic intended to improve the accuracy of Capex estimates at the small region level include, but are not limited to:

- Terrain: The network module is sensitive to terrain characteristics faced in wireline construction via the use of a variable factor based on predicted (not actual) topology.

- Density: The network module is sensitive to aggregate density of a Census Block through multiple factors including user quantity driven wireline costs, bandwidth driven demand for wireless (cell splitting), and scaled backhaul (second and middle mile) costs based on aggregated demand in a given serving area.

Validation of Data and Outputs

Validation of investment module inputs and outputs considered the following:

- The robustness of input structure to adequately reflect differences in factors such as terrain, density of customer locations, size of serving company, presence of existing infrastructure, and other factors.
- The alignment of capex with published company information about expenditures, parsed by different technologies and company sizes.
- The consistency of model logic and input structure with major policy and regulatory principles such as infrastructure sharing, interconnection requirements, obligation to serve, spectrum access, universal service and so forth.

- The reasonableness of predicted investment values for specific technologies and differing geographic and market circumstances.

The process of validating input structure and model logic for wireline telecommunications investments was somewhat simplified as much of the underlying CostPro information had already been developed and tested in multiple states and subject to expert cross-examination in adjudicated regulatory proceedings. For wireless and cable broadband network models it was necessary to rely more on confidential industry data available and expert knowledge.

The validation process considered the extent of model input structures and logic adequately captured disparity of capex investment associated with differing terrain, customer density, provider characteristics and other factors. Data and statistical modules developed in the Baseline Module provided the foundation for this validation process. The extensive GIS data base assembled through the Baseline Module provided a detailed profile of unique regional characteristics for every Census Block in the 50 States and District of Columbia.. To the extent possible, the regionally specific variables identified as having an important impact on investment were included as specific variables within the capex investment module.

The predicted capex investment outputs were reviewed at a granular level to test whether the electronic sizing was appropriate and the fiber distance logical for selected areas to ensure the predicted capex investment falls within expectations. Additionally, a broader set of largely qualitative validation tests were utilized to ensure both inputs and output for the investment module fell within a reasonable range. For terrestrial wireline telecommunications, these tests were primary based on other cost model work. For the wireless and cable technologies, the reasonableness tests were accomplished through comparisons with independent industry data and reliance on expert opinions from the FCC.

The outputs of the Investment Module are captured in CostPro tables loaded into the CostPro database in BAM.

Opex Module

The Opex Module pairs with the Investment Module to estimate relevant incremental cost associated with a network augmentation.

Important design parameters

Important design parameters (i.e., guiding logic structure) for the Opex module include:

	Design Parameter
1	To derive valid baseline opex drivers the model will use a regression equation approach grounded in publicly available industry information.
2	The model will accommodate diversity of costs across technologies, company size, terrain and other operational praxis by the determination of distinct opex adjustment factors.
3	Opex will be modeled through a set of cost drivers to approximate impact of technology, company size/type and location.

Assumptions

The modeling of all opex costs requires certain assumptions – all of which must be considered with an eye to how they might impact the predictive value of results. Key assumptions in the modeling of opex costs include the following.

	Assumption
1	Industry reported financial data is reasonably accurate and sufficiently segregated to develop opex cost drivers to model opex costs at appropriate geographic granular levels.
2	Opex factors predominantly based on historic financial data for served areas provide a reasonable base from which to derive opex for unserved areas.
3	Historic financial data comprising a mix of technological generations can be adjusted to reasonably predict the opex implications of deploying new technology.
4	Validation of varying types of expense detail against sufficient industry or company specific data will produce acceptable variance metrics.

Scope and Purpose – Opex Module

The Opex module is designed to estimate operating costs for three specific provider types (i.e. Telco, Wireless, and Cable) by size (i.e. Large, Medium, and Small) and by density (i.e. Demographic, Geographic, and Terrain) to apply to Census Block profiles for the purposes of provisioning broadband in un-served areas and with consideration for coverage requirements defined by a set of user assumptions and augmentation investments.

To provide estimated operating costs for augmentation areas for each provider type noted above, relevant provider data available within the public domain was gathered and analyzed to develop a set of three neutral baseline cost profiles for each provider type and a corresponding set of factors or cost functions designed to adjust the baseline views by provider size and density. The opex cost profiles are presented within a hierarchy of costs referred to as the CostFACE. From the highest level in the hierarchy down the components of the CostFACE are as follows:

F – Cost FAMILY (e.g., Network vs. Customer Operations vs. G&A)
A – Cost AREA (e.g., Plant Specific vs. Plant Non-Specific)
C – Cost CENTER (e.g., Cable & Wire vs. Circuit Equipment vs. Switching)
E – Cost ELEMENT (e.g., Copper Aerial vs. Fiber Aerial vs. Copper Buried vs. Fiber Buried)

The purpose of the CostFACE is to help organize and align costs with relevant cost drivers (e.g., associated capex investment, revenue, etc.). See Attachment 3 for the primary CostFACE tables.

The model output is rendered in a set of static tables (e.g., CostFACE tables) made available to the BAM assessment module for purposes of computing operating costs. The types of opex cost drivers vary by technology type, as illustrated in the table below (e.g., telco cost drivers include investment based drivers, revenue based drivers and subscriber based drivers).

Technology Type	Investment Drivers		Customer Drivers	
	"Site"	Investment	Revenue	Subscriber
Telco		X	X	X
Wireless	X		X	
Cable		X	X	X

The steps in this process vary by provider type; however, are summarized generally below:

- Research & gather Opex data;
- Segment data to uniform expense lines;
- Analyze data;
- Identify appropriate BAM Opex cost drivers based on best "available" data;
- Develop baseline Opex detail;
- Develop factors for size and density adjustments;
- Develop location adjustments for labor and property taxes; and,
- Validate and revalidation of results.

While the process noted above provides results within an acceptable range for the designed purpose of the module, consideration was given to certain assumptions made and existing limitations that constrained an absolute predictability of the Opex module as summarized in the Assumptions section above. In addition to the fundamental assumptions outlined above, the modeling process and resulting outputs confirmed that (a) varying formats and expense detail levels of publically available financial data can be reconciled to provide neutral detail, (b) the compilation of publically available information can be analyzed using regression equations supported with industry information to derive a valid baseline opex detail and (c) the resulting neutral baseline expense detail can be presented in the context of a set of BAM cost drivers to approximate reasonable estimates of operating expenses for a selected provider type, size and density.

The utility of available data sources is an important factor in the modeling of opex costs. The core opex cost development strategy is grounded in the opex challenge: there is simply no existing readily available source for the detailed opex cost information preferred for the BAM (e.g., cost by technology by detailed operating cost category, by geographic area, by density, etc., and aligned with accessible cost drivers). Rather there are a limited number of relevant data points found across an array of information sources (some public and some private). The opex challenge is to derive useful *information* out of the available *data*.

