Federal Communications Commission

Broadband Assessment Model

(BAM)

Model Documentation

[Provided by CostQuest Associates, updated March 2010]

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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.

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- 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.

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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.

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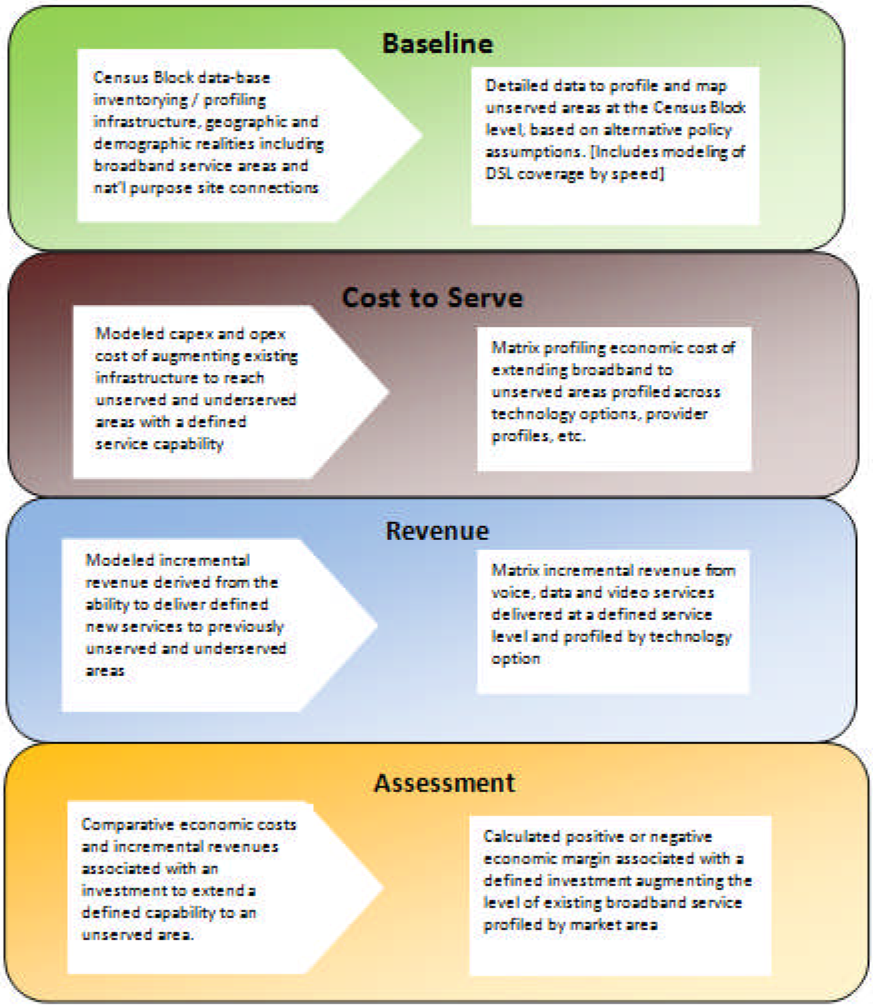
High Level Overview

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.

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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

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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.

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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.

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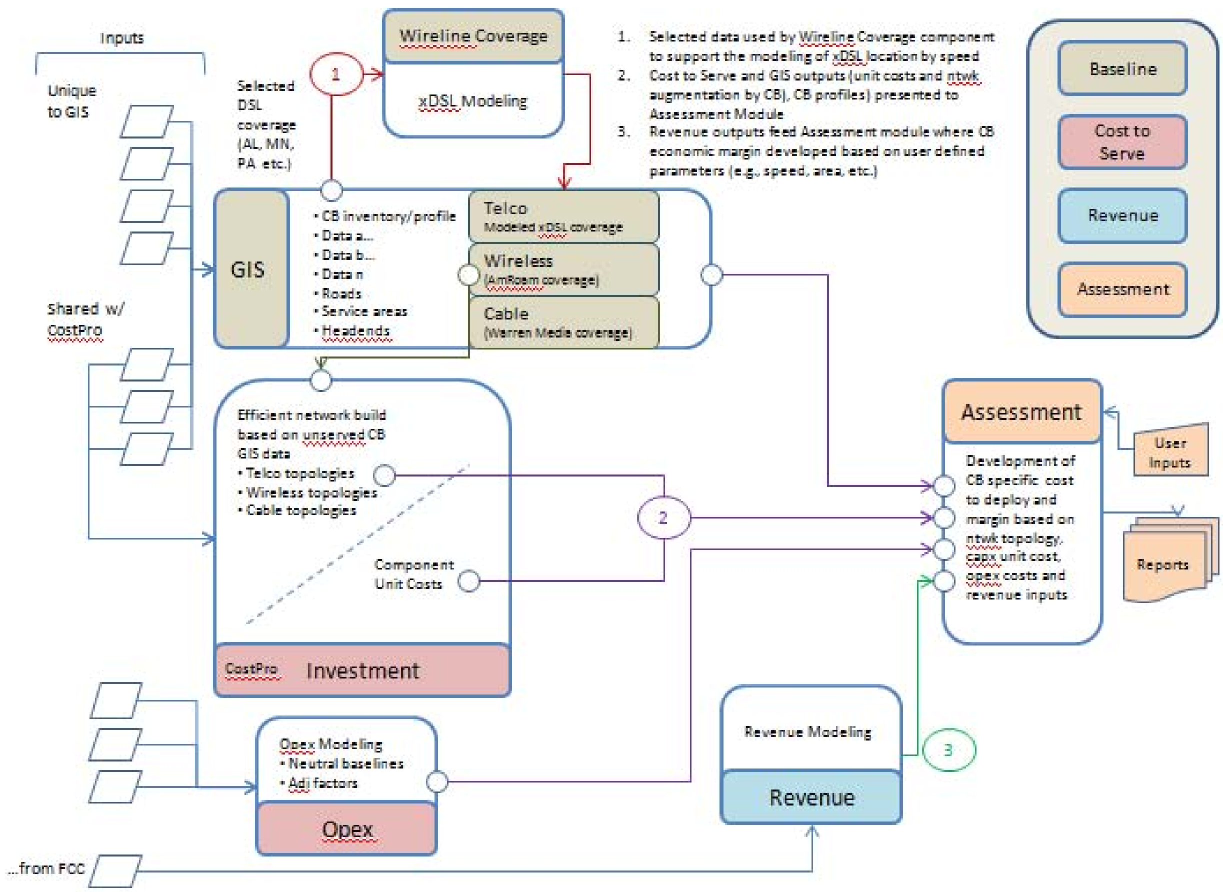

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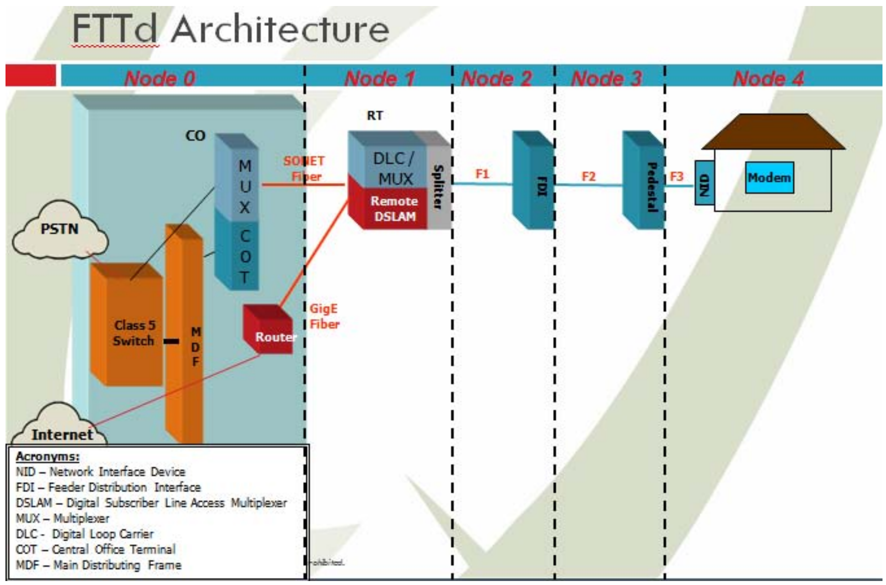
Network Architectures

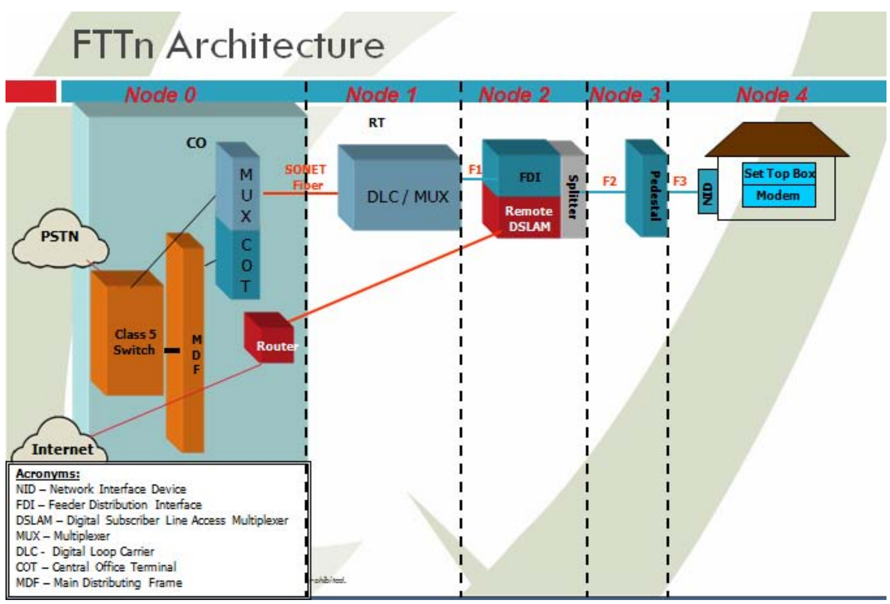
The BAM is designed to model expected outcomes in terms of broadband coverage and related financial expectations (i.e., revenue, capex, opex and economic contribution margin) for contemporary wireline, wireless or cable deployments to fill broadband gaps in unserved areas.

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



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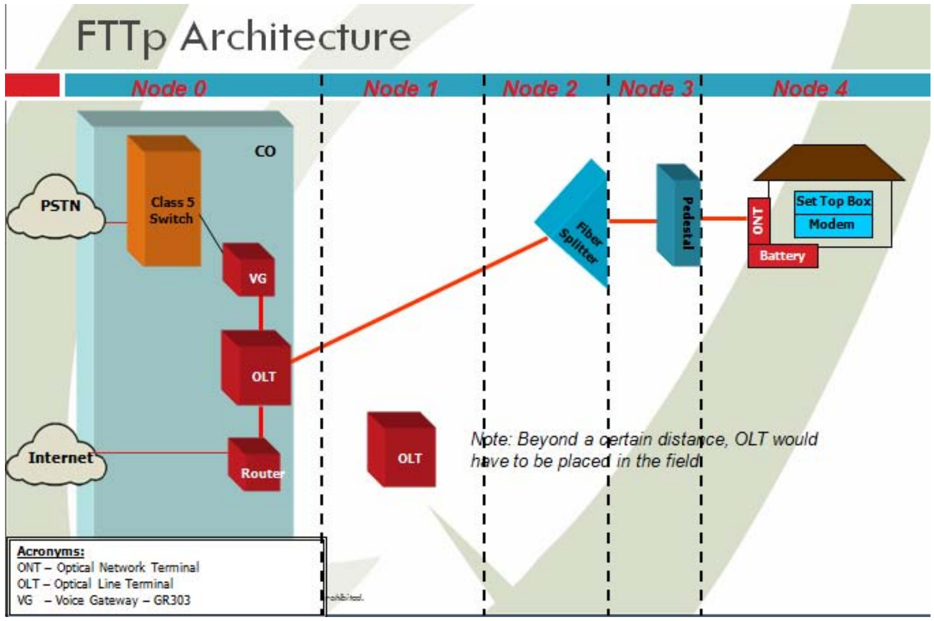
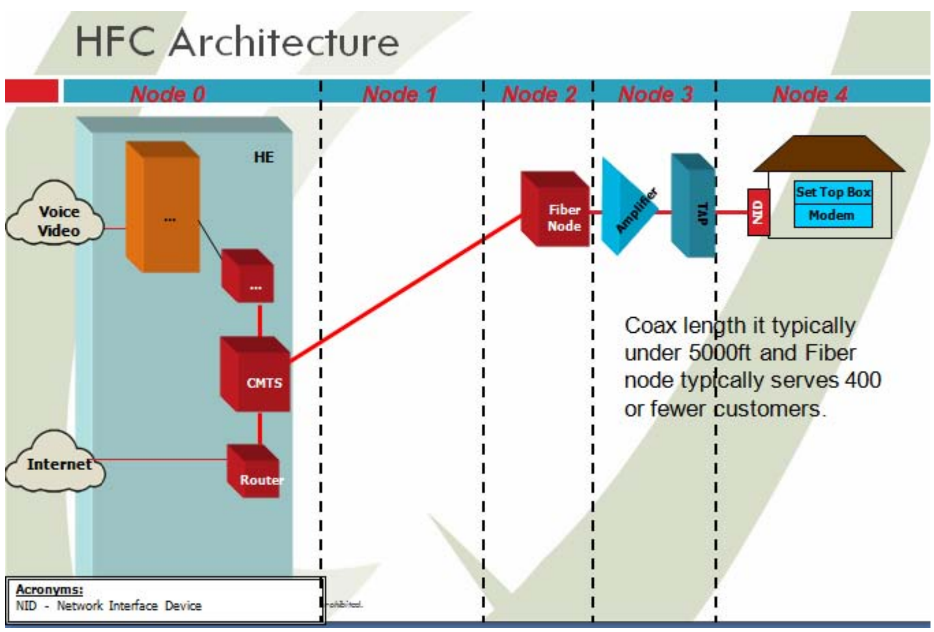
For the converged cable and telco sector, Fiber to the premises



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



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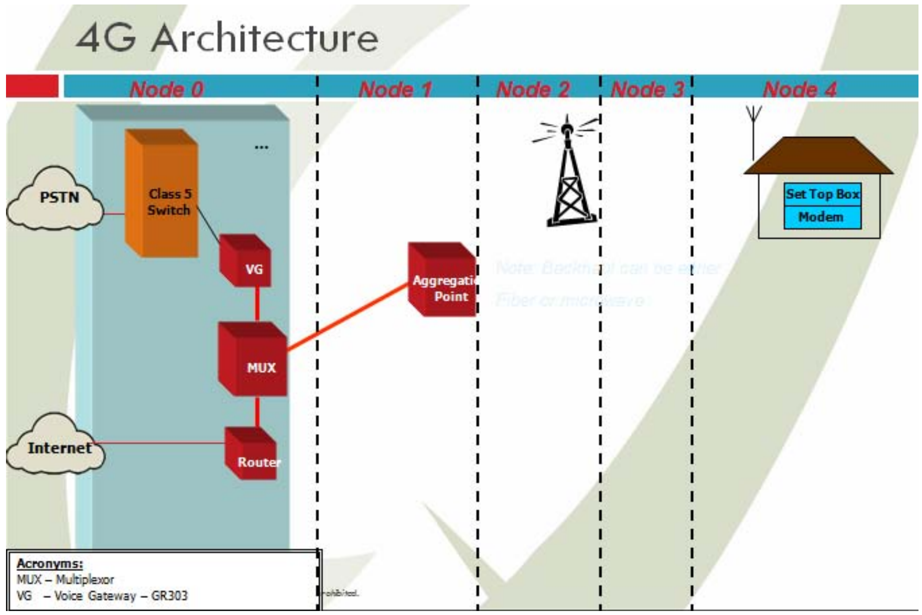
And in the wireless / mobility sector the 4G architecture is as follows:



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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.

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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.

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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).

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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.

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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.

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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

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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.

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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

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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.

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- 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.

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- 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.

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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).

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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.

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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

Telco

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

Cost Face						Driver/CostType			DE…
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	0.0650366…
					FO Aerial Expense	Incremental Investment	Estimated based on "industry" data	FO Aerial Cable Investment	0.0273153…
					CU Buried Expense	Incremental Investment		CU Buried Cable Investment	0.0407070…
					FO Buried Expense	Incremental Investment	Estimated based on "industry" data	FO Buried Cable Investment	0.0166899…
					CU Underground Expense	Incremental Investment		CU Underground Investment	0.0199233…
					FO Underground Expense	Incremental Investment	Estimated based on "industry" data	FO Underground Investment	0.0079693…
					Poles expense	Incremental Investment		Poles Investment	0.041861378…
					Conduit Systems expense	Incremental Investment		Conduit Investment	0.0078974…
				Circuit Equipment / Transport		Incremental Investment		Circuit / Transport Investmen	0.0372936…
				Switching		Incremental Investment		Switch Investment	0.0632507…
			Plant Non-Specific	Network Operating Expense		Incremental Investment		Total Plant Investment	0.0177671…
			Backhaul	Fast-E lease Per Month	Backhaul	Aggregation Point (Wirecenter)		Aggregation Point (Wirecente	$ 1,12…
				Gig-E lease Per Month	Backhaul	Aggregation Point (Wirecenter)		Aggregation Point (Wirecente	$ 4,17…
				General Support & Network Support Expense		Incremental Investment		Total Plant Investment	0.0147313…
	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	Video	Content	n/a	n/a	RevenueFactor		Video Re…	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,

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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.

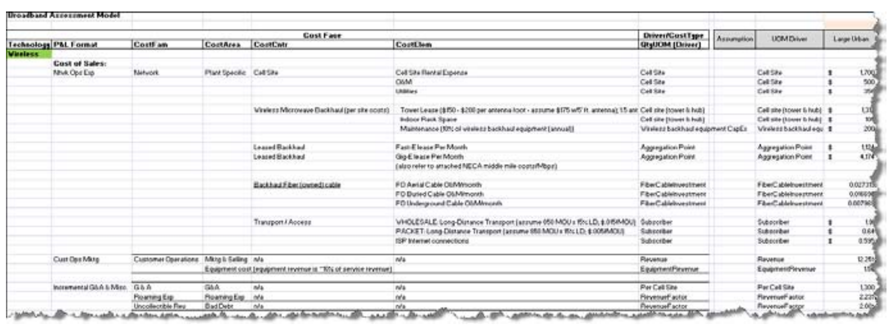
Using the variables previously described, stepwise regression analysis was performed to arrive at multivariate equations for each of the 8 expense accounts below. The table here shows the analysis of variance (ANOVA) results for each regression. The significance level of this analysis in summation is 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.



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

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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% *

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$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.

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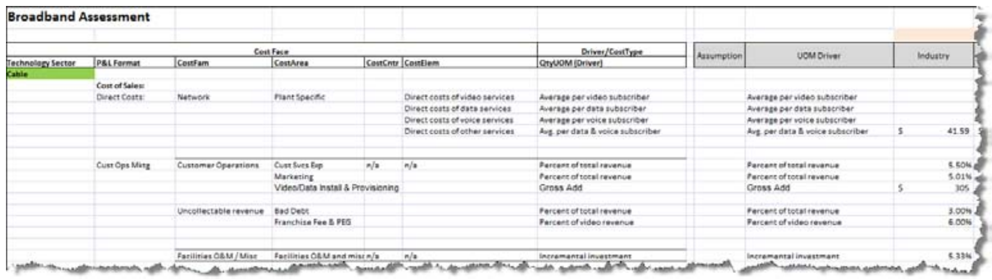
Cable

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

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	6.60%
			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	6.33%

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:

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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:

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	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

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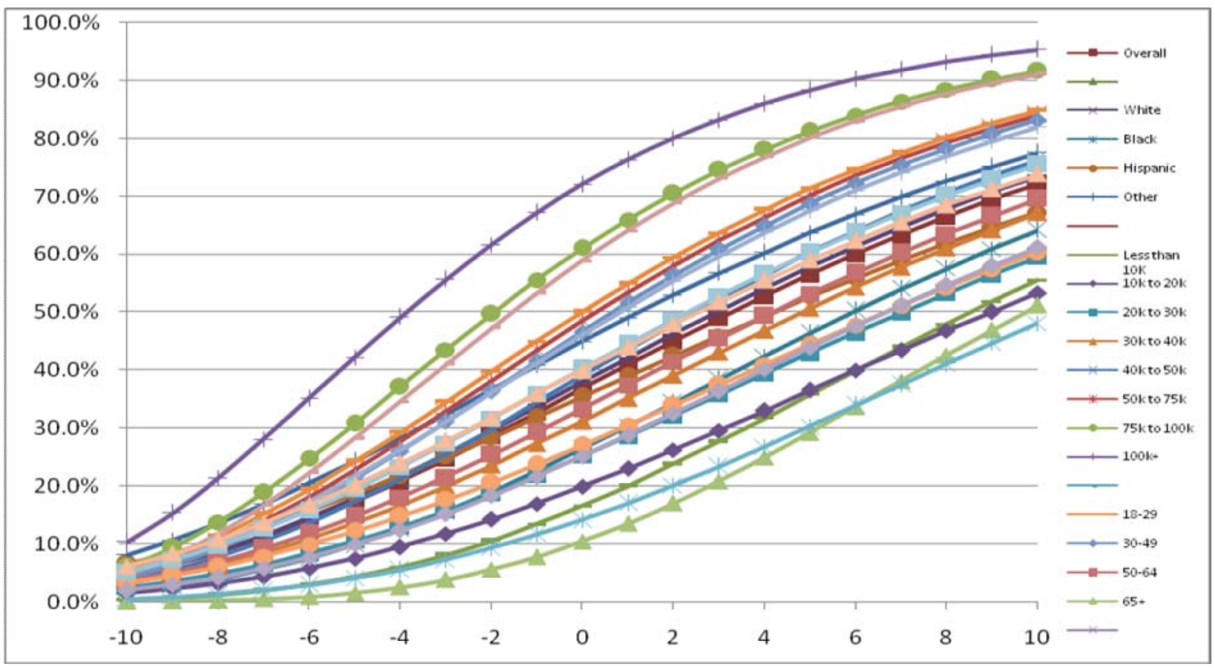
As noted above, the FCC revenue team used confidential industry data to create a benchmark ARPU table by broadband delivery technology for different demand scenarios including voice as well as for data, video and bundled offerings assuming either a high or low usage.

