Meeting of the Broadband Task Force
Wednesday, June 15, 2015
Ackerman Room, City Hall, 2nd floor
6:00 P.M.

Agenda:

- Opening Remarks/Introductions/Announcements
- Consultant Services Update
- Presentation/Discussion:
    - Digital Divide and Digital Equity
    - Community Outreach
- Task Force Member Updates
- Any other items that may properly come before the Task Force
- Public Comment

Question regarding the Broadband Task Force should be directed to:
Lee Gianetti, Director of Communications and Community Relations
lgianetti@cambridgema.gov or 617-349-3317

TILSON

Amy Witts
Purchasing Agent - City of Cambridge
795 Massachusetts Avenue
Room 303, City Hall
Cambridge, MA 02139

Dear Ms. Witts,

Tilson and Winbourne (the Tilson team) is pleased to provide this response to the City of Cambridge's RFQ for Broadband and Internet Infrastructure Design Services. Tilson has worked with over 50 communities throughout New England to design and implement broadband solutions. Winbourne specializes in government communications systems and has advised over 400 local and state governments. Both teams have extensive experience in the greater Boston area. Together, Tilson and Winbourne bring an unparalleled, and technologically unbiased, public sector telecommunications expertise to the project.

Having served as the consulting engineer and owner's project manager for two of the largest eastern BTOP infrastructure projects; the Maine Fiber Company's *Three Ring Binder* (3RB) network and the Massachusetts Broadband Institute (MBI)'s *MassBroadband123* network, Tilson knows what it takes to design and build telecommunications public-private partnerships. Our development consultants and network engineers have comprehensive understanding of backbone, middle-mile, and last-mile network design. With decades of combined experience in communications network construction and consulting services, our team offers cutting-edge knowledge of procurement costs for materials, labor, and third party make ready costs. We are also intimately familiar with the Massachusetts telecommunications landscape. Winbourne's lead consultant is a former CIO of the City of Boston. Tilson has a five year consulting relationship with several agencies within the Massachusetts Technology Collaborative and MBI in particular.

Tilson and Winbourne specialize in crafting public-private partnerships between municipalities, network operators, and internet service providers. We know how to design internet infrastructure projects that deliver the best possible services at the lowest prices. Our team of financiers and technologists know how to structure these deals and source the right kind of capital to deliver the best value to the shareholder or tax payer.

We hope to have the opportunity to speak with you at greater length in the interview stage. As per the RFQ, our proposal is good for 90 days.

Aaron Paul
Director, Energy and Broadband Consulting
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About our Team

Aaron Paul is the Director of Tilson's Energy and Broadband consulting practice. He leads consulting teams in developing solutions to state and municipal broadband challenges. He works with engineers, policy makers, and stakeholders from problem identification through solution deployment. He has advised over 40 state and local government entities on telecommunications challenges since 2013.

His background is in managing complex public, private, and public-private partnership infrastructure developments. Aaron brings six years of analytically intensive management consulting experience to the team. He provides financial analysis, market strategy, market analysis, and business modeling services to his teams. He is an expert at quantifying the financial and non-market economic benefit of public investments in infrastructure and policy programs. Benefits quantified include productivity increases, wage improvements, job creation, tax base increase, and improvements in consumer well-being. Aaron's research, analysis, and technical writing have produced over one dozen white papers and articles.

Prior to joining Tilson, Aaron helped guide military and civilian policymakers in areas including U.S. Department of Defense procurement, land conservation policy, tax policy, and mission decision analysis. He has advised all five branches of the military on acquisition and management strategy. His analyses have helped govern natural resource conservation policy in four states. He sits on the boards of the Maine Technology Institute and the Maine Appalachian Trail Land Trust. He holds a BA in History from Reed College, as well as an MBA and a Masters of Environmental Management from Yale University.

Christopher Campbell is Tilson's principal broadband strategist and has a 20 year career in technology, public policy and community development. He is a skilled developer of initiatives that bridge the business and public sectors to capitalize on opportunities and is an experienced and effective communicator to a wide range of external and internal audiences. Chris has excellent in-depth program management abilities with experience from conception to implementation and is a seasoned leader with team development skills. At ease with budget limitations, deadlines, and high pressure situations, Chris possesses a strong ability to influence thinking, forge strategic alliances, and build consensus.