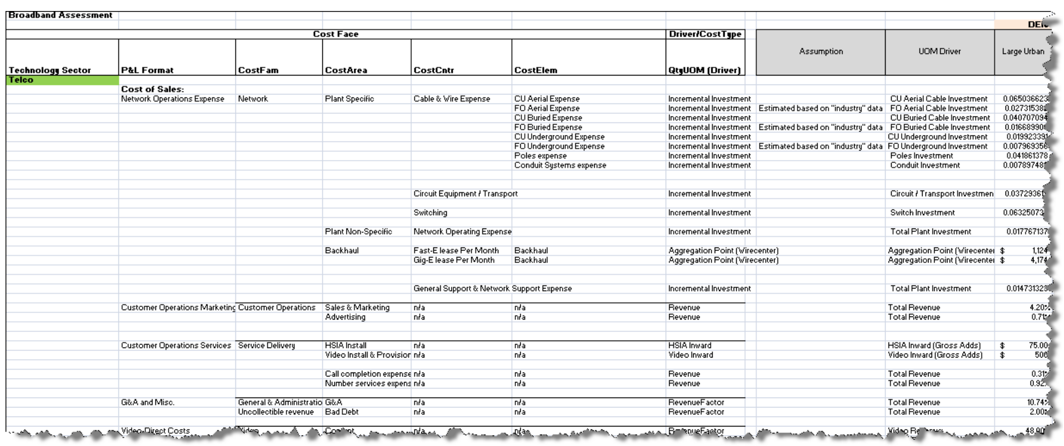
Attachment 8 provides a complete inventory of opex input sources and process. These sources are publicly available through free media or by subscription and are the primary sources from which the Opex data was derived, analyzed, and tested.

Given that certain assumptions were made and limitations existed as noted above, the strengths and limitations for the results varied by provider type depending on the data available for analysis. As a supplement to the earlier discussion on this topic, specific strengths and weaknesses relative to the modeling of opex costs are outlined below.

Strengths
• Telco & Wireless – inputs sufficiently granular / network investment specific • Initial test results indicate opex factors are reasonable • Appropriately captures technological differences within each technology modeled • Results are scalable • Results adjust for penetration differences • Results reflects locational operating differences • Telco and cable information is density specific.
Limitations
• Cable - limited detailed network expense data necessary to determine opex adjustments (e.g., size, variable vs. fixed, etc.) • Cable – limited detailed expense data and/or publically available research to model required broad assumptions to be made to determine opex break-out / drivers • Cable & Wireless – limited data to validate opex with statistical analysis to test predictability. Used other methods to test reasonableness • Lack of Specific – company / industry participation in the opex review / validation

<u>Telco</u>

Similar to the steps outlined above, Telco Opex data was mined from researching the publicly available sources of information noted above and analyzed to develop factors using the Cost Face format illustrated here.



Broadband Assessment									DE
Cost Face						Driver/CostType			
Technology Sector	P&L Format	CostFam	CostArea	CostCntr	CostElem	QtyUOM (Driver)	Assumption	UOM Driver	Large Urban
Telco									
	Cost of Sales:								
	Network Operations Expense	Network	Plant Specific	Cable & Wire Expense	CU Aerial Expense	Incremental Investment		CU Aerial Cable Investment	0.065036623
					FO Aerial Expense	Incremental Investment	Estimated based on "industry" data	FO Aerial Cable Investment	0.02731538
					CU Buried Expense	Incremental Investment		CU Buried Cable Investment	0.04070709
					FO Buried Expense	Incremental Investment	Estimated based on "industry" data	FO Buried Cable Investment	0.01668990
					CU Underground Expense	Incremental Investment		CU Underground Investment	0.01992339
					FO Underground Expense	Incremental Investment	Estimated based on "industry" data	FO Underground Investment	0.00796935
					Poles expense	Incremental Investment		Poles Investment	0.041861378
					Conduit Systems expense	Incremental Investment		Conduit Investment	0.00789748
				Circuit Equipment / Transport		Incremental Investment		Circuit / Transport Investmen	0.03729361
				Switching		Incremental Investment		Switch Investment	0.06325073
			Plant Non-Specific	Network Operating Expense		Incremental Investment		Total Plant Investment	0.017767137
			Backhaul	Fast-E lease Per Month	Backhaul	Aggregation Point (Wirecenter)		Aggregation Point (Wirecente	$ 1,124
				Gig-E lease Per Month	Backhaul	Aggregation Point (Wirecenter)		Aggregation Point (Wirecente	$ 4,174
				General Support & Network Support Expense		Incremental Investment		Total Plant Investment	0.014731323
	Customer Operations Marketing	Customer Operations	Sales & Marketing	n/a	n/a	Revenue		Total Revenue	4.20%
			Advertising	n/a	n/a	Revenue		Total Revenue	0.71
	Customer Operations Services	Service Delivery	HSIA Install	n/a	n/a	HSIA Inward		HSIA Inward (Gross Adds)	$ 75.00
			Video Install & Provision	n/a	n/a	Video Inward		Video Inward (Gross Adds)	$ 500
			Call completion expense	n/a	n/a	Revenue		Total Revenue	0.31
			Number services expens	n/a	n/a	Revenue		Total Revenue	0.92
	G&A and Misc.	General & Administratio	G&A	n/a	n/a	RevenueFactor		Total Revenue	10.74%
		Uncollectible revenue	Bad Debt	n/a	n/a	RevenueFactor		Total Revenue	2.00
	Video Direct Costs	[illegible]	[illegible]	n/a	n/a	[illegible]		[illegible]	48.90

Specifically, 9 years of NECA data was compiled in a readily available and sufficiently segmented format. Regression analysis was then used to determine the relationship between capital spend on assets and ongoing costs required to maintain the plant. A random sample covered 758 unique rows of data across 86 companies. The NECA data reported Total Plant in Service (TPIS) amounts for these companies across Switch, CO Transmission, Circuit Equipment, and Cable & Wire accounts. The TPIS dollars were adjusted to account for today's dollars in a Replacement Cost New approach (i.e., using current prices for comparable functionality). This data was further categorized with a size variable by classifying the parent company as either small (less than 1M lines nationwide), medium (between 1-10M lines nationwide), or large (greater than 10M lines nationwide). A rural classification was added by layering in the results of a CostQuest 2003 study of rural costs by company. The cable and wire accounts were broken out into Aerial Cable, Buried Cable, Conduit, Poles, and Underground Cable using industry data percentages of distribution plant. Then, the data was unitized on a per-household basis to improve the accuracy of the regression analysis.