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.

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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)

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- 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.

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- 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

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- 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.

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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.

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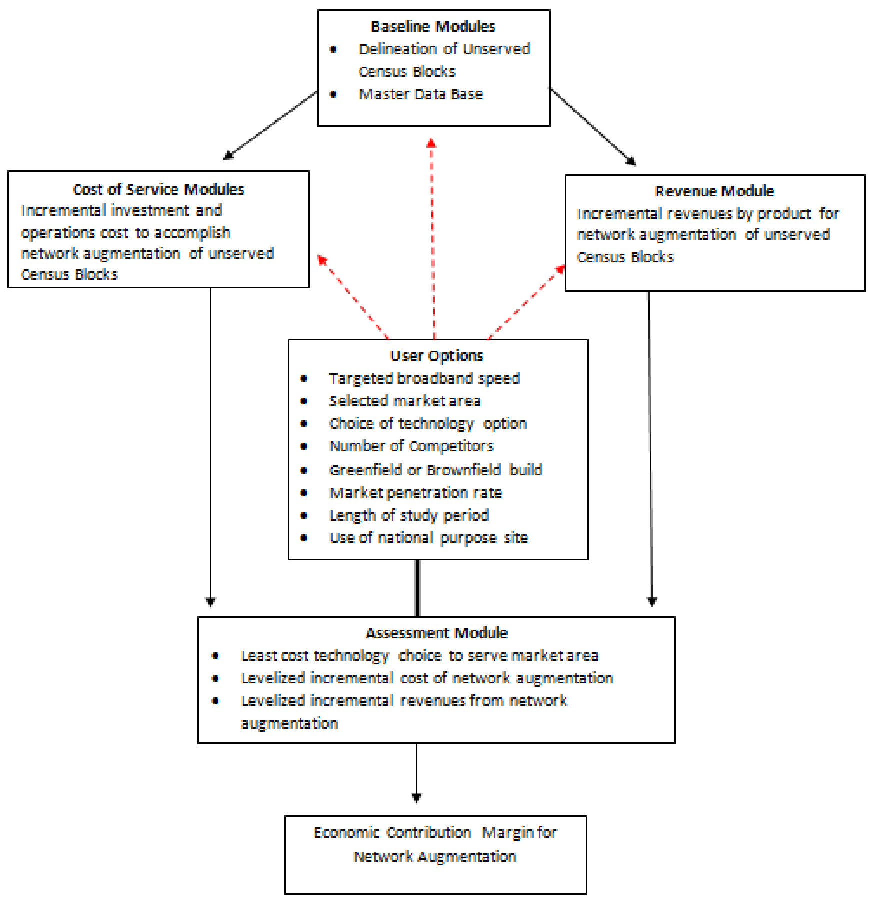
- **Study period** – the time frame (ranging from 5 to 30 years in five year increments) over which revenues and costs are normalized.
- **Middle Mile Adjustment** – option to raise or lower the modeled cost for the middle mile network.
- **Fixed Wireless Capex Adjustment**– option to raise or lower 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

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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

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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.

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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.

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BAM Attachment 1 - Glossary

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

Term/Phrase	Definition and Issues Relevant to FCC BAM
Broadband	Generally used to refer to a high data rate internet access capability typically contrasted with dial-up access using a 56k modem. The general term of broadband includes a variety of speed tiers ranging from 768kbps and greater (768kbps, 1.5mbps, 3.0mbps, 6.0mbps etc.) BAM is designed to model revenue and costs in a discrete range of broadband speed tiers.
Middle Mile	High capacity transport connections between a service provider's network core and its second and last mile network. In the BAM the Middle Mile reaches the point of interconnection (which is a designated existing fiber location) with second and last mile network built for unserved areas. See schematic below.
Second Mile	Transport connections between the Middle Mile and Last Mile. In the BAM the Second Mile is the transport between Middle Mile connection and network nodes (e.g., DSLAMs, ONT's, and wireless base stations) providing Last Mile customer connections. See schematic below.
Last Mile	This is the link between the customer (end user) and the service provider's network node. Also referred to as a local loop, this connection can be fiber, copper, wireless, or coaxial. See schematic below.
ARPU	Average Revenue Per User – a measure / estimate of the average revenue from a subscriber relative to a defined unit of sale.
Latency	Refers to a short period of delay (usually measured in milliseconds) required for the conversion of analog and digital representations of the sound data.
Augmentation	Refers to an area for which broadband must be installed or increased to accommodate the defined broadband need. Also refers to the required incremental network modeled to provide service and the related capex and opex costs and revenues.
Greenfield	A term used to describe the situation where service is provided to an area where, to this point, there has been no such service.
Brownfield	A term used to describe the situation where service is provided to an area where related services exist but not in a sufficient capacity or feature set.
Census Block	The smallest geographic unit used by the United States Census Bureau for

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	tabulation of 100-percent data (i.e., data collected from all houses, rather than a sample of houses). Within the BAM the census block is the most granular geography for which service availability is assessed.
Competition Effect	The impact one or more competitors have on market take rates and resulting incremental revenues realized in a broadband augmentation.
Market Area	A collection of census blocks that represent a larger relevant collection of households / subscribers and potential business customers. Market areas can be census block groups or census block tracts, are often defined by geo-political boundaries (e.g., counties, states, trading areas), and can also be defined by carrier service areas (e.g., franchise areas, license areas, wire centers, study areas).
xDSL	Digital Subscriber Line – a generic name for a family of digital lines being provided by CLECs and local telephone companies for high speed data services including broadband internet access. [The "x" notation refers to an unspecified underlying technology (e.g., ADSL, VDSL, HSIA) and the attending speed realized.]
Opex	Operating expenses generally experienced by broadband providers including network related operating costs, sales and marketing costs and a wide range of administrative costs (including bad debt).
Capex	Capital expenditures representing the investments required to design and install communications facilities – including the related cost of money associated with capital investments.
1G	First generation wireless technology - analog introduced in early 1980s
2G	Second generation wireless technology – digital introduced in early 1990s
3G	Third generation wireless technology – digital broadband technology still being introduced in parts of the country. 3G allows the simultaneous use of voice, data, and video on a wireless network and includes technology standards such as GSM EDGE, UMTS, CDMA2000 and WiMAX.
4G	Fourth generation wireless technology based on Long Term Evolution (LTE) standards. 4G is an advanced digital broadband technology just emerging in domestic markets
FTTc	Fiber to the curb – a hybrid transmission system which involves fiber optic facilities to the curb and either twisted pair (copper) or coaxial cable to the premise
FTTh	Fiber to the home – a transmission system in which optical fiber is carried all the way to the customer premise / place of business

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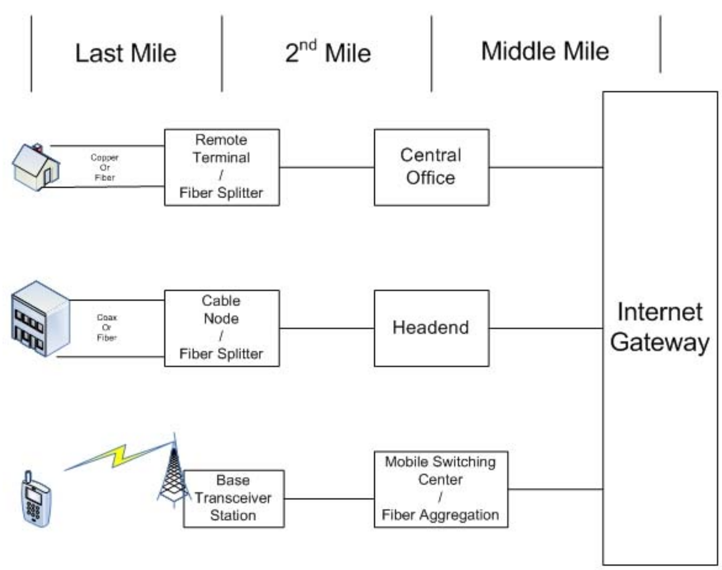
FTTn	Fiber to the neighborhood (or node) – a hybrid transmission system involving optical fiber from the carrier network to a neighborhood node. The final connection to the customer premise can be either twisted pair (copper), fiber or coaxial cable.
GIS	Geographic Information System – computer applications involving the storage and manipulation of maps and related data in electronic format
POP	Point of Presence – a physical location that allows an interexchange company (IXC) to connect to a local exchange company (LEC) within a LATA
POTS	Plain Old Telephone Service – the basic service supplying standard telephone single line service and access to the public switched network
QoS	Quality of Service – a measure of the quality of telephone service provided to a subscriber which embraces a wide range of specific definitions depending on the type of service provided
IP	Internet Protocol – a protocol describing software used on the internet that routes outgoing messages, recognizes incoming messages and keeps track of address for different nodes
VoIP	Voice Over Internet Protocol – a process of sending voice telephone signals over the internet which involves converting signals to digital format and the development of information packets when the initiating signal is analog
Capacity Threshold	A threshold demand level based on total demand at an existing fiber fed POI
Sharing Effect	Dealing with potential shared use of backhaul built by first carrier serving an unserved area.

Schematic of Last-Second-Middle Mile



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BAM Attachment 2 - Data Source and Model Application Summary

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

			Applications within the BAM				
Data Category	Model Variables	Data Source	GIS Baseline	Wireline Coverage	Investmt	Opex	Rev
Census Boundaries	Full census block; full census block group; full census tract; full census county; census state	2008 TIGER®	x	x	x	x	X
Wire center boundaries	Wire center code; wire center area. Serving Office points	TeleAtlas	x	x	x		
Geographic characteristics	Land area, total road length by type within fragment or Census Block; total road length by wire center; x and y coordinates of fragment.	Tiger; TeleAtlas	x	x	X		
Physical Geography	Elevation variance, landcover, Statsgo	NOAA, Landcover.org	x	x	x		
Population size	Population by block and block group;.	2009 Geolytics and 2000 Census	x	x	x		x
Housing units	Occupied housing units, total housing units, total households by block; and total housing units by block group.	2009 Geolytics and 2000 Census.	x	x	x		x
Population composition	Number and percent of people by census block: inside urbanized area, inside urban clusters, rural farm, rural non-farm.	Census (SF1, SF3)	x	x	x		x

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Race and ethnic composition	Number and percent of total census block population by race and ethnicity	2009 Geolytics	x	x			x
Linguistic composition	Number and percentage of households by block group that are primarily Spanish speaking or otherwise linguistically isolated	2000 Census	x	x			x
Income	Household median and aggregate income	2000 Census and 2009 Geolytics	x	x			x
Age	Number and percentage of people in detailed age distribution categories by block group. Median age by block group.	2000 Census and 2009 Geolytics	x	x			x
Education	For each block group, educational attainment by gender and age.	2009 Geolytics	x	x			x
Commuting profile	For each block group, total number and percent in the workforce and number working at home. Distribution of commuters by hours of commute.	2000 Census	x	x			
Area Wealth	Medium housing value by block group. Rented dwellings annual expenditures by block group.	2000 Census	x	x			
Composition of business market	Number of business firms and total employees by block. Distribution of business employment by block group.	GeoResults 2009	x	x	x	x	x
Provider size and organizational structure	Corporate ownership, size of parent company, number of wire centers operated by carrier.	TeleAtlas, NECA Tarrif 4	x	x	x	x	
National Purpose sites	By blocknumber and type of National Purpose Sites	Various sources as provided by NP team	x		x		

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Economic region	For each census block: the associated Business Trading Area and Economic Trading Area, and Metropolitan Statistical Area.	FCC County to trading area files.	x		x		x
Company opex financial data	A wide array of company specific financial information (and underlying business volumes) from public and subscription service sources. Data centers on operating expense by category (e.g., maintenance, sales, interconnection, sales and marketing, G&A, bad debt, taxes, etc.)	See Attm 4 for a comprehensive list of opex data sources				x	
Average Revenue per User	Average revenue per user by product (voice, high/low volume data, high/low volume video, high/low volume bundled).	FCC					x
Cable carrier operating Internet Service	Existence of cable incumbent in a block group within a block.	Media Prints	x		x		x
Wireless tower location	Used to test existence of tower infrastructure in an area	TowerMaps	x		x		
Wireless carrier service	Existence of wireless service in an area.	American Roamer	x		x		x

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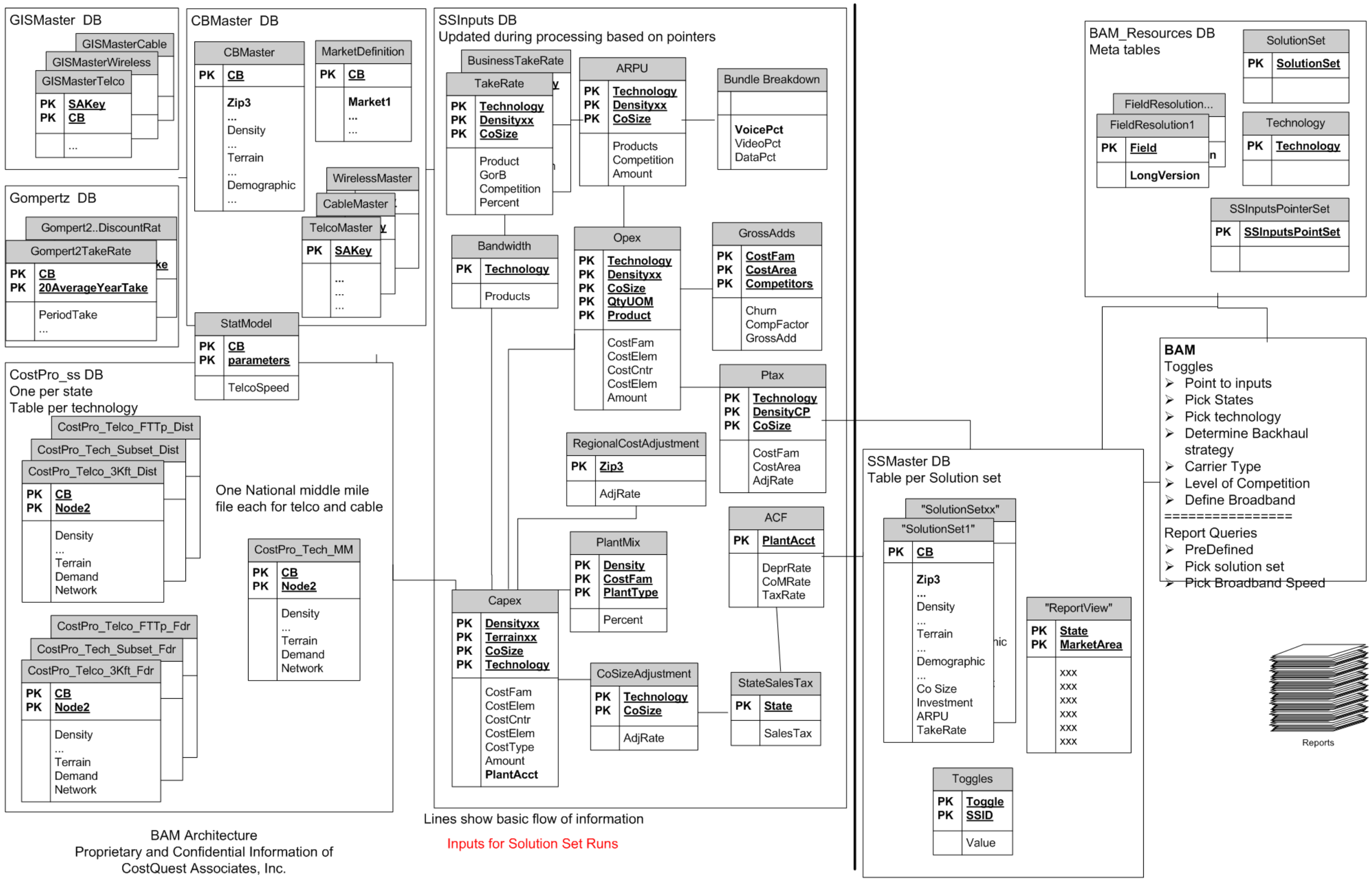
BAM Attachment 3 – Model Data Relationships

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



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BAM Attachment 4 – Statistical Baseline Modeling

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Introduction/Overview

The purpose of this project was to develop predictive models for estimating the presence and speed of xDSL coverage throughout the United States.

A multi-phase approach was taken. Each project phase was designed to inform later phases as well as prepare data at the appropriate scale for the final set of predictive models. Time constraints required that all relevant data be identified by the end of Phase I and be acquired by the end of Phase II. Models developed in Phases I and II guided the conceptual development of the final (Phase III) model.

During the first two Phases, data were identified, collected, assembled, checked for reasonableness and consistency, and statistically characterized. Essential preliminary computations were made, including finding all mutual intersections of wire center[1] polygons and Census blocks, deemed "fragments," and calculating geographic characteristics of these fragments (such as their areas).

Indications of xDSL availability at all speed thresholds were computed throughout Alabama and were obtained for Pennsylvania (at 1.5 Mbps nominal download speed) and Minnesota (at 768 Kbps nominal download speed).[2] Collectively these comprise the "estimation dataset" from which the model coefficients are ultimately estimated. One-half of the estimation data, selected by taking one-half the wire centers at random, were used to explore the data and to fit and assess the models, reserving the remaining estimation data (the "hold-out" data) to check model quality. Final models were fit using all the estimation data.

Model estimation proceeded in stages, closely paralleling the procedure advocated in Hosmer & Lemeshow (2000) chapters 4-5. After determining how best to express the variables (in many cases by using their logarithms), initial models were estimated at target speeds ranging from 384 Kbps to 6.0 Mbps using both forward and backward stepwise logistic regression. Data were weighted by the fragment area relative to the area of its parent block: in effect, this weighting conducts the analysis at the conceptual level of the Census block, while accommodating the complication that some blocks cross wire center boundaries. Due to the large amount of data available—the smallest data set used still had more than 30,000 fragments — stepwise regression rarely rejected a variable as insignificant. However, certain variables were collinear with others and other groups of variables (such as the distribution of non-family income) were so close to being collinear that including them created unstable models, as evidenced by widely varying coefficients from one speed to the next. Such groups were systematically dropped or coalesced into fewer variables until the models appeared stable.

---

[1] Wire center boundaries were obtained from TeleAtlas, September 2009

[2] Broadband availability datasets were examined from other states, including New York, Maine, California, and Wyoming. These were found not to be usable for this project due to differences in the quality of the data, the procedures used to collect them, their comparability, their lack of specificity (to xDSL alone), and their geographic scale.

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The base model was augmented by introducing pairwise interactions, again using stepwise logistic regression. Almost all interactions with [hascable] were significant and had sizeable coefficients. This variable indicates cable coverage in a block[3]. Therefore, it was decided to create two families of models: one for blocks within the cable coverage areas and one for blocks outside the cable coverage areas. Both models use the same variables but are separately estimated. Each model is appropriate only for the kinds of blocks used for its estimation. Because the no-cable blocks will be closely associated with unserved and underserved areas, attention focused on optimizing the quality of the no-cable version of the model for each speed.

The result of these efforts is a set of twelve complementary models: a no-cable and with-cable model for each of six speed thresholds: 384K, 768K, 1.5M, 3.0M, 4.0M, and 6.0M.[4] Each pair of these models computes a single linear combination of the variables within each block fragment to produce a "logit." This is a number typically between -10 and 20. It can be interpreted as the strength of evidence for availability of xDSL within a fragment, with larger values corresponding to a greater likelihood of availability. Three additional steps were needed to produce the final results. First, for each speed a binary determination of xDSL availability—yes or no—is made by comparing the fragment logit to a *model-specific* threshold, which typically is a number between -0.1 and 1.0. Fragments with a logit exceeding the threshold are predicted to have xDSL available. Second, a Census block is considered to have xDSL available whenever xDSL is predicted in any of its fragments. . Third, to assure consistency among the model results at the various speeds, the predictions are adjusted where necessary so that prediction of xDSL at speed *x* implies prediction of xDSL availability at all speeds less than *x*, too.[5]

Prediction for the hold-out data indicated these models are typically 80% to 90% accurate within populated blocks. (Including unpopulated blocks would increase the apparent accuracy rate.) That is reasonable accuracy, but it will still produce estimation errors nationwide. Errors are of two types: false positives, where xDSL is predicted at a speed but is not available at that speed, and false negatives, where xDSL is predicted not to be available at a speed that is really available in a block. The importance of an error is proportional to the number of occupied housing units it affects, [hu_occ]. For example, a false positive in a block with ten occupied housing units does not fully compensate for a false negative in a block with 20 housing units: the latter is twice as important. The thresholds were chosen to make the errors exactly balance out on average: the numbers of *housing units* within the false positive blocks equal the numbers of housing units within the false negative blocks for each of the twelve models. These counts are based on Alabama data, which are common to all the models. Assuming that the proportions of errors of each type occurring in Alabama are typical of what will occur nationwide, this method of choosing thresholds gives predictions whose false positive errors should numerically balance its false negative errors when weighted by housing unit. Thus, statistical summaries of predicted xDSL availability expressed in terms of total housing units should be, at least to this first approximation, unbiased.

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[3] This variable was derived from an analysis of MediaPrints September 2009.

[4] As 384K reflects a speed below minimum current reporting standards, these models were later dropped from the final results.

[5] This adjustment is based on the logits independently calculated by each model within each Census block. The final speed assigned to a block is the maximum speed for which all lower speed models indicate xDSL availability. For example, a block that shows availability at 6 Mbps, no availability at 4 Mbps, and availability at all speeds less than and equal to 3 Mbps would be assigned a speed of 3 Mbps. Such apparent inconsistencies, although rare, can occur because the models at each speed are estimated independently of one another.