Prior to Tilson, Chris served as Executive Director with the Vermont Telecommunications Authority, where he led efforts to build new fiber networks and expand access to broadband and cellular service. In addition, he built and managed a team responsible for diverse activities, including fiber optic construction, cell site development, commercial contract development, grant making, and federal grant seeking, while developing programs and defining strategies for the Authority to achieve its objectives.

Chris has also served as Director for Telecommunications at the Vermont Department of Public Service and Assistant Chief Information Officer for the State of Vermont. He holds a Master of Regional Planning from the University of Massachusetts-Amherst and a B.A. in Economics and Environmental Studies from the University of Pennsylvania.

Mike Hernon is a recognized expert in wireless (radio and cellular) communications technologies. He has identified and implemented cellular cost savings practices for the Department of the Navy which resulted in tens of millions of dollars in annual savings. Identified underperforming/over budget programs in the Commerce Department for remediation. Also, he served as the primary author of the US Department of Defense's Business Case Analysis for Mobile Communications which led to $135M in program funding for cellular-based communications. He has serviced the Chief Information Officer for the City of Boston and as the Chief Technology Officer for Washington, DC. As a CIO, Mr. Hernon was widely recognized as a leader in the strategic implementation of technology culminating in him being cited by ComputerWorld as a "Super CIO". His post-CIO career has also won accolades including a Hammer Award and the Meritorious Public Service Award for his work with the civilian federal government and DoD respectively. Mr. Hernon has also laid out the strategic vision and created collaborative teams to execute in environments from major cities to small towns to include overall use of information technology as well as for public safety agencies. He is recognized for establishing Public Private Partnerships (PPP) delivering millions of dollars of value including wiring every school, library and community center in the City of Boston. He has industry certifications ITIL3- and COBIT5.

Joshua Broder is the owner CEO of Tilson. Joshua has a diverse background in information technology, telecommunications, organizational leadership, and corporate growth as a former Army Signal officer, an industry consultant, and an executive.

While in the U.S. Army, Joshua served as Operations Officer in charge of the tactical satellite communications network supporting U.S. and NATO Combat Forces and other U.S. Government agencies at 33 remote locations in Central Asia (Afghanistan, Uzbekistan, and Pakistan). Joshua was awarded the Bronze star for his tour in Afghanistan.

Joshua joined Tilson in 2006 as the third employee. Today, Tilson employs 100 people and has a worldwide practice, providing clients with cutting-edge consulting services. Under Joshua's leadership, Tilson has managed the planning, design, and construction of over a dozen telecommunications deployments throughout New England and the mid-Atlantic, including smart grid, fiber optic, and cellular LTE projects. Currently, Joshua leads Tilson's efforts to support Central Maine Power in its roll out of territory-wide AMI infrastructure and the Maine Fiber Company and the Massachusetts Broadband Institute to deploy large-scale, publicly-funded fiber optic networks in rural Maine and Massachusetts respectively.

Paul Fahey has 20 years of government and private sector experience -- 15 of them in public safety: Next Generation 9-1-1 (NG9-1-1), emergency communications, 9-1-1 policy, and legislative and regulatory aspects of 9-1-1. Paul has served the public safety industry as both an end-user and provider, advising on fiscal and governance issues to vendors and non-profits. As Senior Consultant, NG9-1-1 Projects & Programs at Winbourne Consulting, Washington, D.C., he serves as lead SME on budget, finance, legislative, policy, program, and regulatory issues for clients preparing for and implementing NG9-1-1 solutions and facilitates and develops transition plans with clients to incorporate legacy 9-1-1 regulatory facets for each program. As President of the Fahey Consulting Group, Paul provided administrative, management, fiscal, governance, government affairs, and policy analysis services to emergency communications companies and organizations. Further, at Cassidian Communications, Paul directed association and government affairs activities for an emergency communications solutions provider. He actively represented the company with associations involved in emergency communications policy, including National Emergency Number Association (NENA), Association of Public Safety Communications Officials (APCO), and Industry Council for Emergency Response Technologies (iCERT). In addition, Paul represented the company's policy interests at regional, state, and national government agencies involved in emergency communications and managed consultants and lobbyists hired to monitor and influence emergency communications policy and regulatory activities in various states of interest.