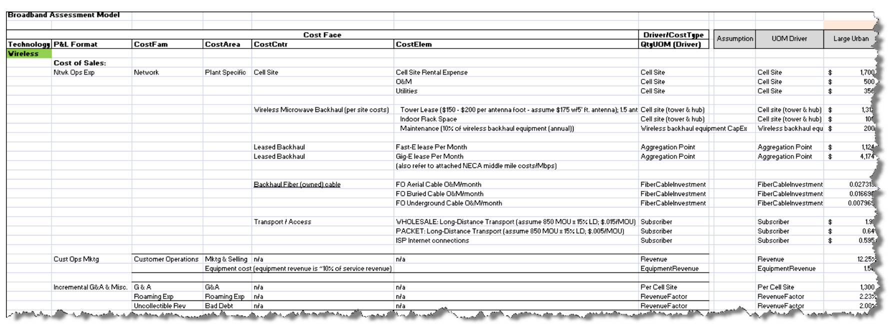
Using the variables previously described, stepwise regression analysis was performed to arrive at multivariate equations for each of the 8 expense accounts below. The table here shows the analysis of variance (ANOVA) results for each regression. The significance level of this analysis in summation is reasonable to an 80% significance level on the basis of the largest p-value observed (1 – 0.2096 = 0.7904).

Telco Expense Account	Multiple R	P Value	Maximum P Value of Explained Variables
Switch	0.6135	< 0.0001	0.0125
CO Transmission	0.5945	< 0.0001	0.0002
Gen & NW Support	0.3474	< 0.0001	0.0168
Network Ops	0.3602	< 0.0001	0.0371
Aerial Cable	0.3973	< 0.0001	0.2096
Buried Cable	0.3973	< 0.0001	0.2096
Conduit	0.3973	< 0.0001	0.2096
Poles	0.3973	< 0.0001	0.2096
Underground Cable	0.3973	< 0.0001	0.2096

From this 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.

<u>Wireless</u>

Similar to the general steps outlined above, Wireless Opex data was mined from publicly available sources of information (e.g., 10K's), SNL Kegan, Yankee Group, and data provided by the FCC's National Broadband Task Force. In addition to this information, we relied upon industry reports such as CTIA, S&P Market Insight, Telecommunications Industry Association ("TIA"), Pioneer and Hatteras. This information was then analyzed to develop opex factors organized in the CostFACE format illustrated here.



Broadband Assessment Model

Technology	P&L Format	CostFam	CostArea	CostCntr	CostElem	Driver/CostType QtyUOM (Driver)	Assumption	UOM Driver	Large Urban
Wireless									
	Cost of Sales:								
	Ntwk Ops Exp	Network	Plant Specific	Cell Site	Cell Site Rental Expense	Cell Site		Cell Site	$ 1,700
					O&M	Cell Site		Cell Site	$ 500
					Utilities	Cell Site		Cell Site	$ 350
				Wireless Microwave Backhaul (per site costs)	Tower Lease ($150 - $200 per antenna foot - assume $175 w/5' ft. antenna); 1.5 ant	Cell site (tower & hub)		Cell site (tower & hub)	$ 1,31
					Indoor Rack Space	Cell site (tower & hub)		Cell site (tower & hub)	$ 10
					Maintenance (10% of wireless backhaul equipment (annual))	Wireless backhaul equipment CapEx		Wireless backhaul equ	$ 200
				Leased Backhaul	Fast-E lease Per Month	Aggregation Point		Aggregation Point	$ 1,124
				Leased Backhaul	Gig-E lease Per Month	Aggregation Point		Aggregation Point	$ 4,174
					(also refer to attached NECA middle mile costs/Mbps)				
				Backhaul Fiber (owned) cable	FO Aerial Cable O&M/month	FiberCableInvestment		FiberCableInvestment	0.02731
					FO Buried Cable O&M/month	FiberCableInvestment		FiberCableInvestment	0.01669
					FO Underground Cable O&M/month	FiberCableInvestment		FiberCableInvestment	0.00796
				Transport / Access	WHOLESALE: Long-Distance Transport (assume 850 MOU x 15% LD; $.015/MOU)	Subscriber		Subscriber	$ 1.9
					PACKET: Long-Distance Transport (assume 850 MOU x 15% LD; $.005/MOU)	Subscriber		Subscriber	$ 0.64
					ISP Internet connections	Subscriber		Subscriber	$ 0.595
	Cust Ops Mktg	Customer Operations	Mktg & Selling	n/a	n/a	Revenue		Revenue	12.25%
			Equipment cost (equipment revenue is ~10% of service revenue)			EquipmentRevenue		EquipmentRevenue	1.5
	Incremental G&A & Misc.	G & A	G&A	n/a	n/a	Per Cell Site		Per Cell Site	1,300
		Roaming Exp	Roaming Exp	n/a	n/a	RevenueFactor		RevenueFactor	2.23%
		Uncollectible Rev	Bad Debt	n/a	n/a	RevenueFactor		RevenueFactor	2.00%

Below is a general overview by the BAM Cost Element of the process used to develop the wireless opex base cost:

1. **<u>Ground Lease Opex</u> -** The first direct expense factor listed in the Broadband Assessment Model is ground lease expenses. The ground lease opex is based on tower operating cost data provided by the FCC, Crown Castle data reviewed, and other related data. From these sources we derived the monthly ground lease opex per cell site by density area.

2. **<u>Tower Space Lease Opex</u> -** Similar to above, tower space lease costs were derived using data provided by the FCC, Crown Castle data, and other publically available data. When analyzing the data we determined that an average monthly tower lease rate of $1,700 was reasonable. We then adjusted this average rate

to account for differences in density resulting in tower lease rates per cell site of $2,100 for urban; $1,750 for suburban and $1.300 for rural.

3. **Operations & Engineering** - Operations and engineering monthly costs of $370 per cell site was a combination of RAN maintenance, technology and engineering expenses provided by the FCC. Additionally, a monthly utilities expense of $350 per cell site was based on data provided by the FCC and other industry data reviewed.

4. **Core Equipment Opex** - The core equipment operating and maintenance opex was calculated using information provided by the FCC. Based on this information, we determined that the core operating expenses and maintenance opex could be reasonably estimated by taking 8% of the estimated core equipment costs. This figure was then divided by the total cell sites to reach an estimated core equipment monthly operating and maintenance opex.

5. **Microwave Backhaul Opex** - Monthly co-location tower lease costs for the first antenna was determined to be $650 per cell site based on industry data and information provided by the FCC. The co-location tower monthly lease cost for each additional antenna is $543 per cell site. The monthly maintenance opex of $75 per cell site was based on industry information and data provided by the FCC.