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The model coefficients and thresholds were developed on a combined GIS-statistical platform built on ArcGIS 9.3.1 and Stata 8.2 SE and then ported to a SQL Server platform for application to the national dataset. To accomplish the port without error, field definitions, model coefficients, and thresholds were tabulated to double precision in a computer-readable format and processed into a SQL stored procedure. The original Stata predictions were compared to the SQL Server predictions for 20% of the Alabama data to check that agreement was achieved within expected floating point roundoff error.

Dependent variables

Pennsylvania and Minnesota

A binary indicator of broadband availability within Pennsylvania was obtained from a statewide, Census block level analysis of broadband availability at a nominal download speed of 1.5 Mbps, classified by technology (xDSL, cable, *etc*.). A binary indicator of broadband availability within Minnesota was obtained from Connect Minnesota. The nominal speed threshold is 784 Kbps.[6]

Alabama

In Alabama, xDSL speeds were derived from calculations of wireline loop distances to the nearest DSLAM or xDSL-enabled Central Office (CO) located within the parent wire center. The distances are those along the network of roads and other likely wire loop rights of way. Conversion from loop lengths to download speeds was accomplished by interpolating published attenuation curves for ADSL-2 and VDSL technologies (Converge Network Digest, http://www.convergedigest.com/bp/bp1.asp?ID=15&ctgy=). See Table I, which also shows the interpolated distances for ADSL-2, ADSL-2+, and VDSL at speeds from 384 Kbps to 6.0 Mbps to demonstrate that the assumed technology has only a small effect on the speed-distance relationship.

The distances were then summarized to obtain the *smallest* distance found within each fragment within 25 meters of a road or right of way. Thus, the speed associated with a fragment corresponds to the *largest* speed that can be delivered within 25 meters of the roads within that fragment. (xDSL is therefore presumed unavailable within any fragment having no roads or rights of way.)

Table I Speed-distance conversion

	Speed, Mbps:	**0.384**	**0.768**	**1.5**	**3**	**4**	**6**
Meters	VDSL	7,038	5,990	4,979	3,932	3,497	**2,884**
	ADSL 2+	5,168	4,661	4,116	3,470	3,167	2,688
	ADSL 2	**5,475**	**4,923**	**4,323**	**3,598**	**3,250**	2,684
Kft	VDSL	23.089	19.654	16.335	12.899	11.473	**9.463**
	ADSL 2+	16.956	15.290	13.502	11.383	10.389	8.819
	ADSL 2	**17.963**	**16.151**	**14.184**	**11.805**	**10.664**	8.807

The bold figures indicate the distances used for each speed.

[6] Minnesota data were supplied from Connected Nation. Pennsylvania data were supplied by the Department of Community & Economic Development, Technology Investment Office, State of Pennsylvania

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Independent Variables

An initial "data dictionary" of possible independent variables was constructed from a comprehensive list of variables found to be significantly associated with xDSL availability in eleven published, (generally peer-reviewed) papers. Most of these studies were performed with data obtained at geographic levels ranging from zip codes to entire countries, and therefore included many strong ecological correlations that may not apply to block-level data. Thus, it was expected that only some of these variables would eventually be useful, but that almost any useful variable would appear somewhere in this list.

We supplemented the data dictionary with additional variables, primarily measuring economic characteristics of wire centers, that could be associated with entry-to-market decisions made by DSL providers. Some variables, such as population and income, were summarized at coarser levels of geographic resolution (often the wire center) in order to produce some indicators of conditions within the wider spatial neighborhood.

Results

Unlike many regression models, interest here lies in the accuracy of the predictions rather than the accuracy of the model coefficients or their interpretation. Prediction of a binary attribute like xDSL availability (at a specified speed) is *discrimination*: the model must divide all cases (here, Census blocks) into two categories. Perfect prediction occurs when no case is put into the wrong category.

As explained above, the model combines values of the independent variables to produce a numerical value (the logit) for each block. If the logits for all blocks truly <u>with</u> xDSL are numerically separated from the logits for all blocks truly <u>without</u> xDSL, then perfect discrimination is possible by comparing the logits to any value lying between the two groups of logits, a "discrimination threshold." Because the dependent variables, numerous as they are, are not perfectly correlated with xDSL presence, overlap occurs: the logits for some blocks with xDSL will overlap with typical values for blocks without xDSL, and *vice versa*.

Figure 1 illustrates a difficult case: the no-cable model for 6 Mbps service. This model was developed entirely from Alabama fragment data, which were the only ones with information for this speed. The histogram on the left summarizes the block logits for blocks <u>without</u> xDSL at 6 Mbps or better, *weighted by the number of occupied housing units per block*. It covers mostly negative logits, but its right tail—representing about 30,000 occupied households—extends into positive territory. The histogram on the right similarly summarizes the logits for blocks <u>with</u> xDSL, representing 133,000 occupied households. It covers mostly positive logits, but its left tail—about 33,000 occupied households—extends into negative territory. The overlap of the histograms near zero indicates perfect discrimination is not achieved. Evidently, about as many false positive errors are made (as counted in terms of occupied households) as false negative errors when the discrimination threshold is set near zero. The threshold used in this case was actually -0.062, causing approximately 31,500 households to be false positives and an equal number to be false negatives.

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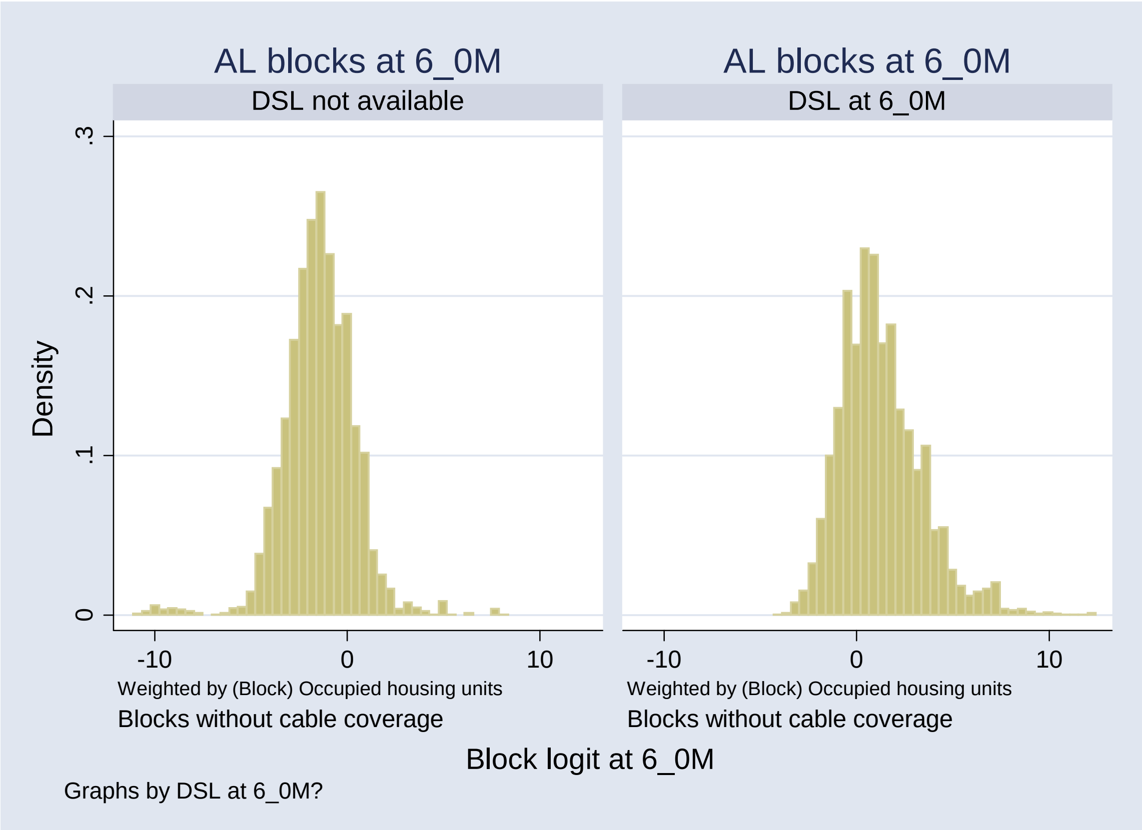
Figure 1 Performance of a logistic model



In this fashion discrimination thresholds were estimated for each model (by speed and cable availability). The error rates were typically better (*i.e.*, lower) than observed in this example, which exhibits only 80% accuracy overall.

Discussion

It is noteworthy that the model's discrimination accuracy is substantially higher, at 85%, when measured as the proportion of Census blocks correctly predicted (*i.e.*, when not weighted by numbers of occupied households). This comes about for many reasons relating to the fact that discrimination is most difficult at the boundaries of xDSL coverage areas where population densities are still relatively high (compared to rural areas). Households situated just outside a boundary are likely to share many characteristics of those just within the boundary. In such locations, only 50% accuracy can reasonably be expected. When spatial correlation is high, these bands of low-accuracy discrimination can be wide, significantly degrading predictive performance. This phenomenon is almost impossible to eliminate with a statistical model. The attempt to divide households by equal numbers into the false positive and false negative groups is motivated by the hope that such errors will tend to balance each other in follow-on summaries and analyses based on relatively large regions, such as entire states. Thus, although at the scale of the individual Census block these accuracies might be 80% to 90%, at the larger scale of a state or the nation we expect accuracy to be higher.

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It may be tempting to look at other gauges of model fit, such as the “pseudo R-squared” values emitted by the statistical software. These are numbers between 0 and 100% that might be interpreted like the familiar squared correlation coefficient of ordinary regression, R-squared. Indeed, pseudo R-squared was useful in model selection—and it improved tremendously from Phase I through Phase III—but it indicates little about the accuracy of any particular prediction. The reason is that it mixes a number of factors, not all of which are relevant. For example, if a few unusual blocks (such as the unpopulated blocks) are included in the estimation dataset, they will greatly increase the pseudo R-squared but likely not add anything (and maybe take away something) from the model accuracy.[7] Another gauge is the standard error of prediction. So many records were available for estimation (at least one per block, which translates to tens or hundreds of thousands of records per model) that the standard errors of prediction would likely look small no matter what. Moreover, there is no way to combine these standard errors when “rolling up” the logits from the fragments to the blocks.

The plan to divide the data into estimation and prediction datasets worked well, but in the end it may not have captured enough of the potential for variation. At this point it is not known how xDSL availability varies geographically over areas greater than one state or within states with characteristics substantially different from those used for model estimation. It has also been impossible to identify a reliable relationship between xDSL availability and some potentially important explanatory variables, such as indicators of the financial deployment decisions of the carrier, because those variables did not exhibit sufficient variability within the estimation datasets. As more estimation data, consistent in production methods and vintage, are obtained it would be a useful next step to re-analyze and adjust the models based upon data that are more representative of conditions across the United States and its territories.

These uncertainties are mitigated by several factors. In particular, follow-on analyses are protected by the fact that this model is used to estimate the speeds only in a minority of blocks; namely, those where cable coverage is not independently indicated.

[7] This is related to the better known phenomenon with R-squared: if in any scatterplot a single additional point is placed beyond the end of the scatterplot, then R-squared can become close to 1.0 because the data look almost linear when the picture is zoomed out far enough to see both the original points and the new point.

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CostProLoop

Loop Economic Modeling

Model Documentation

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Table of Contents

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Introduction / Summary

This document provides an overview of how the wireline loop economic modeling data was developed for the Broadband Analysis Model ("BAM"). It includes an overview of the underlying model platform (i.e., CostPro) as well as a discussion of methods used in the modeling, a summary of key data sources and an overview of results.

CostPro configures the telecommunications networks, for the BAM application. It produces the network topology including cable lengths, DSLAM sizes and locations, etc.. The cost of the network is then developed within the BAM application.

Corresponding documentation provides similar information relative to the development of fixed wireless economic design.

Current economic modeling across all plant categories are grounded in similar design principles applied by comparable network models and use real-world forward-looking engineering practices and assumptions.

The goal of economic modeling is to develop an estimate of the network required to provide the desired level of service. The modeling of network includes all components to prepare the asset / system for productive use.

Central to understanding the resulting network topology that is designed is an appreciation of the underlying inputs, assumptions and economic models.

- Inputs, as outlined in this document, are based on publicly available data for customers, service area boundaries, and switch or cable service areas.

- Assumptions reflect real-world / current engineering practices, including how these practices are applied within specific terrain.

- The central economic model is a widely accepted, modern approach to network modeling practices used throughout the industry.

The economic network topology is based on results from the CostProLoop model. With longstanding use in the telecom industry, CostPro is a next-generation network modeling platform. It provides an economic topology of a network based on the design of an optimal, forward-looking network developed by a current customer-by-customer analysis of network utilization.

What sets the CostPro platform apart from other modeling approaches and methods is its granular approach, its use of spatial analysis, and its reality-based engineering guidelines. Derivations of the CostPro model are used by companies with operations in over 30 states in the U. S, have been adopted by public utility commissions in every state where it has been filed, have been used in property tax valuations, have been used to value networks in acquisitions, and have been used by international government agencies.

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At its core, the CostProLoop modeling platform is a “spatial” model. It determines where customers are located and “lays” cable along the roads of the service area to reach them. In fact, 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 service area.

Through the use of C++ and Visual Basic code, databases, and a user- friendly interface, CostPro determines the economic topology for wire-line network components, across all categories of plant required to connect a specific service demand group; e.g. customers, former customers or potential customers, to their serving central office or headend and to provide a wide-range of wire-line services to these customers. The model assumes the installation of forward looking, commercially available telecommunications technologies and uses generally accepted engineering practices and procedures.

Accurate Bottoms-Up Design

CostPro’s network related topologies are grounded in a model of network connections between each and every customer. Just like an engineer, the model tallies the necessary length and type of network facilities, including relevant network components and electronics, based on actual customer demand, switch or headend locations and service architectures.

Developing Costs for the Full Complement of Services

The CostPro platform can model the full complement of services provided by modern communication carriers, including POTS services, fiber in the loop strategies and high bandwidth enterprise fiber services such as MetroEthernet and SONET based DS3 and greater services.

For the BAM application, CostProLoop was used to develop a network platform to provide a desired level of broadband service. For example, if one is interested in understanding the network topology required to provide 3-4Mbs download speed, the minimum required build would use a 12kft copper distribution design. If, on the other hand, one is interested in 100+Mbs download service, a fiber to the premise (FTTp) network design could be utilized. In all, 6 versions of the model were run for BAM:

- ✓ 15kft copper distribution design for DSLAM service
- ✓ 12kft copper distribution design for DSLAM service
- ✓ 5kft copper distribution design for DSLAM service
- ✓ 3kft copper distribution design for DSLAM service
- ✓ Fiber to the premise for a telco provider
- ✓ Fiber to the premise for a cable provider[1]

Beyond these baseline runs, additional designs were produced to support National Purpose analysis.

[1] It was assumed the current HFC systems in the country would commercially migrate to DOCSIS3 and would be sufficient to provide most levels of broadband service. The fiber to the premise runs for cable encompassed the currently unserved cable areas of the country.

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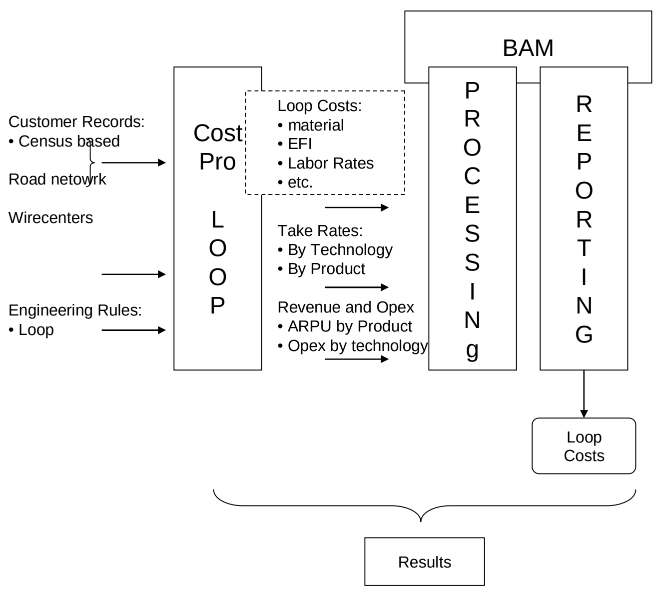
Overview and Administrative Features

Inputs / Processing Schematic

As an overview, the CostProLoop modeling platform accepts, processes and forwards required inputs along the high level path outlined below. Each component of the model builds from and is coordinated with the component that precedes it. The end result is a logical computation of comprehensive network economic deployment costs.

The other important point is that the inputs reflect the real world. Demand, is considered within the context of real engineering rules applied to real, geographic-specific, roads and terrain.



Network Assets

The logic behind economic network modelling is derived from a realistic, engineering-based understanding of what drives; i.e., causes, additional investments.

As a broad guide, the following discussion provides the increments and drivers of the basic assets in the network modelled within the CostPro framework.

Loop: Wireline loop plant connects customers to central offices or headends. The basic drivers of loop plant investment, including electronics, include all manner of customer demand and location. The loop is typically broken into a distribution portion and feeder portion. Distribution runs to the customers' locations while feeder runs to the central offices or headends.

The distribution components, drivers, and nomenclature of the typical loop as modeled in CostPro are described below:

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Network Interface Device (NID) -- The NID serves as a demarcation point between customer wiring and the carrier's distribution plant. In a Fiber to the Premise (FTTP) installation, an Optical Network Terminal and battery are used in place of a conventional NID. In regard to the NID, for telecom deployment it is sized based upon copper pair demand, which is triggered by service demand.

Optical Networking Terminal (ONT) – An ONT is used to provide Voice, Video and Data services to customers in an FTTP topology. An ONT is hosted by an Optical Line Terminal. An ONT is placed at each customer's premise.

Customer Premise Equipment (CPE) – CPE can be capitalized equipment that is placed on a customer premise. Its use is driven by a particular service. This can include the modem for DSL and DOCSIS service and the Set Top Box for video service. CPE investment is driven by the count of services, customers served, and ultimate ownership of the equipment.

Drop Wire (Drop)—For telecom deployment, a cable sheath consisting of two or more pairs of copper wires, which permanently connects the NID to a Distribution Terminal (DT). Essentially, the drop wire connects between the customer premises and the distribution cable at the street. A drop wire can be buried or aerial and is driven by customer demand. For Fiber to the Premise (FTTP) deployments, this drop is fiber, rather than copper, and connects up to the fiber service terminal. For hybrid fiber-coax ("HFC") cable deployments the drop is coaxial cable which then connects to the tap on the distribution run.

Distribution Terminal / Building Terminal (DTBT)—For telecom deployment, the Distribution Terminal (DT) is the point where the drop wires from several customers are connected to pairs in a larger cable. This cross-connect or tap point can be located at a pole, handhole, buried splice, or pedestal. In some circumstances, the cross-connect or tap point can be a Building Terminal (BT). The BT acts as the demarcation point at a location where it is more effective to simply terminate a distribution cable at the customer's premise rather than using drop cables and NIDs. For FTTP (Fiber To The Premise), the DTs and BTs are replaced by fiber service terminals (FSTs) and are fed by fiber cable. For typical Hybrid Fiber-Coaxial ("HFC") cable systems, the tap provides the connection with the distribution network.

For reporting purposes, the cross-connect point, whether it is a DT or BT, Tap or FST is described and tracked as a DTBT within CostPro.

Distribution Cable (DT-FDI)--The loop component that connects the DTBT with the feeder cable at the Feeder Distribution Interface (FDI). Distribution cable in the loop network for Fiber to the DLC (FTTD) and Fiber to the Node (FTTN) architectures is copper. For FTTP designs, along with optical Ethernet and wideband services, the distribution cable is fiber. For typical HFC cable designs, the distribution cable is coaxial cable.

CostPro allows the user to specify the percentage of distribution cable that is buried, underground or aerial through the entries in the plant mix table.

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Amplifier – In typical HFC cable designs, signal amplifiers are placed within the distribution pathing based upon distance parameters.

The major components of the feeder portion of the loop are described below:

Feeder Distribution Interface (FDI) — In copper loop architectures, the FDI is where distribution cables are connected to a feeder cable. The FDI allows any feeder pair to be connected to any distribution pair. (For reporting purposes, a portion of the FDI is assigned to distribution.) For FTTP designs, the FDI is replaced by the Fiber Distribution Hub (FDH/PFP).

Fiber Distribution Hub / FiberSplitter (FDH/PFP) – In an FTTP design, the fiber cable from the OLT in the central office or in the field is split at the FDH/PFP into 16 to 32 distribution fibers. These 16 to 32 distribution fibers then connect to ONTs at the customers' premises.

DSL Access Multiplexer (DSLAM) – In a copper loop architecture, a DSLAM provides broadband service capability and receives data from multiple customer DSL connections and aggregates the data onto a high speed Gigabit Ethernet (GigE) backbone.

Digital Loop Carrier (DLC) System— In copper loop architecture, a DLC provides voice service capability and consists of equipment required in a CSA (Carrier Serving Area) and at the Central Office to multiplex channels and to convert electrical signals to and from optical signals for efficient transport. In the CSA, the DLC equipment is referred to as a Remote Terminal (DLC-RT). At the central office, the DLC equipment is referred to as the Central Office Terminal (DLC-COT).

FiberNode (FN) – In typical HFC cable designs, the fiber node is the point at which the coaxial cable terminates and the signal is converted from analog to optical for transmission back to the CMTS.

Optical Line Terminal (OLT) – In a FTTP design, the fiber cable from the PFP terminates on an OLT. The OLT performs optical-electrical conversion from the ONUs towards the network. This OLT can either be housed in the central office or at an RT site.

Gigabit Ethernet (GbE or GigE) – A term implying the use of Ethernet to carry data at Gigabit speeds over Fiber Optic cable. For example, GigE is used to transport data from DSLAMs to the Central Office.

Cable Modem Termination System (CMTS) – Used to terminate the cable modem signals from the customer sites. The CMTS provides many of the same functions as the DSLAM, including the provision of broadband service.