Liza Quinn is a Senior Consultant at Tilson, and has a background in energy, telecommunications and town planning. In the energy sector she worked with investor- and municipally- owned utilities to buy and sell electricity to lower their cost of service and/or increase revenues. She also worked on teams to secure project and corporate financing, and provide analytical support to acquisitions and divestitures. Liza's telecommunications background started with cost modeling, pricing and transactional support of wholesale services, and progressed to a role a general manager of a $77 million colocation services business unit providing networked space in conjunction with power, security, and interconnection

services. She holds an MBA and an MFS from Yale University. She has taught Macroeconomics at SMCC has been on the Cape Elizabeth Planning Board for several years.

John Costa is a Senior Consultant at Tilson. John has worked in the telecommunications field for nearly 30 years and has achieved exceptional results in multiple engineering and systems roles. At Tilson, John handles field engineering for the company's small cell division and has significant experience and success in site review as well as leading and driving cross-functional teams.

Prior to Tilson, John worked as the network engineering manager of construction and OSP engineering for the Maine Fiber Company, where he managed the construction of seven new regeneration fiber huts. In addition, he worked with hut manufacture to ensure that all defined quality standards and requirements were met. John is particularly skilled at determining the optimal route and overall cost and design for fiber routes as well as inspecting communication infrastructure for quality and compliance with safety and standards. Prior to his work with the Maine Fiber Company, John served for nearly 20 years as FTTP manager and Senior Manager of OSP Planning for FairPoint Communications, where he reviewed and approved planning packages for DSL growth and major fiber projects.

Town of New Shoreham
Broadband Plan and Network Designs
January 2015

Report prepared by:

On behalf of:

BBRI is a project of the Rhode Island Department of Administration Office of Digital Excellence in partnership with Rhode Island Commerce Corporation and is funded by the US Department of Commerce National Telecommunications and Information Administration (NTIA)

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Note

Cost information included in the following report is an estimate based on recent quotes, historical data, certain assumptions about the project scope and approach, the regulatory environment and market conditions at a fixed point in time. Given these variables, we recommend updating the estimate as time passes, and allocating sufficient contingency to allow for inevitable but unpredictable changes in the cost environment if the project moves forward.

Table of Contents

Executive Summary 5
Defining Broadband 7
Block Island's Broadband Standard 10
Goal One – Improved Residential and Business Broadband 11
Telecom Asset Inventory 11
Network Design – Fiber to the Home 15
Network Design – Hybrid Fiber Wireless 18
Head End Location 19
Business Model 20
Capital Cost Estimate 22
Fiber to the Home Network 22
Hybrid Fiber – Wireless Network 22
Operating Cost Estimate 23
Fiber to the Home Network 23
Hybrid Fiber – Wireless Network 24
Network Concept – Hybrid Fiber Coaxial Cable 24
Goal Two: Improved Wireless Service 25
Economic Impact of Block Island Network 26
Conclusion 29

Executive Summary

Broadband Rhode Island (BBRI), part of the Rhode Island Office of Digital Excellence (ODE) has engaged EA Engineering Sciences to perform data collection and broadband mapping for the State Broadband Initiative (SBI), a federally-funded NTIA grant. For this project, an extension of the SBI, EA Engineering, Science & Technology, Inc. engaged Tilson to address a broadband service gap in The Town of New Shoreham (Block Island).

Specifically, Tilson was asked to assess the state of telecommunications infrastructure on the island, articulate the community's standard for broadband service, analyze the gap, and design solutions for closing that gap.

Block Island's telecommunications infrastructure is very limited in comparison to mainland Rhode Island, Connecticut, New York, and Massachusetts. There are two communications towers on the island capable of providing cellular service. Verizon provides phone service and basic DSL (digital subscriber line) internet over twisted pair copper wire. The DSL service fails to meet many of the needs of residents and businesses. Alternative internet service can be purchased via satellite subscriptions. The former Block Island Cable Company used to provide cable television services but has been shut down for several years without another provider filling the gap. Unlike other offshore island communities such as Martha's Vineyard and Nantucket, Block Island does not have a physical telecommunications connection to the mainland. All of the island's broadband utilizes wireless microwave signals for backhaul.[1] Furthermore, the age and condition of the copper plant likely hinders broadband performance.