6. **Microwave Backhaul Opex (Cell-Split Sites)** - Monthly tower lease microwave backhaul expenses for cell-split sites were also developed. The cost to attach the first antenna at a split microwave cell site was determined to be $250 per month per cell site. The opex to attach each additional antenna at a split microwave cell site was calculated by taking one-half of the aforementioned cost of $250 per month (e.g., $125) and multiplying it by an adjustment factor of 1.67 under the assumption of a 3-hop daisy chain configuration. This resulted in monthly opex for each additional antenna at a split microwave cell site of $209 per cell site. The maintenance factor of $75 per cell site was not changed under this method.

7. **Leased Backhaul Expense -** We relied on data from the National Exchange Carrier Association's ("NECA") Middle Mile Cost Study, Hatteras Network's The Complete Executive's Handbook on Ethernet Backhaul, Visiant Strategies, Inc.'s US Mobile Backhaul 2010 Study, other industry information & research, and information provided by the FCC to estimate the leased backhaul opex. Based on this information, we estimated monthly backhaul costs For Fast-E (100 Mbps) of $1,124 for urban areas, $1,653 for suburban areas, and $2,880 for rural areas; For Gig-E (1,000 Mbps),backhaul lease opex per month were estimated to be $4,174 for urban areas, $6,158 for suburban areas, and $10,720 for rural areas

8. **Company-Owned Backhaul Opex -** Company-owned backhaul operating costs were based on the BAM Telco regression model discussed earlier in this report.

9. **Transport & Access Opex -** Transport and access expenses were segregated into three components: wholesale, packet, and ISP interconnection cost per subscriber. To estimate the wholesale cost per subscriber we started with the estimated average subscriber minutes of use at 850. We then assumed that 15% of all calls are long distance. This combined with the industry assumption of $0.15 per minute of use for wholesale cost gave us the necessary components to estimate the final wholesale cost per subscriber. The final estimated wholesale cost per subscriber was $1.91 or 850 * 15% * $0.15. The packet cost per subscriber was estimated using a similar methodology. The industry assumption for packet cost per minute of use is $0.05 thus the estimated packet expense cost per subscriber is $0.64 or 850 * 15% *

$0.05. Finally, the ISP interconnection rate per subscriber was estimated using the $0.0007 per minute of use as regulated by the FCC, we adjusted this to $0.001, and $0.0015 per minute of use for suburban and rural density areas respectively. We then multiplied these rates by the average minutes of use per subscriber of 850. Thus our final ISP interconnection cost per subscriber for urban areas was $0.595 or 850 * $0.0007; for suburban $0.850 or $0.001 * 850; and for rural $1.275 or $0.0015 * 850.

10. **Marketing & Selling Opex -** We relied primarily on publically provided data aggregated by Yankee Research Group ("Yankee") to estimate the monthly marketing and selling operating opex. Based on this data, we calculated an overall marketing expense as a percentage of service revenue of 19 percent. To then estimate the incremental marketing & selling opex, we calculated the marginal marketing & selling cost per customer and compared this to the average marketing cost per customer. Dividing the marginal marketing cost per customer by the average marketing cost per customer resulting is an incremental marketing opex scaling factor. Applying the opex scaling factors to our original marketing expense per service revenue factor of 19% results in an incremental marketing & selling opex of 12.25%.

11. **Wireless Equipment Opex** – The wireless equipment cost opex was based on data from publically available financial data aggregated by Yankee Research Group.. We calculated equipment opex as a percentage of equipment revenue for the years 2004 through 2008. We then determined that the wireless equipment opex can be reasonably estimated based on a factor of 1.5 multiplied by the equipment revenue.

12. **Roaming Opex -** Roaming opex was estimated using CITA's 2008 Wireless Industry indices as released on May of 2009. Based on a regression analysis of the roaming revenue expense as compared to the service revenue, we determined roaming opex could be reasonable estimated based on a factor of 2.23% of service revenues.

13. **General & Administrative Expense –** To estimate the incremental general & administrative (G&A) opex, we ran three regression analyses on industry data to determine a reasonable methodology for predicting G&A opex. We looked at the correlation of G&A expenses as compared to revenue, customers and network PPE. Based on the results of our regression analysis, we concluded a monthly G&A incremental opex could be estimated using $2.84 per incremental subscriber.

14. **Bad Debt Expense -**A bad debt factor of 2% of total revenue was derived from looking at industry specific 10K's and from the use of industry knowledge.

These Factors were then applied to a sample of wireless companies' cost drivers to determine the reasonableness of the model. Results on our validation, given publically available data in aggregated at an entity level, indicated the direct cost element variances were +/- 10%. Using the above data, a baseline view was extracted from the data based on the cost drivers noted in the CostFACE format illustrated above and factors were derived to adjust for size, density, location, and property taxes.

Cable

Similar to the general steps outlined above, Cable Opex data was mined from researching the publicly available sources of information noted above and analyzed to develop factors using the CostFACE format illustrated here.

Broadband Assessment

Cost Face						Driver/CostType			
Technology Sector	P&L Format	CostFam	CostArea	CostCntr	CostElem	QtyUOM (Driver)	Assumption	UOM Driver	Industry
Cable									
	Cost of Sales:								
	Direct Costs:	Network	Plant Specific		Direct costs of video services	Average per video subscriber		Average per video subscriber	
					Direct costs of data services	Average per data subscriber		Average per data subscriber	
					Direct costs of voice services	Average per voice subscriber		Average per voice subscriber	
					Direct costs of other services	Avg. per data & voice subscriber		Avg. per data & voice subscriber	$ 41.59
	Cust Ops Mktg	Customer Operations	Cust Svcs Exp	n/a	n/a	Percent of total revenue		Percent of total revenue	5.50%
			Marketing			Percent of total revenue		Percent of total revenue	5.01%
			Video/Data Install & Provisioning			Gross Add		Gross Add	$ 305
		Uncollectable revenue	Bad Debt			Percent of total revenue		Percent of total revenue	3.00%
			Franchise Fee & PEG			Percent of video revenue		Percent of video revenue	6.00%
		Facilities O&M / Misc	Facilities O&M and misc	n/a	n/a	Incremental investment		Incremental investment	5.33%

Specifically, publically available financial data for nine Cable companies was compiled. Five of these companies where chosen to represent the "large" cable providers and the remaining four where chosen to represent the "small" cable providers. A list of the companies and their size classification is displayed in the table to the right:

Company	Size
Cablevision Systems Corporation	Large
Charter Communications	Large
Comcast Corporation	Large
Mediacom Communications	Large
Time Warner Cable	Large
Grande Communications	Small
RCN Corporation	Small
General Communications	Small
Knology, Inc.	Small

The publically available financial data for the listed companies was aggregated using the SNL Kagan operating income statement format as well as notes from the companies 10K's for the calendar years 2004-2009. The financial statement format provided a high-level segmentation of the companies' revenues and operating costs. The operating costs were further delineated through the use of "Opex Factors" developed from data reported in the company's 10K's.