Multiprotocol Label Switching (MPLS) – A set of quality-of-service (QoS) standards used to manage different kinds of data streams based on priority and service plan. MPLS enables an IP network to maintain priority for voice and video traffic.

Metro Ethernet COT (MeCOT) – A generic description of equipment placed at a Central Office to support Metro Ethernet services.

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Feeder Cable (FDI-DLC and DLC-CO) — The feeder cable transports traffic, either voice or data, between the FDI/PFP and the central office in the telecom environment and between the fiber node and the head end in the HFC design.

Administrative Features

CostPro has a user-friendly GUI interface provides the ability to run and report from easy to follow wizards. The model includes all portions of the wireline loop network, both facilities and electronics. The model is capable of modeling new services and technologies as they are developed and deployed. There is minimal use of hard-coded engineering values. Rather, the model provides user control over engineering rules and functions to more accurately reflect actual / real-world engineering practices. The model produces outputs at a geographically de-averaged level including customer or groups of customers.

With respect to the modeling of loop investment, important engineering features include the following capabilities:

- Toggles to switch on and off various technologies and approaches including Fiber to the Premise (FTTP), Fiber to the Node (FTTN), Hybrid Fiber-Coaxial (HFC), and Fiber to the DLC (FTTD).

- User-controlled engineering rules enhance the model's ability to reflect actual engineering practices. More specifically, the Model reflects engineering rules for:
    - Limits of copper distribution, copper feeder and electronics
    - Use of fiber in the feeder and the use of fiber-fed DLC
    - Capacity of electronics (e.g., DLC system, Fiber nodes, etc...)
    - Deployment of FTTP, FTTN, Coax and FTTD
    - Engineering fills

The model supports all offered services including basic local service (including second lines), Centrex, PBX, ADSL, HDSL, ISDN, Coin, Specials (DS0, DS1, DS3, DS1, E3, etc…), MetroEthernet, broadband, and unbundled loops.

Additional important elements of the overall modeling methodology are described below.

Customer Point Data

Within CostPro, the modeling exercise can begin with address-geocoded customer point data. Address geocoding is a method used to match a customer address to a location on a road network. Address geocoding is a well established technique to derive a locational attribute, such as longitude and latitude, from an address.

CostPro then augments actual geocoded point data with surrogate locations for the customer data points that cannot be located accurately. These surrogate locations are based upon generally accepted data sources (e.g., Census data), client-specific engineering and optimization rules, and standard industry practices.

In addition, CostPro can add locations of actual non-working lines or add estimated locations (based on Census data) of potential customers who currently are not taking service. The use of this data, toggled by user inputs, allows the modeling of a more robust network and the carrier of last resort obligation.

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Alternatively and as used to run the BAM output, CostPro can use Census information and surrogate an entire data set of estimated customer location data. As noted above, the surrogation of points is based upon generally accepted practices and occurs at the finest level of public geography. That is, the surrogation of data takes place at the census block level using the roads and customer counts within each census block. Care is taken so as not to place customers on specific types of roads such as interstate highways.

Engineering Areas

Using industry standard engineering rules, road distance and service demand information (e.g., DS0s, pairs, Living Units, Average Information Rate, etc), service clusters are formed. A service cluster is a group of demand points (customers) which share a common loop network technology. For example for a voice network, a service area could be described for all customers sharing the same remote terminal. Within each cluster, appropriate forward looking digital equipment and copper and/or fiber cable is placed. Service clusters are used to surrogate: Distribution Areas (DAs), Fiber Serving Areas, Carrier Serving Areas, and Allocation Areas (FSA/CSA/AA).

Route Information

Based on user adjustable inputs, engineering rules, and Minimum Spanning Road Trees (MSRT), optimized plant routing is developed to each and every customer. MSRTs are used to develop the routing for distribution and feeder plant.

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Methods - MSRT and Network

CostPro designs a network to serve customers within a service area (e.g., wire center, headend service area, etc.) based on where they actually reside. The model "lays" cable along the actual roads in the service area to connect customer premises with their serving central office or headend. As this section demonstrates, the network can be seen on a map of the actual roads in a service area. In fact, it will aid the reader in understanding the model if he/she begins to immediately consider *visually* the spatial layout of a road network. The figure below shows the road network for a typical service area, as shown in Figure 1.

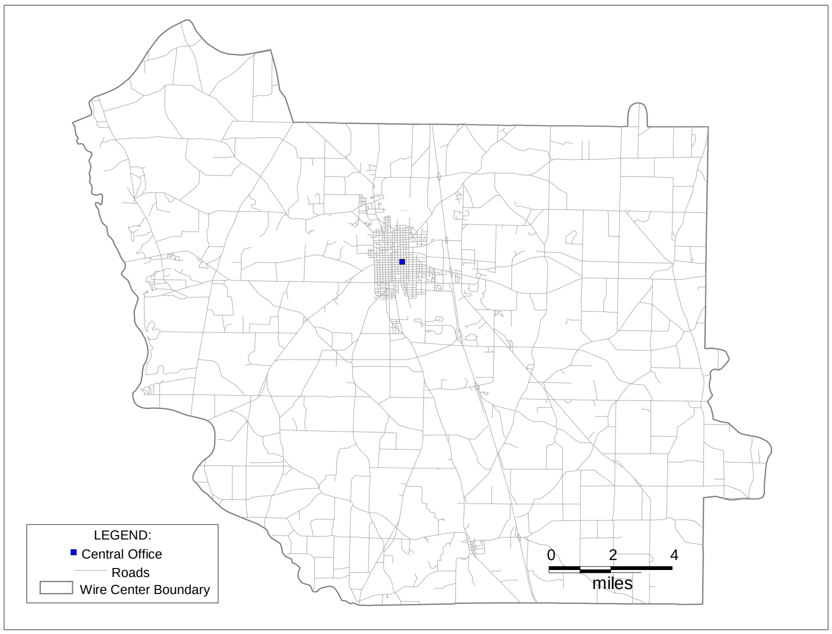

Figure 1 -- Road Network

Demand Data Preparation

For the CostPro BAM runs, the customer data (both business and residential) was pulled from public sources. For residential data, Census based data was used. For business data, third party vendor information was used. In each case, counts of locations by census block are provided. Before the customer data can be used, it must be located on the earth's surface, along a road path so that the network routing algorithms know where to route. For this public census based data, a random placement algorithm is used to place the demand locations along the roads of the census block. Care is taken so as not to use roads that are restricted (e.g., interstate highways). In addition, census units in structure information is used to approximate the location of multifamily locations.

Figure 2, presents a section of the view shown in Figure 1 with customer locations shown as circles. In this example, these circles represent *all* of the service demand points (e.g., both business and residences). The customer and service data are now ready for processing by CostProLoop.

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Figure 2 -- Customer Locations

Optimal Routing

Using the spatially located customer locations and the road network, specifically designed and reviewed algorithms determine optimal network routing and placement based upon standard industry engineering rules. As a first step, CostPro uses a minimum spanning road tree (“MSRT”) algorithm to develop the optimized routing from the central office or headend to all customer locations. Once a full service area MSRT is determined, CostProLoop walks back from the furthest customer toward the Central Office or headend. As the walked path reaches the maximum road-distance for the specified build (e.g., 12kft of copper distribution), an initial node placement is made for a terminal. The model then walks past this node placement until the maximum distance is reached again. As the path is walked, branch road segments are captured for inclusion in the area served by the terminal. Once all customer locations to be served by a terminal node are determined, appropriate components such as Feeder Distribution Hubs (FDHs), Fiber Nodes (FNs) and Feeder Distribution Interfaces (FDIs) are located within each serving area. Once the serving nodes are placed within these “remote” served serving areas, an MSRT is formed to provide the optimal path by which to serve all customers from the remote terminal node. The MSRT within each serving area then becomes the distribution cable path. This process continues until all portions of the service area have been “clustered”.

For those customers served by a terminal in the central office or headend, an MSRT is determined. CostProLoop then compares the customer count against user inputs to determine if this tree is to be “pruned” into multiple central office or headend served trees to meet engineering constraints. Once the main central office served areas are determined, these tree paths are then walked to determine points at which feeder distribution interface (for copper areas) or fiber distribution hub (for fiber served areas) terminals are to be place. These placements are driven by user inputs guiding customer counts and distance limits. The MSRT within each serving area then becomes the distribution cable path.

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As a final step in the pathing algorithms, an MSRT for feeder plant is determined. That MSRT links the nodes outside of the Central Office or headend to the Central Office (CO) or headend.

Figure 3 depicts a distribution network created by the process based on the optimized MSRT approach. Figure 4 depicts the same type of information for the feeder network.

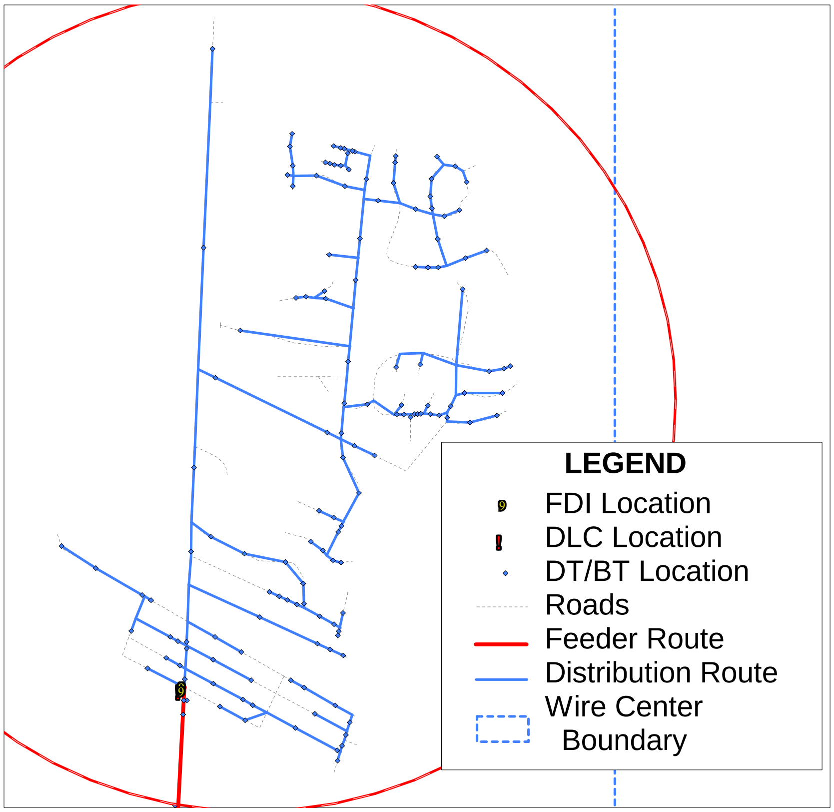

Figure 3—MSRT for Distribution Plant

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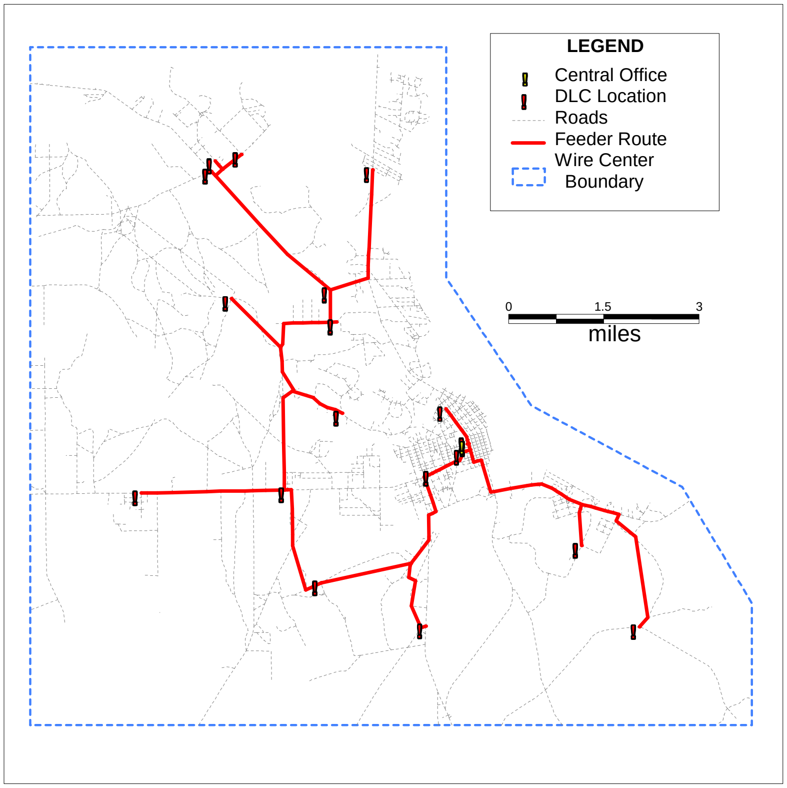

Figure 4 -- MSRT for Feeder Plant

After the serving areas and optimal routings are determined, engineering rules guide the installation and placement of electronics, such as SONET terminals, Fiber Nodes, DSLAMs, and Central Office Terminals.

Once the spatial layout of the network is determined, CostProLoop's Configuration Process connects the network components. This entails the determination of cable sizes, identification of service points requiring special engineering, and selection and sizing of Remote Terminal type. Once the network is configured, CostPro summarizes the network topology information to create the source file for the BAM application. In this summarization, the information about the network build is pushed out to the census block records. As such, each census block record captures the size of the main serving terminal (e.g., DSLAM, FiberNode, FDH, etc..) the customer count at the central office or headend, the length of the feeder and distribution cable and the portion attributable to the census block, and other pertinent information relevant to the network build.

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Methods - CostProLoop Engineering

CostProLoop develops investment estimates for wireline loop plant. The loop is the portion of the telecommunications network that extends from the Central Office (CO) or Headend to the customer's premises. The loop delivers access to voice, data, special access or video services from the Central Office or headend.

A loop extends from a customer premise (a business or living unit). It can be terminated on a Class 5 circuit switch, a soft switch, specific customer equipment, CLEC equipment or any multitude of routers, gateways or specialized equipment necessary to support IP driven services like VoIP or video.

The loop consists of two plant families: distribution and feeder. Distribution plant covers the connection between the customer premises and the Feeder Distribution Interface (FDI). At the FDI, distribution cable is "cross connected" to feeder cable. Feeder plant covers the connection between the FDI and the CO.

CostProLoop designs a network using forward-looking technologies and design principles. To meet the heterogeneous engineering characteristics of today's service providers, CostProLoop is capable of modeling different wireline topologies.

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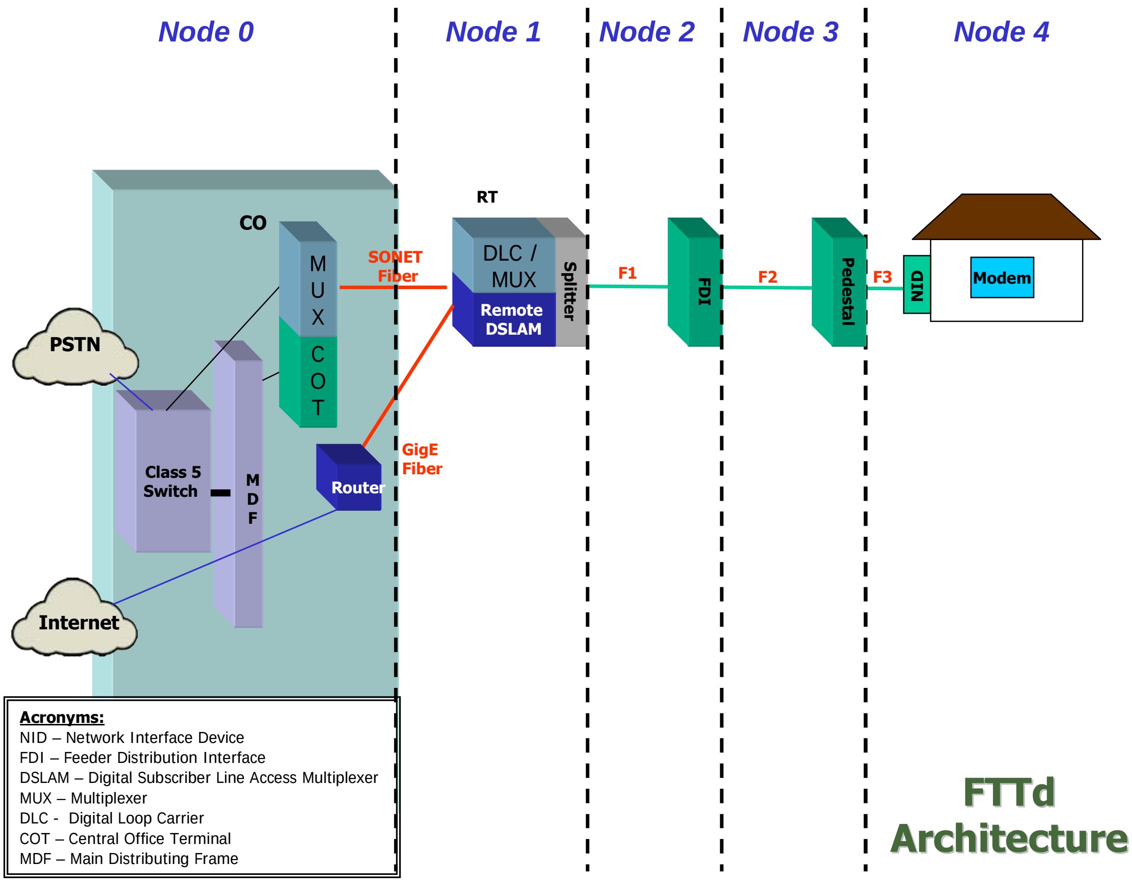
The first topology is the 'traditional' CSA, Class 5 Circuit Public Switched Telephone Network (PSTN), as seen in Figure 5. We refer to this topology as Fiber to the DLC or CSA (FTTD). This topology deploys both fiber feeder and copper distribution cable along with associated loop electronics (such as Digital Loop Carriers) to provide switched voice, low speed data, xDSL and special access circuits. This network design provides minimal broadband service levels.

As you will see in each of the following network designs, we have tried to standardize the reference to network by using the values of Node0 through Node4. Node identifiers are used to help bridge the understanding of functionality across the differing technologies (wireless and various forms of fiber and hybrid fiber solutions) that were used in BAM. The "nodes" are significant in that they represent the way in which costs are assigned / aggregated to enable neutral comparisons across technologies.

Figure 5—Typical PSTN Engineering Design



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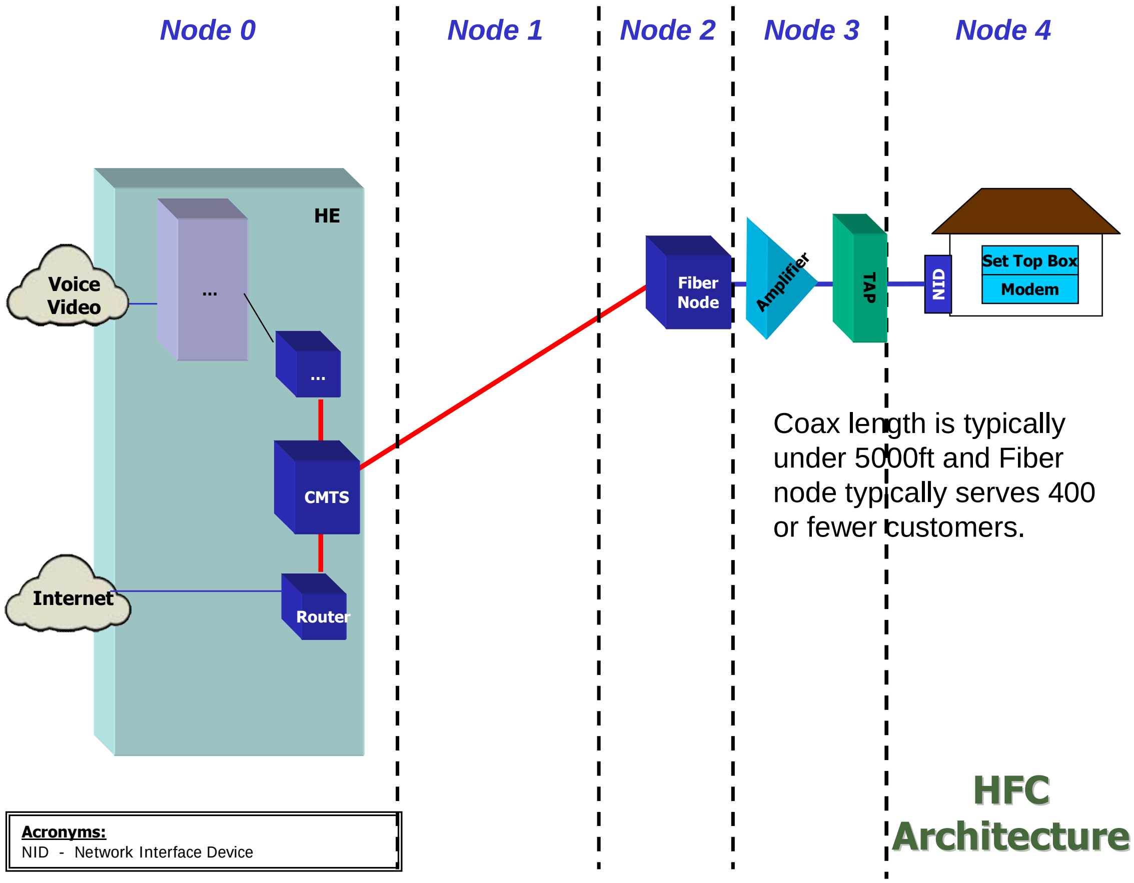
The second topology, as depicted in Figure 6, is the HFC cable build used historically by the cable industry. This topology uses coaxial cable for the distribution plant up to the fiber node. At the fiber node the signal is converted from analog to optical and then transmitted over fiber cable to the CMTS at the headend. This design can support DOCSIS2 and DOCSIS3 deployments and can provide broadband speeds pushing 100mbs.