Many rural communities in North America lack last mile residential broadband coverage. Block Island also lacks the middle mile infrastructure that can connect these facilities to the internet backbone on the mainland. Recent developments will likely change this status quo. The Town currently has an opportunity to lease eight strands of fiber from the National Grid cable running to a proposed offshore wind farm. Assuming these negotiations are successful, this fiber has the potential to provide exactly the middle mile infrastructure necessary to serve homes and businesses. Should these negotiations not succeed, or should the fiber not be built, the Town can secure sufficient backhaul through wireless technology at a fraction of the cost of submarine fiber, but at reduced bandwidth and some sacrifice of reliability.

With this new fiber optic infrastructure in hand, the Town aspires to ensure that all of its residents and businesses have access to 30 mbps symmetrical service, or better. Fiber optics or 4G LTE wireless are the two telecommunications technology that can meet and surpass this threshold. Tilson designed two high level networks that provide this service. Under option one, a fiber optic network is built throughout the Town to every home on the island and mounting equipment on existing utility poles. Tilson estimates the cost of constructing this network to be $4.3 million. Under option two, fiber is run along the major roads in town to connect new cellular antennas that provide a wireless last mile product to homes and businesses equipped with antennas and modems. This project is significantly less expensive than the fiber option at $1.4 million. However, it offers tradeoffs. Cellular broadband tends to experience lower

[1] Backhaul is a telecommunications term referring to the connection between a small network, like Block Island's, and the worldwide web.

signal quality than fiber optic broadband and the implementation of this solution will require the construction of four cell towers on the island. Tilson also considered the possibility of partnering with a cable company to provide service on the island, utilizing the Town's leased fiber for backhaul.

Tilson identified six potential models for operating a new residential and business network. The feasibility of these options partial depend on any restrictions placed on the use of the National Grid fiber. However, any restrictions can be circumvented through redundant microwave connections to the mainland. These business models represent a range of options for balancing the community's preference for network control and risk tolerance. Potential structures for building, owning, and operating a new network include attracting a private carrier to provide service at no cost to the Town, subsidizing the incumbent carrier (Verizon) to build fiber to the premise (FTTP) connectivity, forming a new corporate entity, forming a town utility, building the network as a public asset, and building the network as a public asset but leasing it to a third party. New Shoreham's current poor service offerings may make the town eligible for Universal Service Fund subsidy. Towns in the U.S. with service under the 4 mbps download/ 1 mbps upload threshold that the FCC defines as broadband, can apply for federal funding for network improvements. Usually these applications are done through the incumbent service provider, i.e. Verizon.

The Block Island Community has a number of options available for cost effectively improving its broadband situation. The FTTP solution can provide world class internet access for a generation. The wireless option can cost effectively meet the community's broadband needs in the near term and improve cellular service on the island at same time.

Defining Broadband

It is important to note that the term "broadband" does not refer to any technology in particular. Rather it refers to data transmission through a medium in excess of certain threshold. From an information technology perspective, it represents the amount of data that a consumer can download or upload from the internet in a given second. This is the measurement known as bandwidth. Greater bandwidth is analogous to a faster connection. Connection speeds are generally measured in kilobits per second (Kbps), megabits per second (Mbps) or gigabits per second (Gbps).[2]

In the U.S., broadband standards are defined by the Federal Communications Commission (FCC), which regulates interstate and international communications by radio, television, wire, satellite and cable. The FCC uses a tiered approach to define broadband based on download and upload speeds for wireline and wireless technologies:

FCC Speed Tier	Download Speeds	Upload Speeds
1st Generation Data	200 Kbps to 768 Kbps	200 Kbps to 768 Kbps
Tier 1	768 Kbps to 1.5 Mbps	768 Kbps to 1.5 Mbps
Tier 2	1.5 Mbps to 3 Mbps	1.5 Mbps to 3 Mbps
Tier 3	3 Mbps to 6 Mbps	3 Mbps to 6 Mbps
Tier 4	6 Mbps to 10 Mbps	6 Mbps to 10 Mbps
Tier 5	10 Mbps to 25 Mbps	10 Mbps to 25 Mbps
Tier 6	25 Mbps to 100 Mbps	25 Mbps to 100 Mbps
Tier 7	> 100 Mbps	> 100 Mbps

Table 1: FCC Speed Tiers

Until very recently, the FCC defined broadband as 4 Mbps downstream and 1mbps upstream. As shown in the table above, that standard translates to a minimum Tier 3 download and Tier 1 upload connection to qualify as broadband service. In July of 2014, the FCC announced that it planned to increase the download threshold to 25 mbps. On January 29th, 2015 the FCC formally redefined broadband as 25 mbps download and 3 mbps upload. This redefinition has the potential to dramatically increase the number of communities in the U.S. eligible for subsidy.