In addition to the opex factors, a two-part SG&A factor was developed. For the variable expenses such as customer service, marketing and bad debt a factor was derived that uses the companies' total revenue as a driver. For the fixed expenses under SG&A a factor driven by the companies' total PP&E was created. A separate regression analysis was performed to determine the correlation between the companies' SG&A fixed costs and it's PP&E for the "large" and "small" categories. The regression analysis for the "large" companies returned an R-Squared of 0.87 and a factor of 2.73%. The regression analysis for the "small" companies returned an R-Squared of 0.76.

The accuracy of the "Opex Factors" and the "SG&A Factors" was then tested by applying the factors to company specific cost drivers for the years 2006-2008. When applying these factors to the cost drivers of the nine company sample, the results of the model varied only 1 percent from those actually reported by the companies for the year 2008. These factors were then applied to the "large" and "small" companies separately. The large companies returned a variance of 0.8 percent from the actual operating expenses while the small companies returned a variance of 6.5 percent from the actual reported operating expenses. Smaller companies produced a larger variance due to the widely varying operating expenses inherent to the difference in size of operation and lack of economies of scale. The 2008 results, as well as those for years 2006 and 2007 are displayed in the table below:

CABLE COMPANIES
OPEX SUMMARY - TEST RESULTS

INDUSTRY	2008 (ACTUAL)	2008 (EST)	2007 (ACTUAL)	2007 (EST)	2006 (ACTUAL)	2006 (EST)
REVENUE (ACTUAL)	$ 68,497,225	$ 68,497,225	$ 62,331,016	$ 62,331,016	$ 50,787,709	$ 50,787,709
OPEX	$ 43,480,156	$ 43,045,831	$ 39,781,732	$ 39,253,051	$ 32,660,972	$ 32,588,428
COE MARGIN	$ 25,017,069	$ 25,451,394	$ 22,549,284	$ 23,077,965	$ 18,126,737	$ 18,199,281
	36.5%	37.2%	36.2%	37.0%	35.7%	35.8%
OPEX EST VARIANCE AS A % OF ACTUAL		-1.0%		-1.3%		-0.2%
LARGE COMPANIES	2008 (ACTUAL)	2008 (EST)	2007 (ACTUAL)	2007 (EST)	2006 (ACTUAL)	2006 (EST)
REVENUE (ACTUAL)	$ 66,567,010	$ 66,567,010	$ 60,629,856	$ 60,629,856	$ 49,275,893	$ 49,275,893
OPEX	$ 42,067,871	$ 41,725,071	$ 38,493,507	$ 39,253,051	$ 31,503,118	$ 31,578,888
COE MARGIN	$ 24,499,139	$ 24,841,939	$ 22,136,349	$ 21,376,805	$ 17,772,775	$ 17,697,005
	36.8%	37.3%	36.5%	35.3%	36.1%	35.9%
OPEX EST VARIANCE AS A % OF ACTUAL		-0.8%		2.0%		0.2%
SMALL COMPANIES	2008 (ACTUAL)	2008 (EST)	2007 (ACTUAL)	2007 (EST)	2006 (ACTUAL)	2006 (EST)
REVENUE (ACTUAL)	$ 1,930,215	$ 1,930,215	$ 1,701,160	$ 1,701,160	$ 1,511,816	$ 1,511,816
OPEX	$ 1,412,285	$ 1,320,760	$ 1,288,225	$ 1,276,822	$ 1,157,854	$ 1,009,540
COE MARGIN	$ 517,930	$ 609,455	$ 412,935	$ 424,338	$ 353,962	$ 502,276
	26.8%	31.6%	24.3%	24.9%	23.4%	33.2%
OPEX EST VARIANCE AS A % OF ACTUAL		-6.5%		-0.9%		-12.8%

From this data a baseline view was extracted from the data based on the cost drivers noted in the CostFACE format illustrated above and factors were derived to adjust for size, density, location, and property taxes.

The output of the Opex module is capture in the Opex input table into BAM. Please refer to the contents of that table for the current values used.

Module Three: Determine Demand and Revenue

The FCC revenue team provided leadership for the development of the third Module. Specifically the team utilized available industry data to create an estimate of Average Revenue Per Unit (ARPU) associated with services enabled for each of the specific technology options considered in the BAM. Statistically estimated take rates applied to known business and residential customer counts in each Census Block were used to estimate the number of customers in each Census Block that would take services across the following service array.

Voice	Data	Video	Bundle
	High	High	High
	Low	Low	Low

Combining estimated take rates with the technology specific ARPU table produces an estimate of revenue by Census Block – differentiated by technology-specific broadband service options. This section provides a description of the design parameters, assumptions as well as the scope and purpose of this third Module.

Important design parameters

Important design parameters (i.e., guiding logic structure) for the Revenue module include:

	Design Parameter
1	The model must reflect incremental revenues associated with a broadband augmentation consistent with market results that can realistically be obtained for each specific technology option. For example, in an existing telecom provider's service area, voice revenue is NOT incremental to the deployment of broadband service. As such, the revenue for telco service is assumed to be 0.
2	The model must reflect impact of competition by way of a factor which can be applied to appropriately allocate total potential take rate among the competing providers and reduce the overall ARPU as a result of competition.
3	Model revenue is to be grounded in an ARPU that is determined based on estimated revenues from voice, video and data services attributable to each specific technology.
4	Model revenue is tied to the broadband technology being deployed. As such, incremental video revenue is NOT available from all technologies.

Assumptions

	Assumption
1	Take rates vary with the socio-economic dynamics at the Census Block level as impacted by factors such as population density, typical service available by technology, provider company size and other factors associated with consumer demand.
2	The Average Revenue Per Unit by product type will remain constant into the future.
3	The historical observed formulae of take rates as modeled using historical data can serve as a basis to accurately predict take rates in the future.