Figure 6—HFC cable



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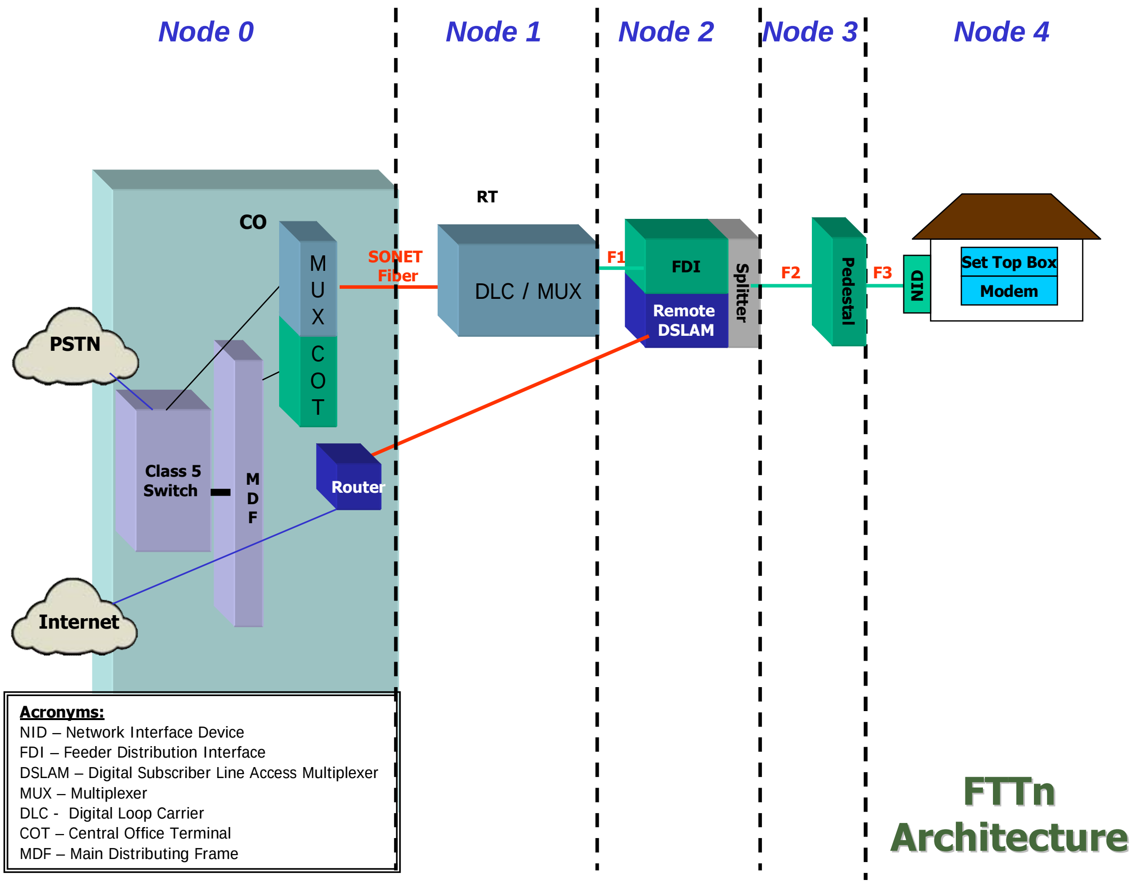
The third topology is FTTN (Fiber to the Node), as depicted in Figure 7. In this topology a DSLAM is deployed at the FDI. In a circuit switch deployment, the customer's loop is 'split' at the FDI rather than the DLC in the FTTD design. This split separates the voice from the data packets. The data stream is sent to the DSLAM, while the voice stream is passed back to the traditional DLC. The topology pushes the availability xDSL services to customers farther away from the Central Office and typically reduces the copper distance from the customer to the DSLAM to ~3000 ft. This topology expands the footprint of where xDSL services can be provisioned, increases the potential bandwidth to up to 50Mbs (with pair bonding), and allows for the provisioning of services including video. To support the Gigabit Ethernet data stream, fiber optic cables go from the DSLAM to the Central Office.

Figure 7-FTTn Topologies



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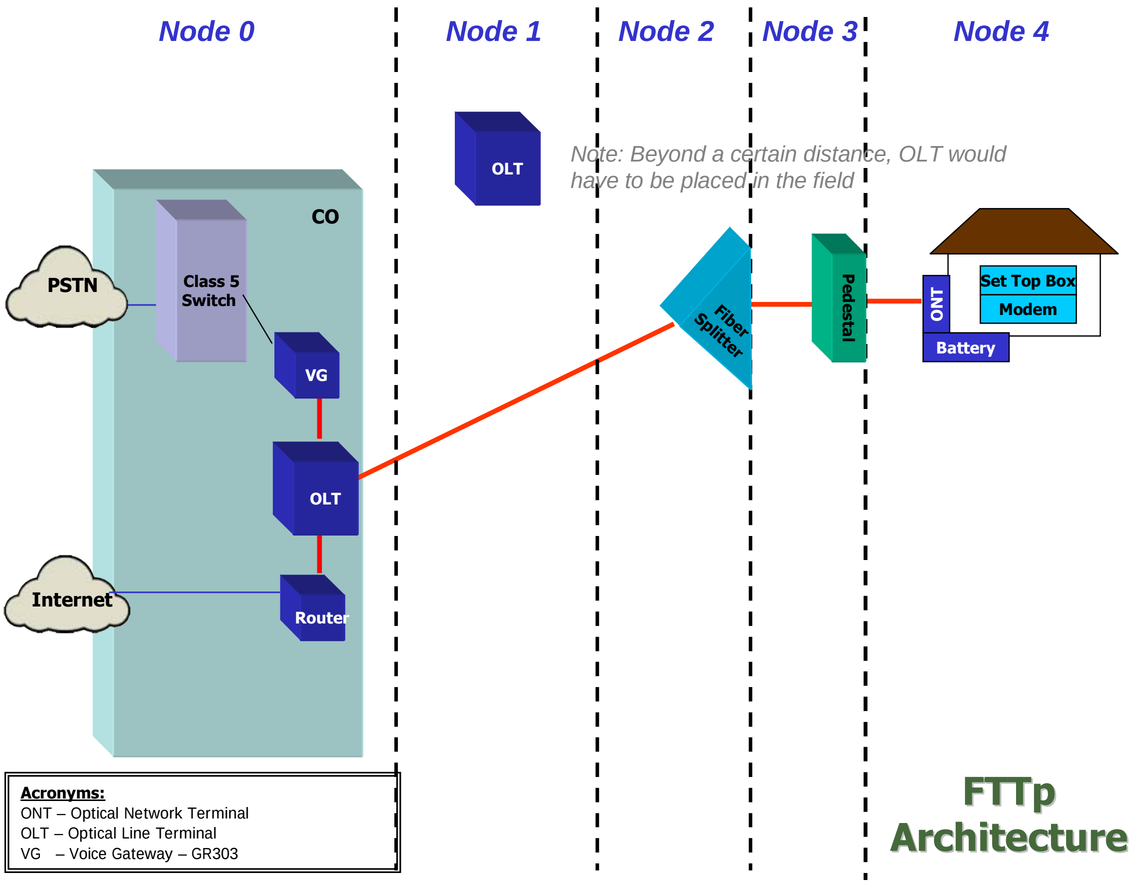
The final topology is passive optical, FTTP (Fiber to the Premise), as depicted in Figure 9. In this topology an ONT (Optical Network Terminal) is placed at the customer's house, along with a battery for back up power. Fiber cable then connects the customer to the Central Office or headend. Along the path, the fiber from the customers is concentrated at the FDH (Fiber Distribution Hub) in a typical 32 to 1 ratio. At the central office or headend, the fiber from the FDH terminates on an OLT (Optical Line Terminal). The traffic is then sent to an Ethernet switch. In circuit switching is to be used, the voice packets are routed to a class 5 switch. Data packets are routed to the IP network via a connection to a router. This gateway router can be in central office or headend or can be located at an intermediate office to support multiple central offices or headends. Broadband speeds over this design are only limited by the electronics used. Currently, providers are deploying 50-100Mbs broadband speeds.

Figure 8—FTTP topology



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Data Sources

The CostProLoop modeling process requires data inputs and modeling assumptions unique to BAM's requirements and assumptions. Input data and relevant sources are outlined below.

Engineering data

Public domain and commercially licensed data products provided the foundation for the CostProLoop model. This included service area boundaries, Central Office and Headend locations and demand sources.

Telecom Wire center boundaries

- TeleAtlas, wire center boundaries (Jun, 2009).

Switch Location and Function

- TeleAtlas wire center boundaries (Jun 2009). If there was no point located in wire center boundary, fall back to NECA tariff 4 switch point. If there was no NECA point, an interior centroid was used.

Cable Greenfield Service Area

As noted earlier, the cable build used in BAM reflected those areas not currently serviced by cable. The development of a Greenfield cable network required a specific augmentation to the general wireline demand scenario.

In this case all demand in Census Blocks covered within Census Block Groups identified by Media Prints Cable Boundaries as Operating Internet was excluded.

This left only residential and business demand in currently unserved cable areas. New service areas were derived by dissolving unserved Block Group boundaries and placing a serving node at the interior centroid of the Block Group boundary. This process created an analog to a telecommunications wire center boundary and serving central office.

The new serving node proxied for as a fiber served network hub under the Greenfield Cable FTTP design. Each serving node was linked homed to the nearest head end point via middle mile logic. Headend location was derived as the centroid of a census place boundary sharing a common name with the Media Prints system information. If a common name link couldn't be made, the headend was the interior centroid of the Media Prints served community.

Cable System Information

- Media Prints, September 2009

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Demand data

Demand Data - Customer Address and Services Table

As the 'goal' of BAM was to produce investment for all potential broadband customers, CostPro developed a broadband network serving all potential residential and business locations.

Residential demand was based upon Geolytics (2009) estimates of housing unit counts at a Census block level. Housing Unit demand points were placed randomly along the roads of each census block based upon the Geolytics estimates.

Business demand was based upon Georesults (July 2009) estimates of business counts at a Census block level. Business locations were placed randomly along the roads of each Census block based upon Georesults estimates.

Supporting Demographic Data

CostProLoop requires several additional data sources to support road pathing and demographic analysis.

These data sources are described below:

- Roads
  - Source: US Census TIGER
  - Vintage: 2008
- Census Blocks
  - Source: US Census TIGER
  - Vintage: 2008
- Residential Demographics
  - Source: Geolytics Block Estimates 2009
- Business Demographics
  - Source: Business Counts by Census Block, Georesults
  - Vintage: 2008 (2ndQ)
- ZIP Centroids
  - Source: StopwatchMaps
  - Vintage: 2009

Key Engineering Inputs

To better model real world network deployments, the CostPro platform allows the user to enter a variety of adjustable inputs. These inputs affect not only the investment of the provisioned network, but also the manner in which the network is provisioned.

These inputs were based upon FCC direction and CostQuest's understanding of industry standard practices.

User Adjustable Investment Inputs--Samples rule inputs include the following:

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♦ Maximum fiber and copper cable size	♦ Percentage of plant placement of aerial, buried and underground plant by density zone and plant location
♦ Minimum fiber and copper cable size	♦ Maximum copper distances for voice and data services
♦ Effective Fill/Utilization percent of equipment	♦ FTTx trigger points
♦ Average distance between manholes	♦ FTTx specific engineering
♦ Average distance between poles	♦ Service engineering
♦ Percentage of sharing of structure paths	♦ Etc.

Results

Model results are a set of files for each state that capture the feeder and distribution network topology.

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CostProWireless®

Wireless Economic Model

Model Documentation

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Underlying CostProWireless® Model:

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Contents

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Background

The purpose of this document is to further the understanding of users of the FCC Broadband Assessment Model (BAM) concerning the design logic and structure of the 4G wireless network architecture used as the basis for deriving the wireless cost to serve.

The primary purpose of the BAM is to support FCC policy consideration relevant to the development of the National Broadband Plan. To that effect, the 4G Wireless component of the BAM was designed to estimate the financial impact associated with providing wireless broadband to areas deemed unserved by adequate broadband speed and/or broadband capacity required to fulfill national purposes.

The underlying 4G wireless network architecture is created through CostProWireless® and its derived investment is determined within Investment Module of Broadband Assessment Model. The purpose of the Investment Module is to estimate incremental deployment investment (capex) required for delivery of broadband services to unserved areas. The modeled architecture 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 routing, 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 are developed using a classic capacity costing technique and include all necessary plant, structure and electronics to support the designed network.

Overview of Network Modeling

Current economic modeling across all plant categories is grounded in similar design principles applied by comparable network models which use real-world forward-looking engineering practices and assumptions.

The goal of economic modeling is to develop an estimate of the network required to provide the desired level of service. The modeling of network includes all components to prepare the asset / system for productive use.

Central to understanding the resulting network topology that is designed is an appreciation of the underlying inputs, assumptions and economic models.

- Inputs, as outlined in this document, are based on publicly available data for customers, service area boundaries, and switch or cable service areas.
- Assumptions reflect real-world / current engineering practices, including how these practices are applied within specific terrain.
- The central economic model is a widely accepted, modern approach to network modeling practices used throughout the industry.

Introduction to CostPro®

CostPro® configures the telecommunication network for the BAM application. It produces the network topology including tower counts, RAN capacity configuration, backhaul type, distance of backhaul fiber, etc.. The cost of

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the network is then developed within the BAM application. CostProWireless® is the application used for development of the 4G wireless network[1].

The economic network topology is based on results from the CostProWireless® model. With longstanding use in the telecom industry, CostPro® is a next-generation network modeling platform. It provides an economic topology of a network based on the design of an optimal, forward-looking network developed by a current customer-by-customer analysis of network utilization.

What sets the CostPro® platform apart from other modeling approaches and methods are its granular approach, its use of spatial analysis, and its reality-based engineering guidelines. Derivations of the CostPro® platform are used by companies with operations in over 30 states in the U. S, have been adopted by public utility commissions in every state where it has been filed, have been used in property tax valuations, have been used to value networks in acquisitions, and have been used by international government agencies.

At its core, the CostProLoop® modeling platform is a "spatial" model. It determines where customers are located and "lays" the network required to reach them.

Through the use of SQL and Visual Basic code, databases, and a user- friendly interface, CostPro® determines the economic topology for wireless network components, across all categories of plant required to connect a specific service demand group; e.g. customers, former customers or potential customers, to their serving tower and to provide a wide-range of wireless services to these customers. The model assumes the installation of forward looking, commercially available telecommunications technologies and uses generally accepted engineering practices and procedures.

Specific to the 4G Wireless network design, CostProWireless® was crafted to incorporate forward looking technology using well understood network architecture and methods of deployment. The design criteria was targeted to practical dimensioning of a deployable network and simplifying assumptions that underpin the logic, purpose, and the computational strategy have been employed.

The 4G wireless network design is intended to produce an efficient network infrastructure in unserved areas assumed to be deployable within 24 months and maintainable for a period of no less than five years to consistently deliver designated user realized broadband performance.

The 4G wireless network must be cost effective, efficient, and designed to achieve the desired standard of speed and reliability. The design was assumed to leverage existing and accessible infrastructure components when known (a 'brownfield' augmentation approach). If no such infrastructure was available, the design defaulted to create a 'greenfield' network. Accomplishing this includes the consideration of issues such as population density within the market area; available infrastructure within in unserved area and in adjacent areas, the size of firm to be providing broadband services, 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).

[1] Corresponding documentation provides similar information relative to the development of wireline loop economic design.

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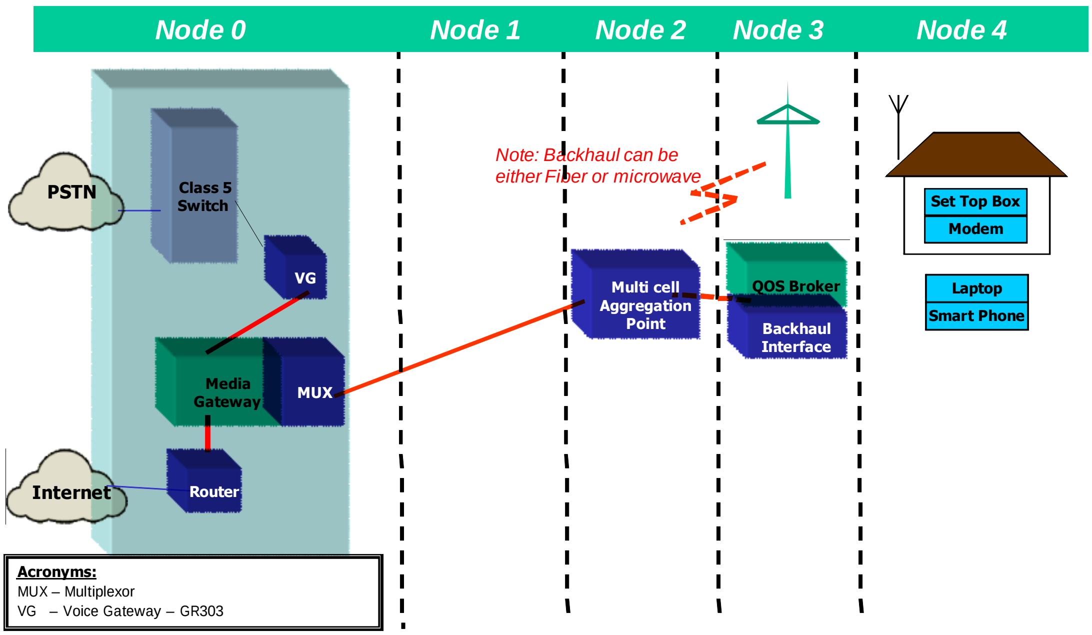
4G Network Architecture

The 4G network architecture for the FCC BAM is designed to produce outcomes for broadband coverage and the related financial expectations (i.e., revenue, capex, opex and economic contribution margin) for contemporary wireless deployments to fill broadband gaps in unserved areas.

The following diagram reflects the fundamental technology architecture for modeling 4G wireless within the BAM. Node identifiers (e.g., Node 0 thru Node 4) are used to help bridge the understanding of functionality across the differing technologies (wireless and various forms of fiber and hybrid fiber solutions) that were used in the BAM. The "nodes" are significant in that they represent the way in which costs are assigned / aggregated to enable neutral comparisons across technologies.



CostProWireless® Process

Locating 4G Users

The BAM is designed to provide broadband information at a Census Block level. 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. The 4G Wireless model produces the cost to provide broadband service at the Census Block level.

Within the CostProWireless® processing, population and, therefore, potential 4G wireless broadband customer data (e.g. population, number of households, housing units, business locations, and anchor institutions) are developed at the Census Block level. However, the available national data does not exist to precisely pinpoint the location of both business and residential populations and must be estimated using a combination of secondary data sources.

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Road networks are to be used as the basis to allocate population among census blocks so as to determine demand and the related costs to serve that demand. This approach best reflects where people live and how networks are built.

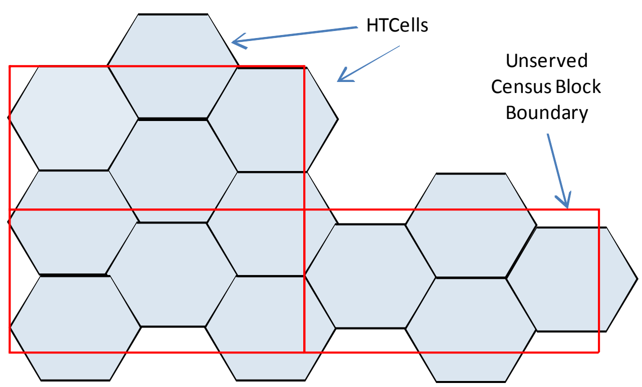
4G user customer adoption rates (or take rates) are developed in the BAM (see Attachment 9 – Gompertz Penetration Rate) and applied to the distributed population within a census block and used to determine demand levels to be satisfied with the 4G network design.

Coverage Approach

The methodology for creating coverage in the 4G wireless architecture for BAM is intended to produce a reasonable dimensioning of base station requirements for early stage planning. Spectrum frequency, channel bandwidth, and actual performance characteristics of yet to be deployed 4G technology is not fixed in the model but are, instead, user input parameters. The methodology used to assign coverage to unserved areas is complicated by the array of existing 3G wireless coverage data juxtaposed to the census block boundary data required for the FCC BAM. Further, because of the geographical scale of the BAM, specific topology data typical for high accuracy radio propagation study and site search ring identification was not available. Instead, CostProWireless® employs method using hexagonal tessellation cell (HTCell) application was selected to approximate site coverage in unserved areas.

HT Cell

The use of HTCell is symbolic of a three sector cell site and the hexagonal shape provides a method to simulate 100% coverage. The following diagram depicts a hypothetical overlay of HTCells in three census blocks deemed to be unserved by broadband. In this example, the unserved census blocks could be covered by thirteen HTCells.



While it is the case that antenna sites would typically lie at the edge of HTCells, for purposes of this model each HTCell would house at least one antenna site. In the case where an existing site structure (e.g., a leasable tower[2]) is used to place a 4G antenna, the actual location of that tower within the HTCell is used in the model. In the case of a 'greenfield' build, the site is assumed to be at the center point of the HTCell.

To prepare the model, a national overlay of HTCells of predetermined radii was created. The range of selectable HT Cell radii[3] provide the model user a basis for adjusting attenuation performance based on demand, density,

[2] Tower locations were extracted from Towermaps database(September 2009)
[3] The hexagon was fully inscribed within the selected radius.

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topology, and speed characteristics. The HTCell radii incorporated into the model are 2, 3, 5, 8, 10, 15, and 20 mile.

To deal with HTCells where demand exceeds the capacity of a single site, a simple cell splitting methodology captured in the CAPEX inputs for BAM is used that results in the addition of one or more sites to meet the overall capacity demanded within the HTCell.

In areas, where the HTCell straddles coverage with served and unserved areas, no adjustment was made to adjust the HTCell counts and tower requirements. As such, the count of HTCells is a conservative value.