The rapid advancement of delivered data speeds in the U.S. caused the change in the definition of broadband. In 2000, only 4.4 percent of American households had a broadband connection (as defined prior to January 29, 2015) in their homes. By 2010, that number had jumped to 68 percent. Moreover, since 2010, average delivered speeds in the U.S. have doubled overall, and today roughly 94 percent of Americans have access to wireline or wireless broadband speeds of at least 10 Mbps downstream. As a result, the FCC raised the minimum threshold.[3] This evolving baseline reflects a growing need for higher

[2] 1 Gbps = 1000 Mbps = 1,000,000 Kbps.

[3] Pg. 4. *Four Years of Broadband Growth*, June 2013. The White House Office of Science and Technology Policy & The National Economic Council. http://www.fcc.gov/document/fcc-finds-us-broadband-deployment-not-keeping-pace

bandwidth as Americans increasingly use the internet and communications technologies in all aspects of their lives.

In terms of functionality, the following table shows download speeds[4] required for a range of common internet-based activities:

	Basic Use (Email, Web Surfing Basic Video)	**Moderate Use (Basic use plus high demand functions i.e. gaming, conferencing, HD video)**	**Heavy Use (Basic use plus multiple high demand functions)**
1 user on 1 device (laptop, tablet, gaming console)	1 – 2mbps	1 – 2mbps	6 – 15 mbps
2 users on 2 devices at a time	1 – 2mbps	1 – 2mbps	6 – 15 mbps
3 users on 3 devices at a time	1 – 2mbps	2 – 5 mbps	15 mbps or more
3 users on devices at a time	2 – 5 mbps	6 – 15 mbps	15 mbps or more

Figure 1: Minimum Download Speed for Common Activities

Download and upload speeds depend on the type of communications technology service providers utilize. There are a number of different technologies currently available to residential and business users, which offer varying bandwidth capabilities:[5]

[4] FCC, Household Broadband Guide.

[5] Pg. 5. The ConnectME Authority. 2012. *Developing Broadband in Maine: Strategic Plan.* Available at http://www.maine.gov/connectme/grants/ntia/planning.shtml.

Technology	Download & Upload Speeds
Dial-up	Up to 56 Kbps
2G Mobile	Up to 100 Kbps
3G Mobile	384 Kbps – 2 Mbps
4G Mobile[6]	2 Mbps – 18 Mbps
Satellite[7]	200 Kbps – 2 Mbps
DSL	768 Kbps – 7 Mbps
Traditional Cable	1 Mbps – 10 Mbps
DOCSIS 3.0 Cable	1 Mbps – 150 Mbps
Fixed Wireless[8]	1 Mbps – 1.5 Gbps
T-1	1.5 Mbps
Fiber Optic	Up to 1,000 Gbps. Effectively infinite

Table 2: Technological Speed Capabilities

The speeds shown above are averages achieved for each technology. Higher speeds are possible for certain technologies depending on network layout and user saturation. If a user is located close to a network node, which houses the networking equipment that sends the network signal, and overall network use at that point in time is low, he will obtain higher connection speeds. DSL subscribers commonly experience this phenomenon. If a DSL subscriber is located close to the service provider's (Verizon for example) remote terminals he can achieve download speeds as high as 15 Mbps.[8] However, as one moves farther away from the remote terminal, download and upload speeds decrease. Outside of one mile from a central office, it is very difficult to achieve a broadband connection over DSL.

[6] AT&T Wireless currently has the highest tested capacity at 18 Mbps.

[7] Current satellite service may achieve broadband level speeds, but the excessive latency or delay precludes the use of many broadband applications.

[8] The Rhode Island company Towerstream offers up to 1.5Gbps.