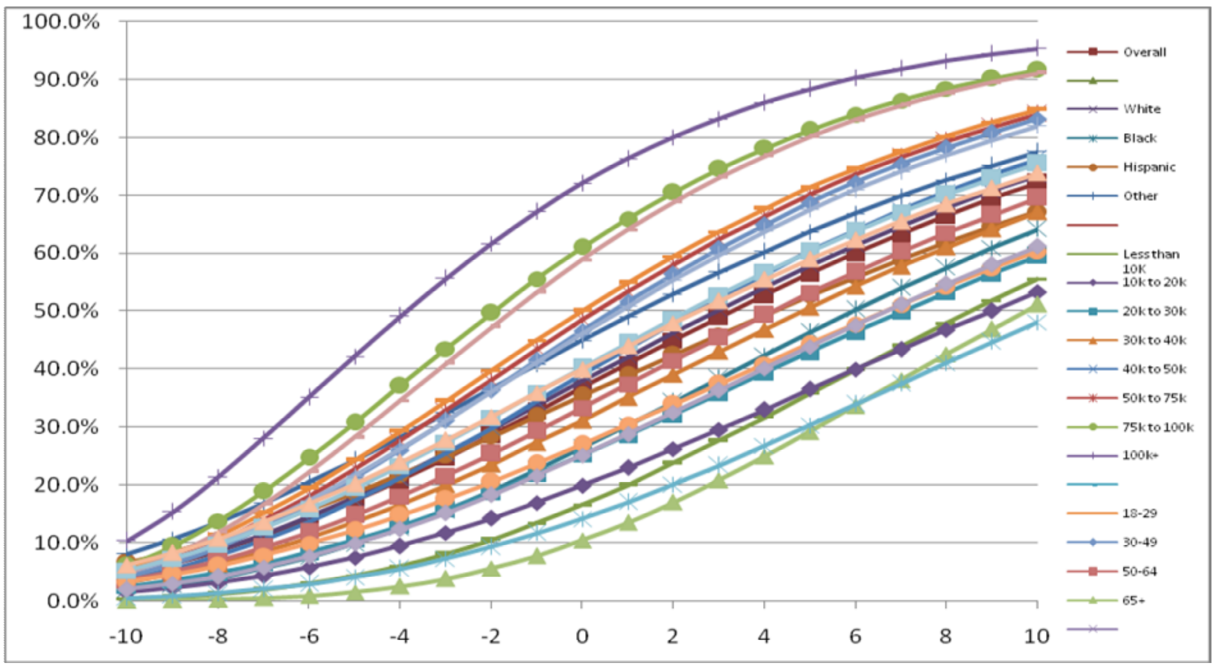
Scope and Purpose – Demand and Revenue Module

A primary purpose of the Demand and Revenue Module is to develop granular Census Block level revenue data as an input to the BAM Assessment Module. Specifically, associated with each infrastructure augmentation scenario in unserved areas is corresponding incremental revenue. Incremental revenues are received from voice, data and video services and differentiated by technology. Further differentiation is provided based on brownfield versus greenfield augmentation considerations. The following broadband technology options were considered:

Type of Augmentation	Services Creating Incremental Revenues
Telco/Brownfield FTTn 3kft; FTTn 5kft;	Data, video
Telco/Brownfield FTTd 12kft	Data only
Telco/Greenfield FTTp	VoIP, data, video
Cable/Brownfield DOCSIS 3 upgrade	Data, VoIP
Cable/Greenfield FTTp	Data, VoIP, Video
Fixed Wireless Brownfield	Data
Fixed Wireless Greenfield	Data, VoIP
Mobile Wireless Greenfield (4G)	Data, VoIP

As noted above, the FCC revenue team used confidential industry data to create a benchmark ARPU table by broadband delivery technology for different demand scenarios including voice as well as for data, video and bundled offerings assuming either a high or low usage.

US Census data was used to identify the number of potential broadband residential customers in each Census Block and GeoResults business counts by Census Block was used to estimate the number of potential business customers in each Census Block. To derive revenue estimates by Census Block, it was necessary to estimate market penetration for each type of broadband service by Census Block. Time series data (2001 – 2009) developed through the Pew Internet & American Life Project document a consistent relationship between factors such as race, income, age, education level as well as rural versus non-rural location as key factors associated with broadband take rates. These time series data developed through periodic surveys conducted by the Pew Internet & American Life Project were utilized within a standard ordinary least squares regression estimation to fit a Gompertz curve for selected demographic factors known to be associated with broadband adoption.



A weighted statistical aggregation developed for the resulting Gompertz coefficients provides a raw market penetration estimate for each Census Block. For purposes of developing incremental revenue, these raw take rates are adjusted to reflect the BAM technology options noted above (voice, data, video, bundled; high or low volume; greenfield or brownfield).

Applying the FCC ARPU estimates to this table of take rates (by technology) provides input to the Assessment Module. Specifically, the Revenue Module provides the capability to estimate incremental revenues for each selected BAM technology option projected over a period of years into the future with expanding take rates capture through the shape of the Gompertz curve. The user has the ability to shift (move forward or back) the Gompertz Curve inflection point to represent different views of product maturity. Attachment 9 provides a more detailed overview of the Gompertz take rate derivations.

User Inputs

Before we discuss the last module – Develop Financial Assessment, it is helpful to first discuss the user inputs that drive the assessment. As noted above, BAM captures the Baseline, Investment, Opex, Demand, and Revenue attributes in the model. However, all key inputs to and/or from these modules are captured or controlled by user input tables. At run time, the user then assembles the appropriate inputs into an "Input Collection" that then guides the processing of BAM.

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

- Current broadband coverage developed by the Baseline module is captured in the CBMaster database
- The various network topologies as produced by CostPro are captured in the Costpro databases (one for each state). These topologies 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
    - Middle Mile
- The Gompertz take rate curves are captured in the Gompertz database. There are various curves depending on the discount rate that is assumed (impacts the levelization of the take rate data)

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

- ACF:
    - Supplied by CostQuest
    - This table captures the Annual Charge Factors that covert Investment into its monthly costs. The current values loaded into BAM are produced by CostQuest's CapCost model. This model has been used in the BCPM (universal service model) and by various telecom 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, including: Gompertz-Makem survival curves, Equal Life Group methods, inclusion of future net salvage, Impact of deferred taxes, mid-year conventions, etc.
        - Key inputs into the derivation are: lives of plant, assumed tax lives, survival curve shapes, cost of money, and cost of debt, debt/equity split, and future net salvage.
        - Currently assumes the same base inputs used in the universal service efforts from the late 1990s
            - Uses 11.25% Cost of Money
            - Uses Depreciation lives prescribed by the FCC in the latest general depreciation order
    - Used to convert Investment into monthly values of Depreciation (DEPR), Cost of Money (COM), and Income Taxes (TAX)

- ARPU:
    - Supplied by the FCC
    - Provides the average revenue per user data by product, by technology, by level of competition for residential customers
    - Used to develop the total revenue within a census block

- Bandwidth:
    - Supplied by the FCC
    - Provides the busy hour bandwidth by product, by technology
    - Used to size the appropriate network components

- BundleBreakdown
    - Supplied by the FCC
    - Provides the approximate revenue breakdown by products components of a bundle
    - Used in the Opex derivation for costs driven by specific revenue items.

- BusinessTakeAndARPU
    - Supplied by the FCC
    - Provides the take rate and ARPU for business customers by SIC classification and company employee size
    - Used in derive the demand and revenue for the business market.