It is important to note that variances in accuracy that occur at the HTCell or 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).

Backhaul Design and Investment

The design for backhaul (also called second mile) of the 4G wireless network involves the transport of broadband traffic between an existing fiber point of interconnection (POI) and 4G deployed sites (Node 3 sites) in an unserved area. The backhaul design incorporates both fiber and microwave in an efficient manner. The model relies on a series of steps for the development of backhaul routes:

- Identification of existing fiber points of interconnection (POIs). This is accomplished using publicly available data that identifies whether a LEC end office provides fiber based services. These POIs are designated as the interface between backhaul (second mile) and middle mile transport (see Attachment 6 of the Broadband Assessment Model (BAM) Model Documentation).
- Association of 4G cell sites to the nearest existing fiber point of interconnection (POI). The 4G Node 3 sites are assigned to the nearest POI to create the initial spatial relationship (‘parentage’) that is most likely to provide least cost backhaul routing.
- For Node 3 sites subtending the same POI, the establishment of backhaul routes uses a spanning tree approach based on shortest distance routing to the POI. Beginning with the most distant Node 3 site, each site is routed to next closest cell site using the lowest cost transport medium (subject to performance parameters of that medium). In most instances, microwave was the lowest cost transport when user established threshold constraints were not met (see below for more detail on microwave constraints).

An example of the implementation of the CostProWireless model logic for backhaul is shown below. The typical result is a site backhaul configuration that uses microwave beginning at the ‘edge’ of the unserved area and converting to fiber when microwave threshold constraints are reached.

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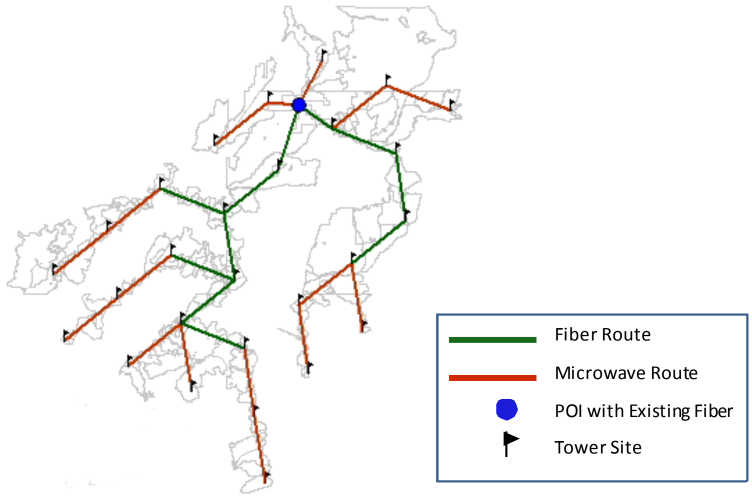
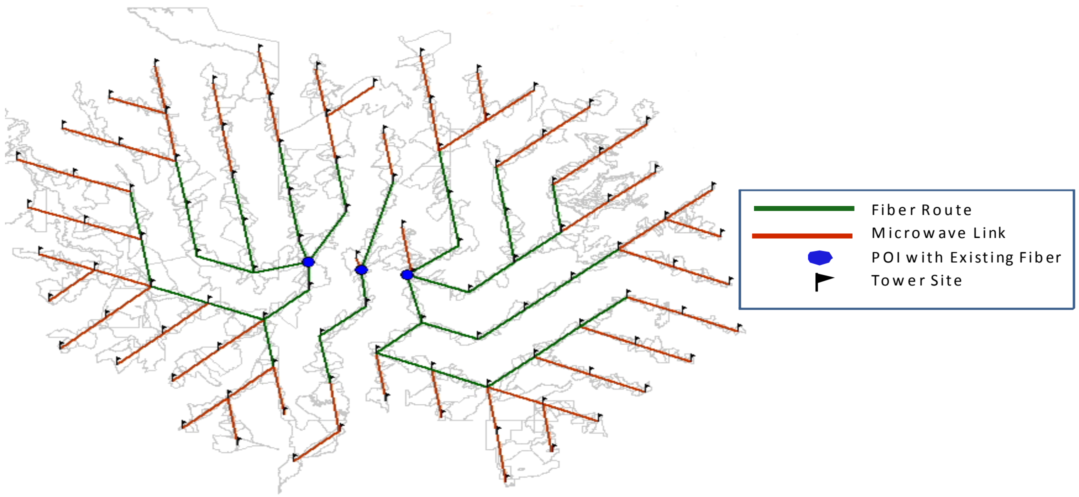


Here is an example of backhaul in a multi-POI unserved area



The use of microwave backhaul is subject to a link distance threshold. For this model, the maximum microwave link distance was set at 20 miles. If maximum link distance is exceeded the model assumes the site needs to be served by fiber.

The 4G backhaul design is sensitive to the aggregate demand associate with sites in an unserved area. The methodology used is based on threshold capacity of microwave links over differing distances. The use of microwave backhaul is also subject to a threshold for parameter for the number of microwave links that can be supported at a single tower. This is a user selectable parameter. If the parameter is exceeded at a site, the model assumes the site needs to be served by fiber.

Output to BAM

Once the CostProWireless® processing is complete, two files per state are stored in the BAM databases. The DIST file contains information about the census blocks, including the HTCell ID. The FDR file contains information about the HTCell and the backhaul components.

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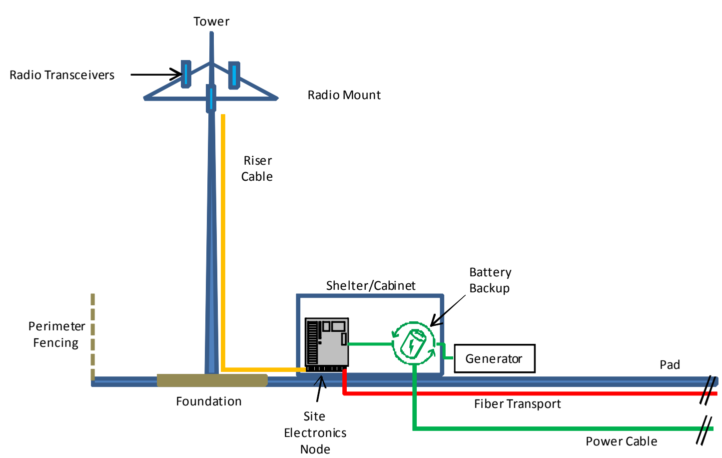
BAM Processing

Site Design and Investment

With the CostProWireless® topology/design complete, BAM uses a uniform design set of equipment and investment components for developing costs associated with the deployment of 4G wireless coverage at each site. Since the model incorporates the use of some existing infrastructure (e.g., existing tower locations assumed to be available for commercial lease) certain equipment or investment may not be necessary at a 'brownfield' site. Certain investment may also be different at a 'brownfield' and a 'greenfield' site (e.g., zoning, site improvements, utility access, etc.). Following is a summary of the key components used in 4G wireless site design. This diagram is a depiction of standard 'greenfield' site equipment and structure components.



Radio Access Network (RAN)

This category incorporates site costs specific to the radio access function. Equipment in this category includes site based radio control, antenna costs, antenna cabling, radio frequency (RF) engineering and optimization.

Depending on the demand density associated with a given site, the antenna array may be different and antenna costs are adjusted accordingly. The determination of the antenna array is typically defined as follows (can be adjusted in the CAPEX User Input workbook):

C = Capacity of single sector 10 Mhz network
S = Total spectrum available
Npop = Total population covered by site
Ncells = Number of cells required to cover area

$$\text{If } \overbrace{\frac{\text{Npop * Take Rate * Busy Hour Load}}{\text{80\% * C}}}^{A} <= (S/10)\text{, Then deploy A * 10Mhz Single-sector site}$$

$$\text{Else If } \overbrace{\frac{\text{Npop * Take Rate * Busy Hour Load}}{\text{80\% * 3C}}}^{B} <= (S/10)\text{, Then deploy B * 10Mhz 3-sector site}$$

$$\text{Else deploy Ncells} = \frac{\text{Npop * Take Rate * Busy Hour Load}}{\text{(S/10) * 80\% * 3C}}$$

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Channel spectrum size is user controllable and will also impact the level of RAN investment that is applied in the model.

Towers

This category incorporates site costs specific to site preparation, tower structure, construction, and power necessary to support the radio access network. Equipment and investment in this category include site acquisition, zoning, fees permits, design and civil engineering, site preparation, tower, tower installation, utility connections, and on-site power supplies. Land is assumed to be leased.

For 'brownfield' sites where an existing tower is leased, costs associated with tower structure and erection are excluded. Certain other costs associated with leasehold improvements, permits, and project management are included but are less than what is incurred at a 'greenfield' site.

Huts:

This category incorporates site costs specific to the shelter or 'hut' that is associated with most sites to house certain electronic equipment, power control, and battery power supplies. Most of these 'huts' are prefabricated and subject to minor modifications to support site specific needs. Equipment and investment in this category include the hut, any modifications or retrofits to the hut, the foundation the hut is placed on, and the cost of placing the hut.

Backhaul:

Based on the aforementioned parameters utilized in CostProWireless®, the model develops backhaul investment based on the medium (fiber or microwave) used for transport:

Investment in second mile fiber backhaul is based on Ethernet over a passive optical network (Ethernet PON). Fibered Node 3 sites have PON equipment that is connected via fiber to an Ethernet edge router assumed to be collocated with the POI. For the fiber links the model computes a cost for fiber material and placement. Investment is developed and allocated thru the following steps:

- The distance of the fiber route is attributed to each tower based on the cumulative potential customers than can use the route.
- For fiber electronics, the model places an Ethernet edge router at each fibered tower location.
- For the fiber placement, the model assumes conduit and poles already exist and does not assign additional costs for conduit and pole attachments. However, the model does compute a cost for fiber and related trenching for the portion that is assumed buried.
- Finally, the model allocates the fiber backhaul cost to each census block based on the proportion of potential customers in the census block (as compared to the total potential customers in the POI serving area).

Investment in microwave is done on a per link basis (i.e., antennas and equipment at both ends of a microwave span are combined to form a link cost). Each link cost is attributed to the location of the tower site requiring microwave. The model then allocates the microwave cost to each census block based on the proportion of potential customers in the census block (as compared to the total potential customers in the Node 3 serving area).

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Network Core Design and Investment

For the purpose of this model, the core network functionality is based on user input. Currently, the value is based on a percentage of total RAN investment. As such, the development of costs at a CB level follows how the RAN investment is attributed.

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Glossary

Term/Phrase	Definition and Issues Relevant to FCC BAM
Broadband	Generally used to refer to a high data rate internet access capability typically contrasted with dial-up access using a 56k modem. The general term of broadband includes a variety of speed tiers ranging from 768kbps and greater (768kbps, 1.5mbps, 3.0mbps, 6.0mbps etc.) BAM is designed to model revenue and costs in a discrete range of broadband speed tiers.
CostPro® and CostProWireless®	Network infrastructure modeling applications developed by CostQuest Associates, Inc.
Middle Mile	High capacity transport connections between a service provider's network core and its second and last mile network. In the BAM the Middle Mile reaches the point of interconnection (which is a designated existing fiber location) with second and last mile network built for unserved areas.
Second Mile	Transport connections between the Middle Mile and Last Mile. In the BAM the Second Mile is the transport between Middle Mile connection and network nodes (e.g., 4G base station sites) providing Last Mile customer connections.
Last Mile	This is the link between the customer (end user) and the service provider's network node. Also referred to as a local loop, in a 4G network this connection is achieved by radio interface.
Augmentation	Refers to an area for which broadband must be installed or increased to accommodate the defined broadband need. Also refers to the required incremental network modeled to provide service and the related capex and opex costs and revenues.
Greenfield	A term used to describe the situation where service is provided to an area where, to this point, there has been no such service.
Brownfield	A term used to describe the situation where service is provided to an area where related services exist but not in a sufficient capacity or feature set.
Census Block	The smallest geographic unit used by the United States Census Bureau for tabulation of 100-percent data (i.e., data collected from all houses, rather than a sample of houses). Within the BAM the census block is the most granular geography for which service availability is assessed.
Market Area	A collection of census blocks that represent a larger relevant collection of households / subscribers and potential business customers. Market areas can be census block groups or census block tracts, are often defined by geo-

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	political boundaries (e.g., counties, states, trading areas), and can also be defined by carrier service areas (e.g., franchise areas, license areas, wire centers, study areas).
Opex	Operating expenses generally experienced by broadband providers including network related operating costs, sales and marketing costs and a wide range of administrative costs (including bad debt).
Capex	Capital expenditures representing the investments required to design and install communications facilities – including the related cost of money associated with capital investments.
3G	Third generation wireless technology – digital broadband technology still being introduced in parts of the country providing bandwidth in a range of… allows the simultaneous use of voice, data, and video on a wireless network and includes technology standards such as GSM EDGE, UMTS, CDMA2000 and WiMAX.
4G	Fourth generation wireless technology based on Long Term Evolution (LTE) and WIMAX standards –is advanced digital broadband just emerging in domestic markets
GIS	Geographic Information System – computer applications involving the storage and manipulation of maps and related data in electronic format
POI	Point of Interconnection – in this document, a physical location that allows an 4G service provider to access the fiber network of another carrier (typically a local exchange carrier) in order to lease fiber transport capacity.
QoS	Quality of Service – a measure of the quality of telephone service provided to a subscriber which embraces a wide range of specific definitions depending on the type of service provided
IP	Internet Protocol – a protocol describing software used on the internet that routes outgoing messages, recognizes incoming messages and keeps track of address for different nodes
VoIP	Voice Over Internet Protocol – a process of sending voice telephone signals over the internet which involves converting signals to digital format and the development of information packets when the initiating signal is analog
Capacity Threshold	A threshold demand level based on total demand at an existing fiber fed POI

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BAM Attachment 7 – Middle Mile Approach

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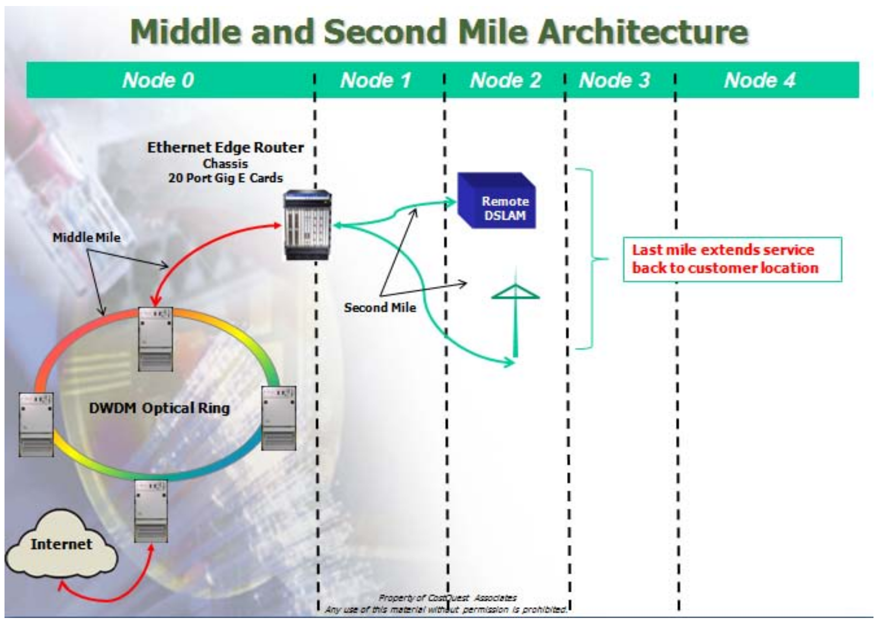
The middle mile methodology and approach uses components of the CostPro platform. As outlined in the full Broadband Assessment Model (BAM) Documentation and the related glossary, the *middle mile* is that portion of the network that provides a high capacity transport connection between a service provider's network core and its second and last mile network. More specifically, in the BAM the middle mile is assumed to extend between the service provider's point of interconnection with the internet and the service provider's point of interconnection (an existing fiber node) with the second and last mile network built for unserved areas. This relationship is illustrated in the schematic provided here.



The material that follows provides additional information on how middle mile costs are developed within the BAM.

The approach used to determine middle mile equipment required – and then to compute the related investment costs – is centered in the spatial relationship between the service provider's point of interconnection (POI) with the second and last mile network (designated as a telco central office or a cable headend) and the service provider's access to a Tier 3 internet gateway (a surrogate for such access is assumed to be on a regional access tandem ring).

Central Office Location: the location of each central office (also referred to as POIs, CLLIs and/or Node0s) is obtained from the FCC's TeleAtlas wire center boundaries database. In those situations where there was no central office identified in a wire center boundary, a NECA 4 location point is used. And in those cases where there was no NECA 4 point available, BAM uses the centroid of the wire center. The results of this approach align with the central office/Node0 locations used in the underlying CostPro model used to create the broadband network overall, including last and second mile related equipment and investments.

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

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The underlying logic (and the process) of developing middle mile investment requirements is grounded in the assumption that the Tier 3 internet peering point is located on the RT ring – meaning that if the modeled design ensures each Node0 is connected to an RT ring, the corresponding Node0 customers all have access to the internet.

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

- The Middle Mile process is run state by state. All CLLIs in a state are homed to an RT in that same state
- Within a state, each Node0 (CLLI or POI) is assigned to its nearest RT (Node00) to create the initial spatial relation of (read "parentage") Node0s to RTs.
- Node0 records are then routed to other Node0 records with the same Node00 parent using a spanning tree approach based on the shortest (most efficient) distance routing back to their proper Node00 record.
- The Node00 records within the same LATA are routed together in a ring. To ensure an efficient (and hence 'most likely') design the shortest ring distance is used. The shortest ring is chosen by starting at each Node00 point and storing the ring distances. After stepping through each potential ring route, the shortest ring distance is then used for further computations.

With that information in hand, the BAM develops middle mile costs thru the following steps:

1) The distance of the RT rings is attributed to each Node0 on the ring in proportion to the number of potential customers at each Node0 as compared to the total potential customers for all the Node0s attached to the RT Ring.
2) The distance on the Node0 tree back to the RT is attributed much in the same way as the routing to DSLAMS is attributed. That is, BAM attributes each route based on the cumulative potential customers that can use the route.
3) For electronics, BAM places a DWDM (fiber mux) at each RT and an Edge router at the Node0 location.
4) For the fiber placement, BAM assumes conduit and poles already exist and does not assign additional costs for conduit and pole attachments. However, BAM does compute a cost for fiber and related trenching for the portion that is assumed buried.
5) For the fiber, for trenching and for the DWDM, BAM captures 1/3 of the costs (2/3 of the costs are assumed to be absorbed by uses other than BAM broadband services, e.g., special access applications and legacy voice transport)
6) Finally, BAM allocates the middle mile cost out to each census block (the basic unit of geography in BAM) based on the proportion of potential customers in the census block (as compared to the total potential customers in the wire center/node0 serving area).

As with any modeling approach, embedded in the middle mile costing process are certain assumptions for which one might have an alternative view. The more significant debatable issues in the middle mile computations would include the following:

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a) Fiber and related trenching costs are assigned on an equal basis across three broad product lines: voice, data and broadband. This "1/3 each" assumption can be seen as overly broad at the micro level – but within the scope of BAM is employed as a workable / reasonable approach.
b) The electronics used at RT sites (DWDM transport gateway) and Node0 locations (Ethernet switch) are assumed commercially available configurations and costs for multi-service support.
c) Within the BAM logic spanning trees are used to connect Node0s to RTs. To this point, one may argue that that these connections should be made via rings. The BAM includes a tree to route adjustment factor (that attempts to estimate the cost impact of converting from trees to rings). However, even with the adjustment factor, current BAM logic assigns costs in greater proportion to Node0s that are further away from the RT.
d) At a more fundamental level, an additional argument could be made that more or less reliance should be placed on legacy LEC hierarchical network routes in developing Node0 to RT paths. These arguments will of course tend to impact augmentation costs in both directions, depending on one's view.
e) And in a related argument, one might argue that the incremental traffic associated with introducing broadband service to currently unserved areas is insufficient to cause additional costs (i.e., trigger additional investment) in the middle mile – other than the cost of providing an additional port on the existing transport network.

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BAM Attachment 8 – Opex Input Sources

The opex input sources are scheduled below.

- Yankee Group – Cable, Telco, Wireless
- Gartner Group – Cable, Wireless
- Pike & Fisher – Telco
- SnL Kagan – Cable, Wireless
- Insight Research Corporation – Telco
- FCC ARMIS Data – Telco
- FCC NECA Data – Telco
- Telecommunications Industry Association (TIA)
- CTIA – International Association for Wireless Telecomm
- Verizon's 9/27/2006 FiOS Presentation to Shareholders
- Standards & Poor
- RIA
- Moody's
- Pioneer Consulting; Wireless Backhaul 2007 – 2012: Role and Significance in Cellular Markets; May 2007.
- Data/Analysis FCC Nat'l Broadband Task Force
- Standards & Poor
- RIA
- Moody's
- Public Financial Statements
- Pioneer Consulting; Wireless Backhaul 2007 – 2012: Role and Significance in Cellular Markets; May 2007.
- LTE Business Case; AltmanVilandrie & Company; January 26, 2009.
- Cost Optimization For Transmission and Backhaul Technologies, Accenture.
- Other related industry analysis and publically available information
- Public Financial Statements

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BAM Attachment 9 – Gompertz Penetration Rate

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Penetration Rate Analysis

In order to determine penetration rates of new broadband deployments in unserved areas, we chose to perform a combination of several statistical and regression analyses. Our primary data source was a table of Home Broadband Adoption metrics from the Pew Internet & American Life Project. Since 2001, the Pew Research Center has conducted extensive, anonymous phone surveys on broadband adoption in the United States, breaking out responses by various demographics. Their surveys reveal positive and negative correlation factors between certain demographic characteristics and broadband adoption[1]. The Pew study notes the most significant factors are, in order of importance:

Positively Correlated	Negatively Correlated
Income greater than $100K	Less than high school education
Income between $75K – $100K	Senior citizen (65+)
College degree or greater education	Rural
	High school degree only

We obtained the results of the Pew study on broadband adoption covering 19 survey periods from October 2001 to November 2009. This data aggregated adoption percentages in each period by the following demographics:

- Overall
- Race
- Income
- Age
- Education Level
- Rural or Non-Rural

Preliminary findings of the data revealed that the trends in broadband adoption matched those of standard technology adoption lifecycles. Our approach to this analysis was to understand the shape and characteristics of the Pew adoption curves in an attempt to model the results into a mathematical model, by which future broadband adoption could then be measured. We began by examining two popular mathematical models used to forecast technology adoption: the Fisher-Pry model and the Gompertz model[2]. The table below highlights the differences between the two.