Block Island's Broadband Standard

The Town of New Shoreham's town manager, public employees, and broadband committee described a desire for universal access to symmetrical high speed broadband that will serve the needs to the community for years and for generations. These needs consist of two goals. First, supporting the year round community's civic, educational, and business activities. Second, improving the seasonal community's ability to work and communicate while on island.

Many of the year round residents cannot access sufficient broadband speeds to video conference, participate in online learning opportunities, or run businesses from the island. Some residents report switching to expensive satellite broadband just to meet their day to day needs. These satellite services provide connections roughly equivalent to well-functioning DSL but at three to five times the cost. For this reason, the Town government and the state of Rhode Island commissioned this study to assess the options for meeting this standard. A FTTP solution can easily achieve these speeds while also allowing residents to increase their service to one gbps one higher. Note that this study does not contemplate phone or video service.

New Shoreham attracts many summer visitors. The community hopes that greater bandwidth will help some seasonal residents work from their Block Island homes, thereby increasing their stay and local economic impact. Furthermore, day trippers comprise a major share of the economic activity on the island. The Town's population can grow to as many as 20,000 people on busy weekends in the summer months. This strains the island's cellular infrastructure, which was designed to serve approximately 1000 residents. The Town has expressed interest in improving the experience of these visitors to the island through improved access to wireless data. While this goal is secondary to the primary goal of serving residents and business, serving as a desirable recreation destination is central to the Town's identity.

Goal One – Improved Residential and Business Broadband

Telecom Asset Inventory

After articulating the broadband standard, the team identified the telecommunications assets on Block Island. Currently, no fiber optic cable connects the Island to the mainland. No fiber optic cables were observed during the telecom asset inventory. The internet service options on the island consist of Verizon New England DSL, Verizon Wireless mobile hot spots, AT&T wireless mobile hot spots, and satellite service broadband offerings. The wireless and wireline communications on island utilize microwave connections for backhaul. Verizon New England provides municipal buildings including the school, town hall, and health center with T-1 copper connections. This provides superior bandwidth to DSL but it does not meet the standard.

The island has two towers that appear to provide cellular service to the island. The Verizon-owned tower is the point at which phone and DSL internet user's data downloads and uploads are transmitted to the internet via microwave. Most towers on the mainland utilize fiber optic cables for their backhaul needs. The locations of the microwave backhaul sites and the cellular antennas on the Verizon tower are shown in the figure below.