- Capex
    - Supplied by the FCC
    - Provides the material and installation costs for the plant build.
        - Data is 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 in derive the total Capex

- Conversion
    - Supplied by CostQuest
    - Provides inputs to help drive the logic in processing
        - SHOULD NOT BE MODIFIED BY USER WITHOUT DIRECTION FROM CostQuest
    - Used in simplify and control SQL logic in code.

- COSizeAdjustment
    - Supplied by…currently defaulted to 1s
    - Provides the user the capability to adjust the assumed purchasing power of small, medium and large providers
        - Currently, 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 in adjust up or down the Capex costs in the model.

- GrossAdds
    - Supplied by CostQuest
        - Sourced from external reports and experiences with clients
    - Provides the estimated churn capturing impact of level of competition
    - Used in drive customer acquisition costs that may be called out in the Opex inputs.

- Multiplier
    - Supplied by CostQuest
    - Provides inputs to help drive the logic in processing
        - SHOULD NOT BE MODIFIED BY USER WITHOUT DIRECTION FROM CostQuest
    - Used in simplify and control SQL logic in code

- Opex
    - Supplied by CostQuest
        - Discussed in the Opex Module above and sourced in Appendix 8
    - Provides the estimated operation costs to run and maintain a broadband network, by technology type, by company size, by density, by function
    - Used in develop the operation costs

- PlantMix
    - Supplied by CostQuest
        - Sourced from the FCC's HCPM model inputs
    - Provides the estimated mix of cable by type: aerial, buried and underground
        - With an augmentation build has less impact – more significant impact for greenfield builds
    - Used in drive determine the type of cable required to serve a census block.

- PTax
    - Supplied by CostQuest
        - 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 in capture the impact of property tax in the operation costs

- RegionalCostAdjustment
    - Supplied by CostQuest
        - 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 in drive differences in CAPEX and OPEX costs due to labor and material costs differences across the country.
        - Applied to All CAPEX and specific OPEX components

- StateSalesTax
    - Supplied by CostQuest
        - Defaulted to 5% in each state
    - Provides the sales tax rate in each state
    - Used in CAPEX derivation – applied to material costs only

- TakeRate
    - Supplied by CostQuest
        - Source in the Gompertz Appendix
    - Provides the scaling factor for the adoption of the various produces based upon the overall data take rate provided by the Gompertz equation for each census block
    - Used in determine the take rate by product by census block

Module Four: Develop Financial Assessment

Module four utilizes results from the previous three Modules along with the user provided inputs to create an analytical modeling framework to calculate the "economic contribution margin" associated with alternative user-defined scenarios for broadband infrastructure deployment to unserved areas. The Assessment Module considers only incremental costs and revenues. For example, in most cases, there is already copper-wire, fiber, or cable or wireless "last mile" connection to the home. Consequently, the incremental typically applies primarily to upgrades of the second and middle-mile portions of the network that enable the delivery and transmittal of broadband speeds to or from the home. Similar, for homes that already have voice telephone service, an incremental xDSL investment will only produce incremental revenues for data and potentially video services. Similarly, a cable system upgrade would generally only produce incremental revenues for data or voice service, but not video. The economic contribution margin derived from the Assessment Module is defined as the difference between estimated incremental revenues and incremental costs associated with a broadband augmentation within an unserved area.

Important design parameters

Important design parameters (i.e., guiding logic structure) for the Financial Assessment module include:

	Design Parameter
1	The assessment module will provide the flexibility for users to explore alternative broadband network designs such as choice of technology; delivered bandwidth speed; degree of competition; greenfield versus brownfield build option; or number of study years.
2	The economic cost and revenue data will be calculated at the Census Block level with the ability to roll the data up into relevant policy regions such as BEA regions, Counties, State boundaries.
3	The Assessment Module will identify the least cost technology option available to fulfill user specified augmentation scenarios for each defined area.

4	Economic contribution margins will be calculated using a levelized value of costs and revenues.

Assumptions

	Assumption
1	The capex and opex costs of a network augmentation can be accurately forecasted into the future for a defined market area, based on model parameters developed through historical data.
2	Incremental revenues associated with a network augmentation can be accurately forecasted into the future for a defined market area based on model parameters developed through historical data.
3	The product offerings (video, data, voice or bundled) that can be delivered by modeled technologies will remain substantially the same over the forecasted future.
4	The modeled market areas will be large enough to mitigate any impediments to accurate modeling of costs and revenues that may result from limitations in granular data availability.

Scope and Purpose – Assessment Module

The primary purpose of the BAM Assessment Module is to support the development of the National Broadband Plan with objective data to examine and compare the economic contribution margin associated with alternative technology/revenue scenarios achieved through broadband augmentation within defined "unserved areas". With this purpose in mind, the Assessment Module incorporates a number of user defined options to facilitate investigation and comparison of alternative policy options and the ability to test the implications of different market structure assumptions. In addition to the selection of a state/territory to process, the user defined options include the following:

- **Targeted broadband speed** – a discrete range of speeds including .784 Kbs, 1.5 mbs, 3 mbs, 6mbs , 10 mbs, 25mbs and 100 mbps

- **Technology selection** – alternative technology build options (for the initial model release) include:
  - Cable_Fiber_FTTp_5k
  - Telco_Copper_FTTn_3k
  - Telco_Copper_FTTn_5k
  - Telco_Copper_FTTd_12k
  - Telco_Copper_FTTd_15k
  - Telco_Fiber_FTTp_5k
  - An array of Fixed Wireless topologies that capture differences in max serving area radii, use of microwave backhaul and the various limitations on it.
  - National Purpose dedicated Fiber

- **Number of competitors** – specify a discrete range of competitors including 0, 1, 2 or 3 competitors

- **Greenfield or brownfield build** – option to select a CLEC "greenfield" build of broadband infrastructure into an unserved area.

- **Market penetration rate** – option to change rate of customer broadband technology adoption as represented by the Gompertz curve use in incremental revenue calculations.

- **Study period** – the time frame (ranging from 5 to 30 years in five year increments) over which revenues and costs are normalized.