---

[1] Horrigan, John. Home Broadband Adoption 2009. Pew Internet & American Life Project: June 2009. http://pewinternet.org/Reports/2009/10-Home-Broadband-Adoption-2009.aspx

[2] Vanston, Lawrence K. and Vanston, John H. Introduction to Technology Market Forecasting. Austin, TX: Technology Futures, Inc, 1996.

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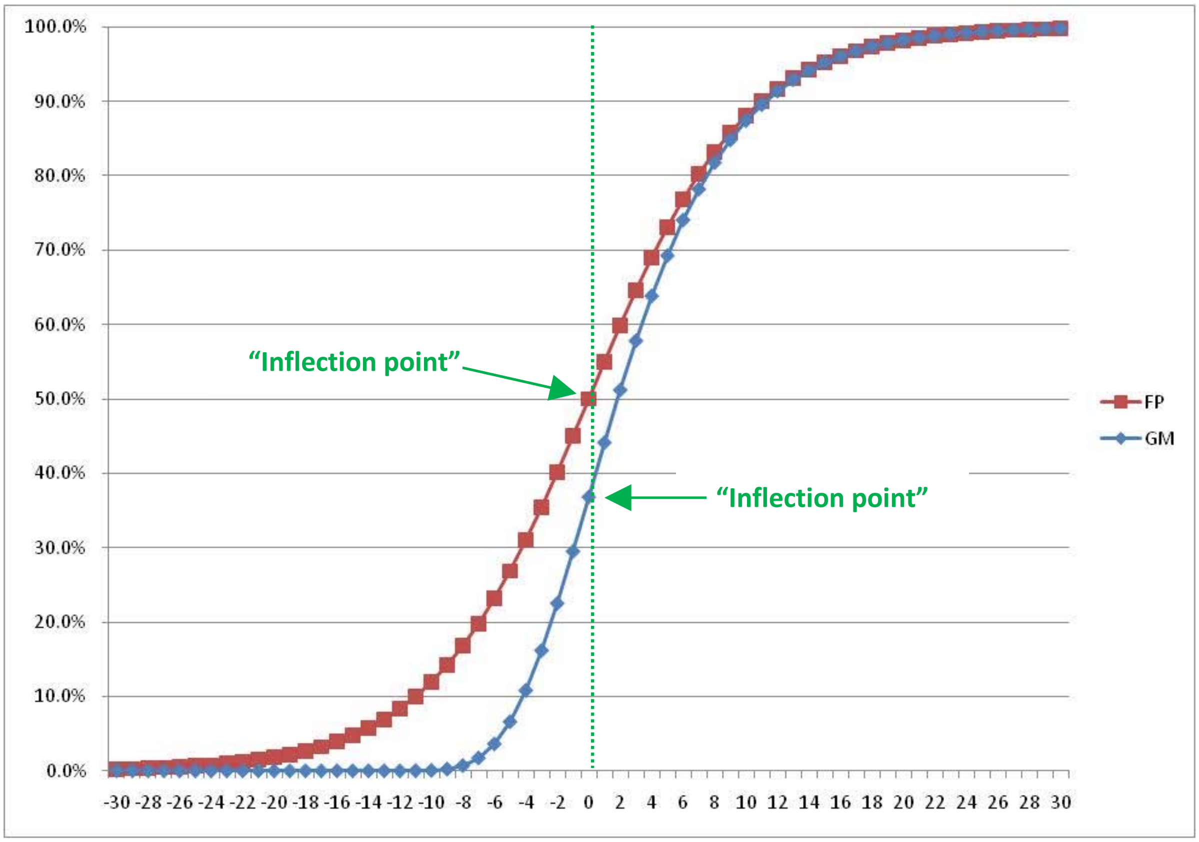
Model	Equation	When Used	Examples
Fisher-Pry	$y = \frac{1}{1+e^{-b(t-a)}}$	When substitution is driven by superior technology. The new product or service presents some technological advantage over the old one.	Internal combustion engine, telegraph, light bulbs
Gompertz	$y = e^{-e^{-b(t-a)}}$	When substitution is driven by superior technology, but purchase depends on consumer choice.	Digital television, mobile phones

The table below illustrates the <u>cumulative</u> characteristics of the two models as a percentage of the installed base:



From an <u>incremental</u> standpoint, the period-to-period technology adoption unfolds as follows:

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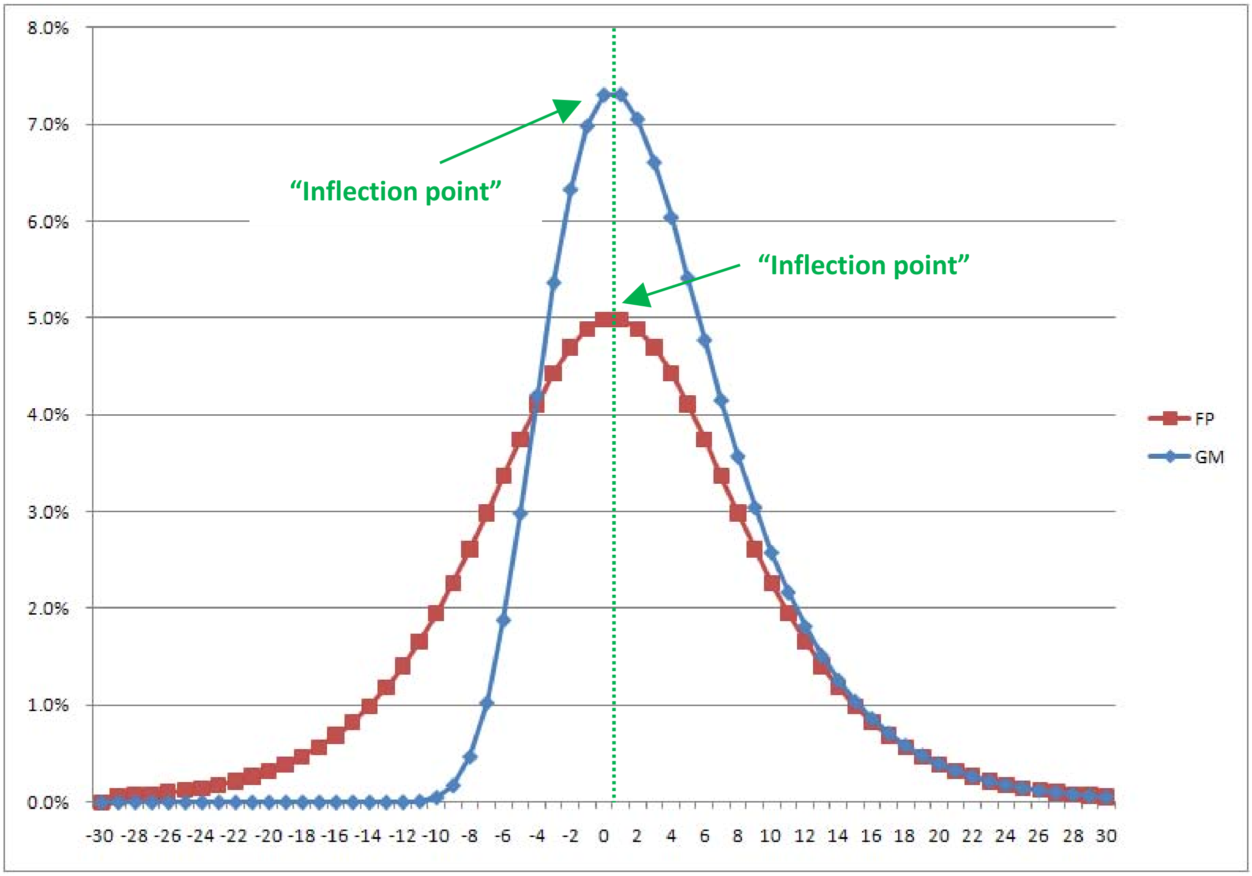

Both models have a characteristic “inflection point” – that is, the point at which the incremental curve is maximized and the cumulative curve flips over[3]. The inflection point should be considered the point where technology adoption reaches its maximum growth rate. The characteristics of the Fisher-Pry and Gompertz models are indicative of the assumptions underlying each model; that is, the Fisher-Pry model reflects revolutionary displacing technology, while the Gompertz curve supports incremental technology change[4]. Consequently, the Fisher-Pry model will inflect at a higher cumulative percentage (50%) than the Gompertz model (36.8%). Also, the adoption will scale much earlier within the chosen timeframe in the Fisher-Pry model than the Gompertz model. Our decision on which model to use for broadband adoption is predicated on how broadband is perceived in the market: is it a revolutionary technology or an iterative one? As innovative as broadband technology has become, it is at its core a replacement for dialup technology (albeit one that is faster and allows access to a larger subset of the Internet). Ultimately, the choice of whether or not to adopt broadband is a consumer choice: broadband, dialup, or nothing? Only the consumer can decide what fits his or her particular needs. Contrast this decision to the light bulb, the antithesis of consumer choice. All things considered, we chose to forecast broadband adoption with the Gompertz model for purposes of this analysis.

[3] Geometrically speaking, the inflection point on the cumulative curve is the point at which the curve moves from convex to concave. For both the Fisher-Pry and Gompertz models, the slope of the tangential line along the cumulative curve is highest at the inflection point, indicating maximum acceleration of adoption.
[4] Vanston, Lawrence K. and Vanston, John H. Introduction to Technology Market Forecasting. Austin, TX: Technology Futures, Inc, 1996.

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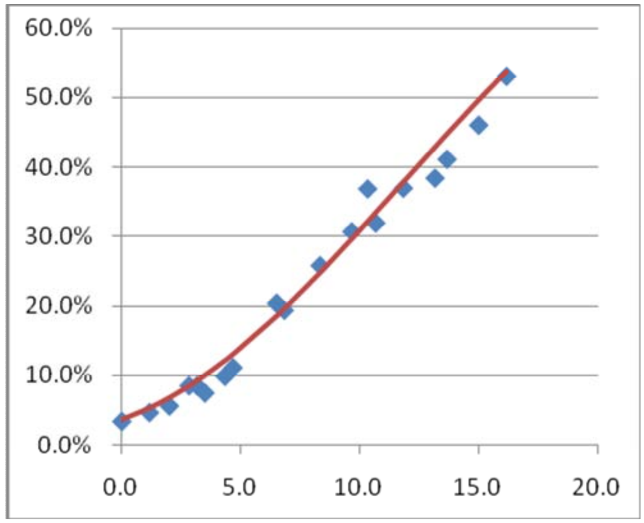
Our analysis of the Pew data consisted of fitting each demographic data breakout (Overall, Race, Income, Age, Education Level, Rural/Non-Rural) into a Gompertz curve using a least squares approach[5]. With a semiannual time period adjustment, the results indicated the Pew data segments could be fit on a corresponding Gompertz cumulative curve with very reasonable least squares accuracy. One such curve fit for a particular demographic (rural populations) is shown below.

Date	period Δ	t	y	GM	LSQ
Oct-01	0.0	0.0	3.4%	0.036610	0.00001
May-02	1.2	1.2	4.7%	0.053224	0.00004
Oct-02	0.8	2.0	5.6%	0.067895	0.00014
Mar-03	0.8	2.8	8.5%	0.084641	0.00000
May-03	0.3	3.2	8.5%	0.092044	0.00005
Jul-03	0.3	3.5	7.5%	0.099810	0.00064
Dec-03	0.8	4.3	9.8%	0.120849	0.00050
Feb-04	0.3	4.7	11.1%	0.129989	0.00036
Jan-05	1.8	6.5	20.4%	0.184940	0.00035
Mar-05	0.3	6.8	19.4%	0.195487	0.00000
Dec-05	1.5	8.3	25.8%	0.247372	0.00010
Aug-06	1.3	9.7	30.7%	0.296037	0.00011
Dec-06	0.7	10.3	36.8%	0.321099	0.00223
Feb-07	0.3	10.7	31.9%	0.333934	0.00022
Sep-07	1.2	11.8	36.9%	0.378052	0.00008
May-08	1.3	13.2	38.4%	0.428415	0.00199
Aug-08	0.5	13.7	41.1%	0.447254	0.00132
Apr-09	1.3	15.0	46.0%	0.495999	0.00130
Nov-09	1.2	16.2	53.0%	0.537326	0.00005
					0.00949
			a =	11.6	
			b =	0.10	
			period =	182.6 days	<< *semiannual*



To the right is a table with the survey date, period delta, time (t) in semiannual periods, Pew results for rural populations (y), the assumed Gompertz value (GM) given the ***a*** and ***b*** values shown in yellow, and the squared difference value between (y) and (GM). The process begins by performing iterative analysis to randomly select ***a*** and ***b*** coefficients simultaneously. The process stops after all possible value ranges for ***a*** and ***b*** have been exhausted. The combination of ***a*** and ***b*** values that minimize the sum of the least squares represents the best fit of a Gompertz curve for rural populations. This particular demographic analysis yields a least squares sum of 0.00949. The graph to the right shows the actual Pew numbers (y) represented by the blue points, while the Gompertz curve fit (GM) is represented by the fitted red line. The fit to the observed data can be visually inspected here.

Our analysis provided us with Gompertz curves by demographic. However, consider that the Pew research starts with an arbitrary date of October 2001. This date does not presume the "start" of broadband; it only represents the date at which surveys began. Therefore we must provide a time-based adjustment for every demographic curve. The solution we determined as most appropriate was to develop a series of demographic adoption curves *relative* to the overall adoption curve. The graph below illustrates the relative Gompertz curve fits for every demographic segment. Here, the overall adoption curve inflects at zero on an adjusted time scale.

[5] The best fit, between modeled data (Gompertz) and observed data (Pew), in its least-squares sense, is an instance of the model for which the sum of squared residuals has its least value, where a residual is the difference between an observed value and the value provided by the model.

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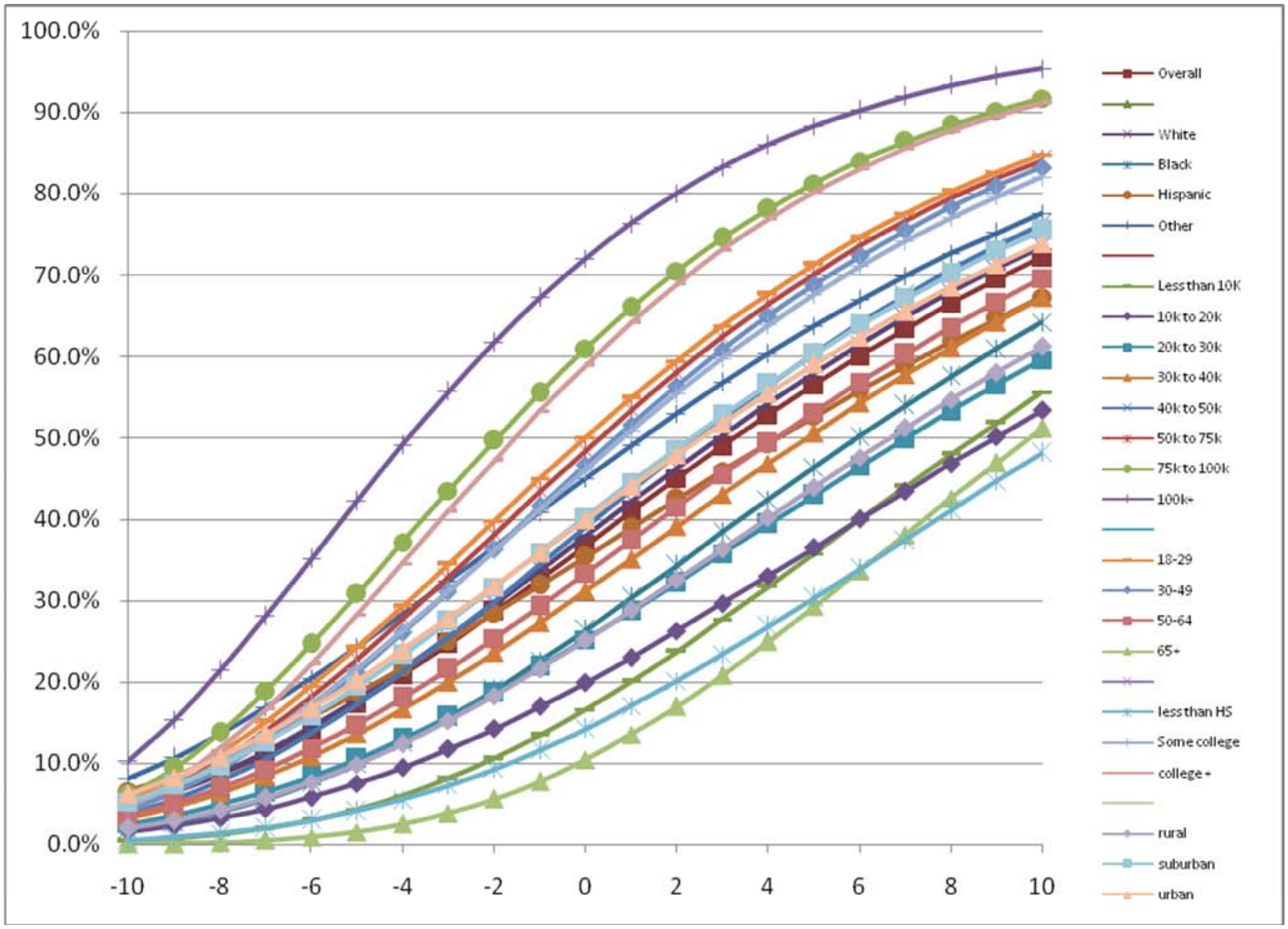

Reinforcing the conclusions of the Pew study, the Income over $75K and College or Greater Education curves are farthest to the left (representing more rapid adoption relative to the mean), while the High School or Less, Rural, and 65+ curves are farthest to the right (representing slower adoption relative to the mean).

It is noteworthy to mention these curves, because they are based upon a nationwide introductory broadband rollout where services have not yet been deployed, represent a Greenfield build. In Brownfield deployments, however, builders are leveraging previous deployments to capture consumers who have already been educated on the benefits of broadband. We therefore allow for an additional time adjustment where Brownfield builds are taking place. This adjustment is discussed later.

These results provide relative Gompertz curves by every demographic measured in the Pew study; however for a number of reasons, we chose to limit the prediction model to only the demographic factors with the largest positive and negative correlation to broadband adoption. While it would technically be possible to measure adoption changes across all the available demographics on the Pew study, it is not cost effective to do so – either the remaining demographics had minimal influence on broadband adoption, or the demographic data in question was not readily available at the census block level.

The census block demographic variables we chose as to predict broadband adoption are the following:

- Income greater than $100K
- Income between $75K – $100K

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- College degree or greater education
- Senior citizen (65+)
- Less than high school education
- Rural
- High school degree only

Using the Gompertz coefficients for each demographic, combined with demographic data at the Census block level, we can build Gompertz curves for every Census block in the nation. To build these custom curves, we weight the demographic Gompertz coefficients (***a*** and ***b***) by the incremental demographics prevalent in the area. For example, if the demographics within the overall curve show 18.5% of households have incomes above $100K, but a particular census block contains 20% households with over $100K income, each "Over $100K" Gompertz coefficient would be weighted by the incremental difference (20% – 18.5% = 1.5%) and added to the overall Gompertz coefficient. By summing up the weightings off each significant variable, our Gompertz equation for each census block would take shape.

The additional step in forecasting broadband penetration rate is to determine how to factor in a Brownfield effect, if any, into the census block time coefficient (***a***). If the Census block was revealed to have a prior broadband deployment, the census block curve would be shifted left a designated number of periods. The number of periods to shift is held constant across all Brownfield deployments.

The final step of developing the census block curve was to determine where to set the inflection point. The zeroed scale is intended to represent the point at which the overall curve inflects, but the time at which the scale hits zero must be determined. The FCC initially chose this scale to be 2 years from the start of deployment; essentially, the overall broadband adoption would reach its maximum growth rate in 24 months. To account for the initial mass influx of customers in the first 24 months, we chose to start with zero subscribers at initial deployment, then trend towards the number of subscribers at 24 months by dividing them into four equal 6-month periods of subscriber adoption. After 24 months, the penetration rates reflected in the Gompertz curve would be in effect. The selection of an inflection point, while initially set at 24 months, is one that can potentially be re-examined and adjusted as needed.

Additional Factors

The resulting census block penetration rate determines the standard broadband adoption rate for that census block. It does not, however, factor in the subscribers of related services (voice, video), the effect of bundled services, or the stratification of tiering (basic vs. premium). To account for each of these we developed factors from which we could adjust the baseline number of expected broadband adopters in every census block. Each factor is discussed below.

Scaling Factor

A scaling factor, in this instance, refers to a multiplying factor developed to predict voice and video subscribers by technology (DOCSIS, FTTp, FTTn, FTTd, and Fixed & Mobile Wireless) based on the number of broadband subscribers. The presumption is that each technology exhibits a constant and unique relationship between broadband subscribers and subscribers to other services like voice and video. In other words, if you know the number of broadband subscribers for a particular technology, you can predict the number of voice or video subscribers as well. Our analysis of industry data affirmed that this relationship is constant and unique for each technology. In this sense, broadband leads the way for technology adoption of ancillary services.

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Bundling Percentages

Customers who subscribe to broadband services belong to one of two groups: those that purchase a la carte, or those that purchase as a bundle. Industry analysis confirmed that the relationship between the two subscriber bases is relatively constant for each technology. Using this data we developed a "bundling" percentage based on the broadband subscribers to arrive at the number of bundled subscribers. The number of bundled customers could then be subtracted from the total number of voice and video subscribers to arrive at the number of a la carte subscribers for each.

Tiering Percentages

Tiering, in this case, refers to the tiered services offered by carriers. To limit unneeded complexity we limit the number of tiers in the model to two levels: an introductory, basic level of service; and a "top-shelf" premium service. These low/high tiers are applicable to video (for example, basic vs. premium cable), data (entry-level vs. top-speed), even bundles. Using industry data we were able to develop percentages by technology which break out the respective service subscribers into low-end and high-end tiers. These "tiering" percentages were then applied to the number of broadband, video, and bundled subscribers to arrive at low-tier subscribers and high-tier subscribers for each.

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FCC BAM USER MANUAL

Developed by CostQuest Associates

December 2009

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Contents

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Introduction and Overview

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This document provides a user of the FCC's Broadband Assessment Model (BAM) an understanding of how to interact with the BAM to generate output to serve the user's interests in support of federal agency and congressional policy considerations relevant to the deployment and adoption of broadband. To ensure a complete understanding of the model goals and underlying assumptions the BAM User Manual should be read in conjunction with the BAM Documentation. The User Manual is not intended to be a technical model administration manual. As much of BAM processing resides in a Microsoft SQL Server 2008 environment, most technical administration is considered within the realm of Database Administration.

The BAM includes a comprehensive collection of inputs, assumptions and modeling logic about where broadband Internet access currently exists across the country – and more importantly, where broadband access does not exist. Further, the BAM develops an estimate of costs (and revenues) that can be expected if infrastructure in areas currently unserved is augmented to provide broadband coverage based on a variety of assumptions (primarily speed and technology).

The BAM processes model scenarios (defined by a set of user selections) to develop an expected economic contribution margin for augmenting (i.e., bringing service to) unserved areas. Three technology options (across a number of different topologies) are considered within the BAM: wireline (e.g., DSL), wireless (both fixed and mobile) and cable.

The schematic here provides an overview of the BAM flow for gathering inputs, processing solution sets and generating reports.

Setup and System Requirements

The BAM has been developed in two components. A very thin 'client' which runs on a standard Windows PC (tested under Microsoft Windows XP or later supporting the .Net 3.0 framework) and a database server (which runs on Microsoft SQL Server 2008.

The client application is a small executable. It has no installation requirements other than the .net framework. The first time it is run it will prompt the user for the name of the database server to log into. The application is precompiled using named user (SQL Authentication) security. If a user wants to import solution sets (described later in this manual), they will need Microsoft Excel on the computer from which they are running BAM.

Solution Set

A Solution Set is a collection of output data processed by the model based on user defined settings and Input Collections. Specifically, Solution Set output (processed data) is a function of the user specifying (1) the States to be included in the scenario, (2) the toggle settings that best fit user requirements and (3) the underlying Input Collection consistent with user needs.

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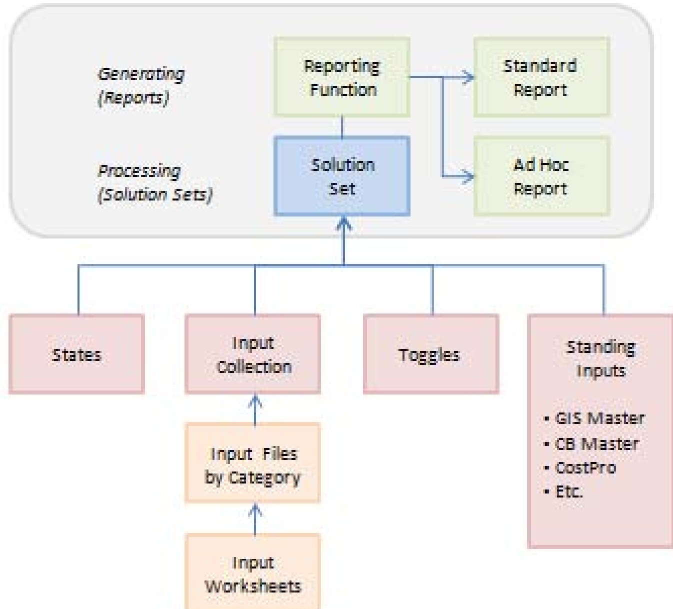
The selection of States is self explanatory. Users can process a single state, a collection of States or the entire 50 state nation plus Washington DC. [The model is designed to accommodate other US territories if/when required input data becomes available.]

The toggle selections enable the user to make decisions such as broadband speed, if the augmentation is performed by a CLEC or not, the study period (in years), an assumed rate of technology adoption (i.e., the inflection point on the Gompertz curve), the number of competitors assumed to be involved with the augmentation and the technology (more specifically, the topology) to be used in the augmentation. The implication of each of these selections is discussed in the full BAM documentation while the process for the user to make these selections is discussed below. These selections are 'dynamic' in that they may change (more toggles added) as the model advances in the weeks ahead.



The Input Collection includes the basic data used in the model, underlying assumptions, and pre-processed information to be used in the scenario being developed. The Input Collection establishes things such as the annual charge factor to be used in the model, the specific version of opex inputs to be used, the property tax array to be used in the model, etc.

As noted above, the user selects the States, the designated modeling parameters (i.e., toggles) and the selected Input Collection. In addition, the processing of data into a Solution Set incorporates a predetermined set of standing data from the GIS Master (technology specific geographic attributes known below the Census Block), the CB Master (demographic attributes known at the Census Block and above level), CostProLoop and other pre-processed data. The user does not interact with these standing (core) elements of the BAM.

Reports

There are two different types of BAM reports: standard (pre-defined) reports and ad hoc reports. The ad hoc reporting routine is still under development as of this version of the User Manual and accordingly is not addressed in detail here. However, the objective with the ad hoc reports is to provide an array of high priority 'selections' for a user to report on – and to allow the user to make selections on these reportable elements to fit specific needs.

Standard (pre-defined) reports are also highly customized – but they are pre-defined (i.e., custom built) by the user (or administrator) and maintained within the BAM model structure as a report option. As illustrated in the screen shots below, the user will select a standard pre-defined report from a drop down menu.

Queue

Within the BAM model Solutions Sets are processed and Reports are generated through a queue. This element of the model provides for the staging of a Solution Set to be processed and/or a Report to be generated. Generally, a processed Solution Set is not accessible by users. Processed data (in a Solution Set) is accessed through a report.

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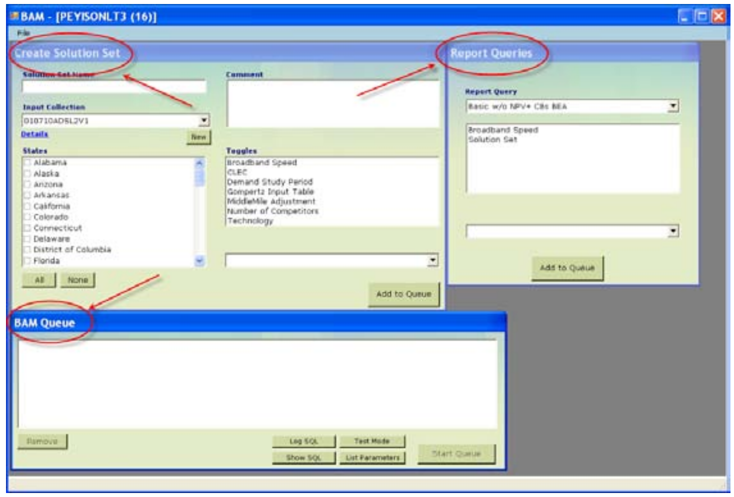
Step-by-Step



Specific processing steps and illustrative screen shots are provided below.

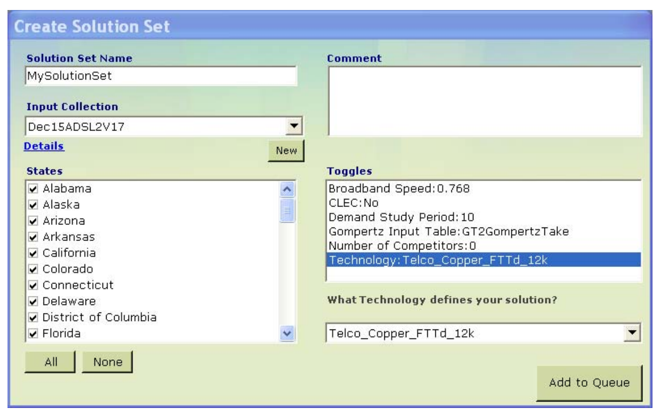
The main (first) screen that appears when you open the BAM includes the three primary functions involved in working with the BAM:

- Defining a Solution Set
- Defining a Report
- Queue

Selecting or Defining a Solution Set

As noted above, a Solution Sets has three main components: a defined set of States, a specific set of model parameters controlled by choice of toggle settings and a designated Input Collection. Multiple Solution Sets exist in the model. A user can either select an existing Solution Set for processing or they can create a new Solution Set. See below for information on managing Solution Sets.

When establishing a new Solution Set the first step is to create a unique name for the new Solution Set. This is done in the upper right-hand corner dialogue box in the "Create Solution Set" BAM window. When a new Solution Set is created a Comment section is provided for the user to make notes regarding that Solution Set.



A second step is to select a set of States. This is done in the States area provided. Select **ALL** and select **NONE** options are provide to facilitate the selection process. NONE clears previous selections.

User controlled model parameter elections are made by clicking on a toggle item (e.g., broadband speed, or demand study period or etc.) and then clicking on the desired option in the dialogue box immediately below (or by entering a specific toggle value, as illustrated below).

In the illustration provided here the user has selected the "Telco_Copper_FTTd_12K" option for the Technology toggle. In this example you can also see that previous toggle selections have indicated that the augmentation will not be performed by a CLEC, the study period is 10 years, there will be no ("0") competitors in the augmentation, the Gompertz input table (i.e., assumed rate of broadband adoption) is GT2 and the broadband speed option is set at 768. If the user fails to make a specific election on each and every toggle – a "Please Select Value" dialogue box will appear as a reminder before the Solution Set can be processed (i.e., added to a queue).

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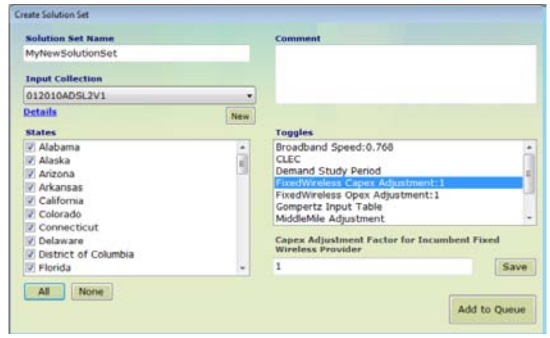
As noted above with certain toggle selections the user is allowed to enter specific values. The screen shot shown here illustrates this functionality for the designation of a FixedWireless Capex Adjustment factor (toggle). The user must click SAVE when entering specific toggle values. This same functionality exists when working with reports as illustrated below.

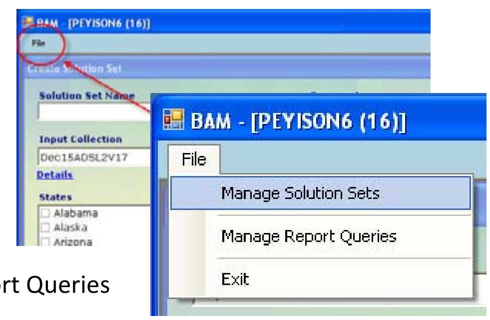


As final step in creating the Solution Set the user will designate an Input Collection. Input Collections are available for user selection immediately below the Solution Set Name box. In the example above (previous page) the Input Collection “Dec15ADSL2V17” has been chosen. See below for information on how to review or create a new Input Collection.

At this point – when the Solution Set has been named, the States have been chosen, the toggles have all been set and the Input Collection has been selected – the Solution Set can be added to the queue for processing. Clicking the **Add to Queue** button inserts the Solution Set name into the Queue area of the main BAM screen. See below for information on processing Solution Sets and generating Reports.

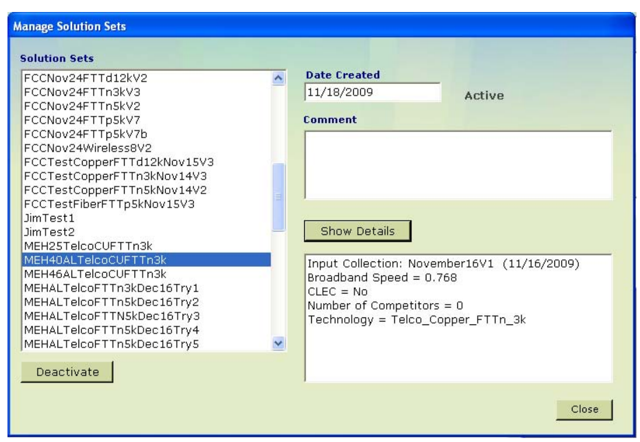
Reviewing and Creating Solution Sets

The BAM will hold multiple Solution Sets. Users can explore / review existing Solution Sets before creating a new one. This is done by way of the File option at the far upper left hand corner of the main BAM screen.



From this point users can elect to manage Solution Sets, manage Report Queries or exit the model.

Clicking on the **Manage Solution Sets** option opens a dialogue as below. From here users can highlight any existing Solution Set and find the date it was created, any comments provided with that Solution Set and most importantly, users can see the underlying ‘detail’ for the Solution Set – including the Input Collection and the toggle selections used.



[Note: in a future release the States included in a Solution Set will be displayed in this dialogue box.]

Outdated Solution Sets can also be deactivated (and reactivated) from this screen. Deactivated Solution Sets are no longer available for processing.

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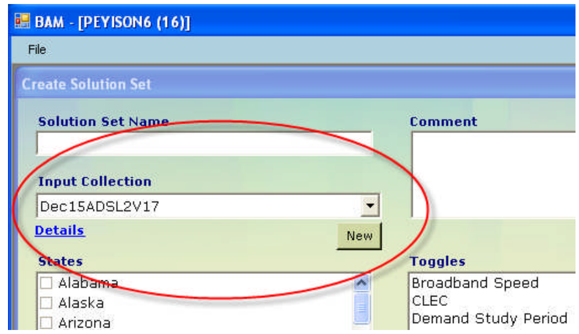
Reviewing and Creating Input Collections

As with Solution Sets, the BAM holds (makes available) a number of Input Collections. As discussed above, an Input Collection is just that – a collection of available input data sets that supply the necessary data (some raw and some preprocessed) and assumption inputs required for processing. Generally Input Collections vary by the 'version' of inputs. Users will typically version their inputs to study different scenarios. An example could be two Input Collections are developed which vary only in the price of certain materials. This allows comparison of output (Solution Sets) given only a change in these known inputs.



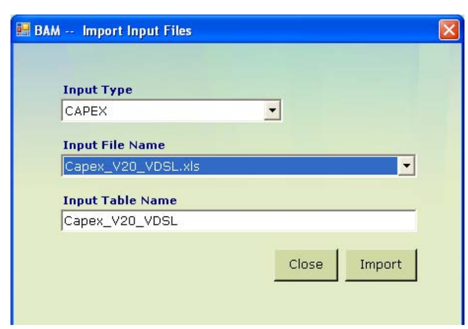
Input Collections can be either (a) reviewed and selected from a list of available Input Collections or (b) created new. To review a selected Input Collection click on the **Details** button. To create a new Input Collection click on New.

If Detail is selected (clicked) a popup panel with relevant detail appears of the form.

If New is selected the dialogue shown here will be opened. From here one can create a new Input Collection by (1) naming the new Input Collection and (2) selecting available Input Table Names for each of the Input Files – that is, for each element of the Input Collection. The process here is identical to the process used for assigning toggle values for a Solutions Set. That process is to highlight an Input File name and then select the appropriate Input Table Name in the box below. In the illustration above the user is in the process of selecting the Capex_V20_VDSL_MDK file to be used as the Capex input file. An Input Table Name selection must be made for each Input File included in the Input Collection. If this is not done a reminder is provided to the user. In addition, a default name is provided based on the filename selected.

When the Input Collection is completed – that is, when all Input Files–Input Tables have been related – click on **Create** to establish the new Input Collection within the BAM structure.

If in creating the Input Collection none of the available/existing Input Tables meet user needs a new Input File can be imported thru this same dialogue box. This applies if there has been a new data version developed that has not yet been incorporated into the BAM. Select **Import New Input Files** to create new Input Tables. With this selection the dialogue box here will be opened. When the appropriate Input Table is selected, click on **Import** to upload the data and in so doing, create the new Input Table. Be aware that the Import function is dependent upon Microsoft Excel.



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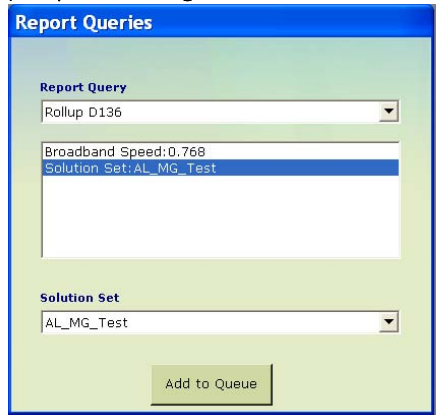
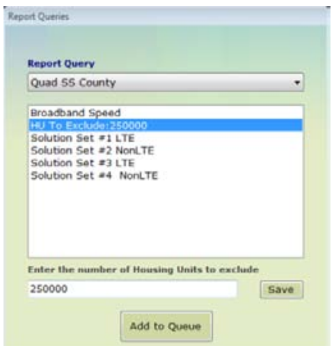
Reviewing or Creating Reports

BAM reports are generated through the Report Queries routine. The dialogue box for this process is located in the upper right hand corner of the main BAM screen (see previous illustration). Reports to be generated can be either selected from an array of existing available reports – or they can be created new.

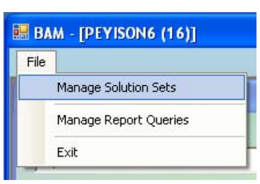


To select an existing Report Query click on the small down arrow in the top section of the Report Query box and select the desired query. When a query is selected the next step is to make selections for the available reporting options from a dynamic (i.e., still evolving) array of Report Query settings. Currently there are two such options for consideration: one for the Solution Set to be used and another for the speed to be used to define "broadband" in the report. As the BAM continues to evolve additional report query option settings will quite likely be made available. The illustration here shows a screen where the user defined broadband as 0.768 by virtue of selecting 0.768 as the report option – and is in the process of designating the AL_MG_Test Solution Set to be used for the report.

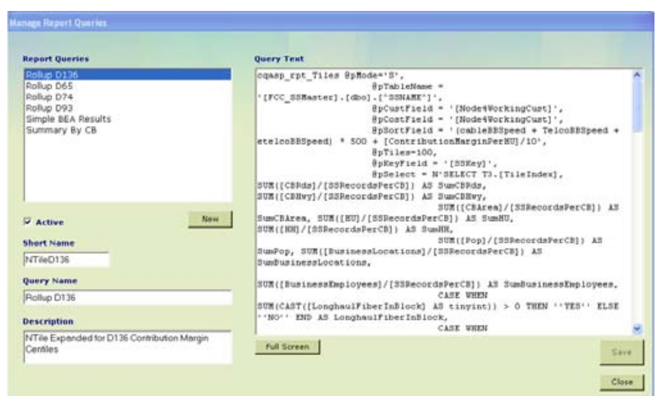


As noted above, consistent with the creation of a solution set certain report query selections allow the user to enter specific values (as illustrated here). When specific values are entered, the user clicks SAVE.

When these two items have been aligned – a specific Report Query with a specific Solution Set and a specific broadband speed – the query can be added to the queue for generation (**Add to Queue**).



If a new Report Query is required – if no existing query will meet user needs – click on **File** in the upper left hand corner and select **Manage Report Queries**. When this is selected the following screen will open. Within this single screen one can name a new query (both short and slightly longer/more explanatory names), provide a brief description of the query and actually write the query in SQL. A Full Screen mode is provided to assist with developing the Report Query itself.



When the new Report Query is completed click **Save** to retain it in the BAM.

Also, an existing Report Query can be made active or inactive within this screen. Only active Report Queries appear in the main screen dialogue for user selection and processing.

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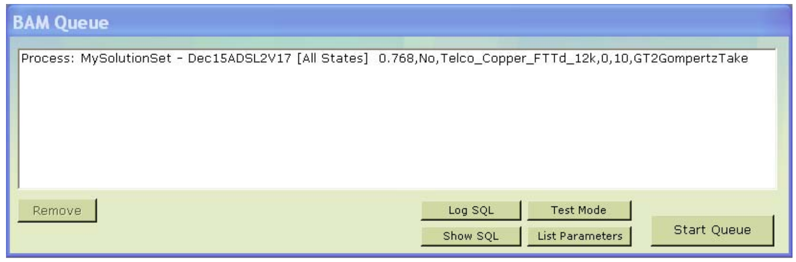
Working with the Queue

A Solution Set is processed and a Report is generated through the BAM Queue. Accordingly, once created/defined users must click on the **Add to Queue** button in both the Solution Set section of the screen and the Report Query section of the screen. When this is done the particular Solution Set and the particular Query will appear in the Queue component of the BAM main screen (illustrated here).



Items can be removed by highlighting the item and clicking on **Remove**.

Note: the Log SQL, Show SQL, Test Mode and List Parameter options are for development purposes only and should not be used. These options will eventually be removed from the standard BAM options.

Processing and Accessing Results

When all jobs have been placed in the Queue, click on **Start Queue** to begin processing Solution Sets and generating Reports. Processing times are roughly 1-8 hours for the full 50 States. A typical Report can be generated in 5-10 minutes.

Report Queries and processed Solution Sets are delivered in the CSV file format and made available in the Results folder within the BAM root directory.

Questions regarding BAM processing should be directed to CostQuest Associates.

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