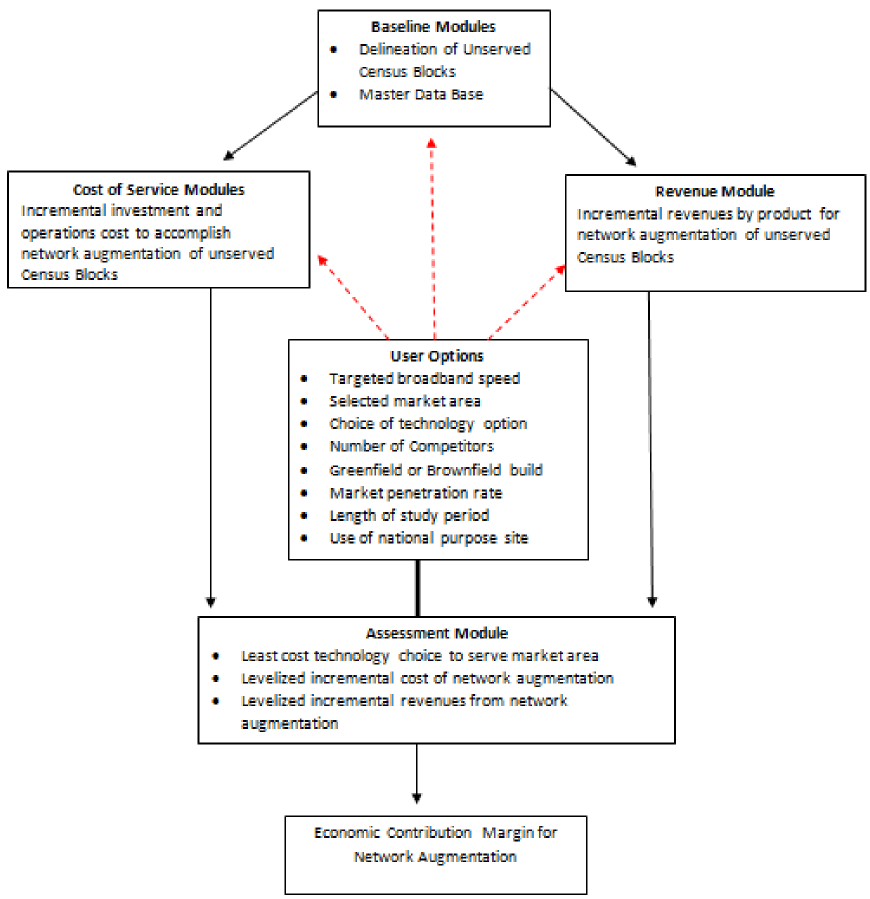
- **Middle Mile Adjustment** – option to raise or lower the modeled cost for the middle mile network.

- **Fixed Wireless Capex Adjustment**– option to raise or lower the modeled capex to incorporate outside assumptions.

- **Fixed Wireless Opex Adjustment**– option to raise or lower the modeled Opex to incorporate outside assumptions.

The Assessment Module calculation of economic contribution margin is driven by each of these user defined choices. Associated with each broadband augmentation scenario consistent with user defined choices is a set of technology deployment costs (capex and capex) and revenues obtained through calculations accomplished through modeling algorithms described in the previous three Modules.

Because the baseline data is assembled at the Census Block level, the BAM user has substantial flexibility to aggregate Census Block into their preferred geographic region of most relevance (e.g. BEA region, County or state). Utilizing outputs from the Module two (capex and opex), the Assessment module identifies and selects the least cost technology option that fulfills desired broadband speed and service capability outcomes. Associated with this least cost option is an estimated revenue stream derived from the third Module.



Initial capital investments, operations expenses and the associated incremental revenues resulting from a network augmentation occur over a period of years (with the number of years and rate of market penetration defined by the user). In general, the longer the forecast period the greater the uncertainty and chance of errors in estimating incremental costs and revenues.

To calculate the economic contribution margin, it is necessary to reduce both cost and revenue streams that occur over a defined period of years into a single comparable value. For this purpose, the BAM adopts the "levelization" method consistent with that used in regulatory decisions regarding the pricing of Unbundled Network Elements, and indeed consistent with incremental cost calculations in the telecommunications industry over the past 25 years. The levelization method applies a fixed discount rate to calculate the Present Value (PV) of both costs and revenues over a defined time period and converts the present value of both costs and revenues into an annual (or monthly) fixed annuity. Consistent with prior FCC decisions a discount rate of 11.25% is used in the levelization of costs and revenues for the FCC BAM.

The following chart illustrates the levelization principle for a simple case example. In this simple illustration, the levelized combined capital and operating costs are assumed to be $7,000 per year with revenues of a fixed $100 per customer. Annual revenues grow proportionally with the number of customers. These values are converted to a fixed annual annuitized value and levelized contribution margin. The sum of the levelized contribution margins over 20 years is identical to the difference between the 20 year Net Present Value of costs and revenues.

Year	Cust. Count	Revenue ($100 per Cust)	Costs - CAPEX and OPEX)	Margin	Annuitized / Levelized Revenue	Annuitized / Levelized Cost	Levelized Contribution Margin
1	30	$ 3,000	$ 7,000	$ (4,000)	$ 6,453	$ 7,000	$ (547)
2	50	$ 5,000	$ 7,000	$ (2,000)	$ 6,453	$ 7,000	$ (547)
3	60	$ 6,000	$ 7,000	$ (1,000)	$ 6,453	$ 7,000	$ (547)
4	65	$ 6,500	$ 7,000	$ (500)	$ 6,453	$ 7,000	$ (547)
5	70	$ 7,000	$ 7,000	$ -	$ 6,453	$ 7,000	$ (547)
6	73	$ 7,300	$ 7,000	$ 300	$ 6,453	$ 7,000	$ (547)
7	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
8	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
9	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
10	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
11	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
12	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
13	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
14	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
15	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
16	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
17	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
18	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
19	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
20	75	$ 7,500	$ 7,000	$ 500	$ 6,453	$ 7,000	$ (547)
20 Year PV		**$50,556**	**$54,844**	**($4,289)**			**($4,289)**

Within the Assessment Module Levelized costs are compared with levelized revenues to derive the estimated economic contribution margin relevant to augmenting broadband infrastructure to a defined capability within chosen geographic regions. Economic contribution margins for given region can be either positive or negative. A value of 0 for contribution margin indicates that the project covers all economic costs, including operational costs, depreciation, cost of money (return on debt and equity) and income taxes.

Related Material

The attachments are designed to provide additional insight into / background for some of the more involved model components, inputs and outputs

Attachment 1	Glossary
Attachment 2	Data Sources and Model Application Summary
Attachment 3	Model Data Relationships
Attachment 4	Statistical Model Overview
Attachment 5	CostProLoop Overview
Attachment 6	CostProWireless Overview
Attachment 7	Middle Mile Approach
Attachment 8	Opex Input Sources
Attachment 9	Gompertz Curve Methodology
Attachment 10	BAM User Manual

[i] Territories in the initial BAM include the 50 states and District of Columbia. Over time (as data becomes available) the scope will expand to include the states plus six territories.

[ii] Provide Media Prints coverage by Census Block Group, acquired September 2009. <http://www.mediaprints.com/>

[iii] American Roamer advanced coverage, acquired September 2009, <http://www.americanroamer.com/coverageright_marketright_packages.php>

[iv] Especially in circumstances where Census Blocks are large a sub-Census block (fragment) prediction does lead to overstated results. This points to the need for household/business level information to calculate better speed and investment estimates.