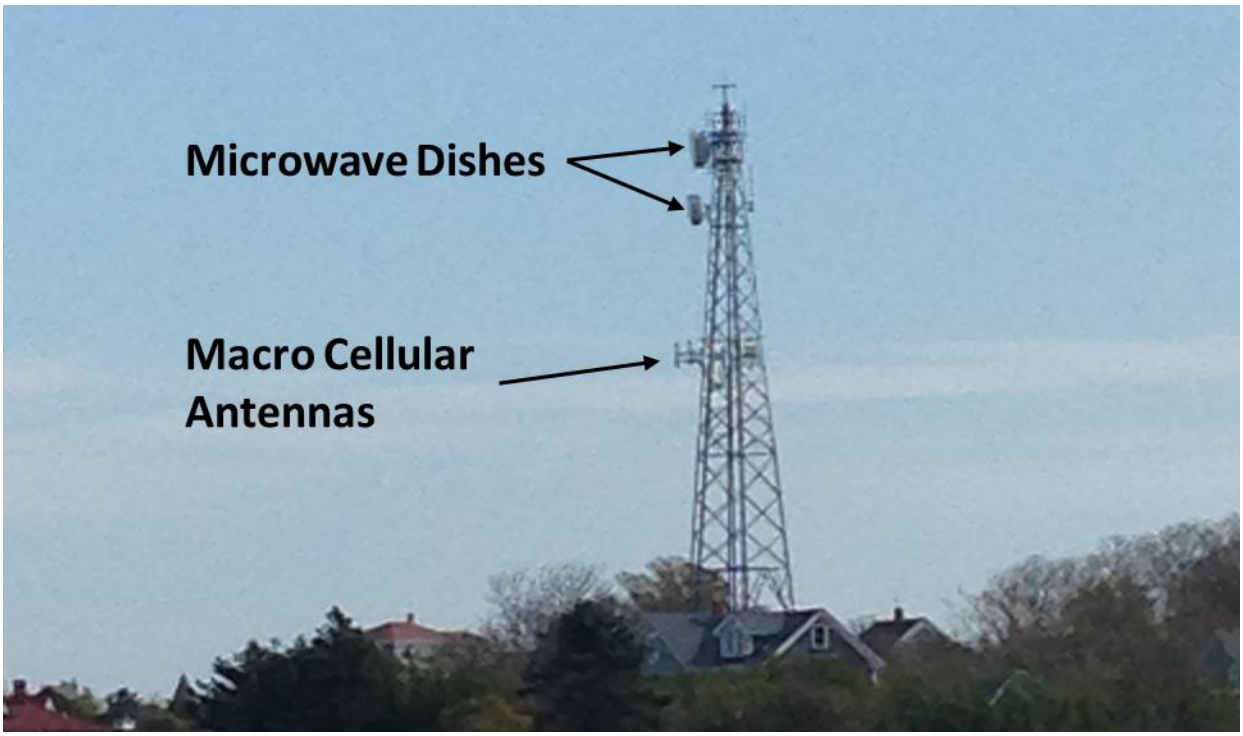

Figure 2: Verizon Tower

The Block Island Power Company tower holds three arrays of cellular panel antennas serving the island. Two of these are 4G LTE or 3G arrays. Analysis of carrier service areas suggests that these belong to Verizon Wireless and AT&T. Sprint also claims to serve the island with 3G data. There appears to be an

additional voice array on the tower as well. Subscribers to other carriers may receive service on the island through roaming agreements with these carriers. As with wireline voice and data service, connection to the internet is provided via microwave arrays. The figure below shows the respective locations of this equipment on the tower. Reports from the Power Company indicate that this tower is fully occupied and that there is no space for additional deployments. Visual inspection corroborates this statement.

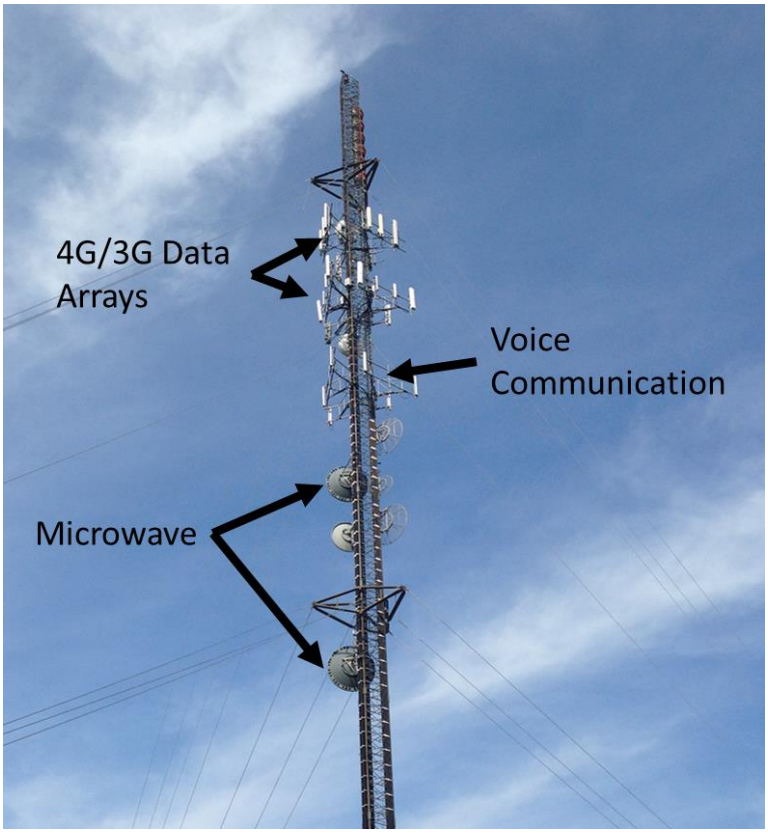

Figure 3: Block Island Power Company Tower

The FCC tracks all towers utilized for cellular communications. The table below gives the FCC data on both these towers as well as a deconstructed tower that once belonged to Astro Telecommunications Corporation, which has gone out of business.

Registration Number	Status	Owner Name	Latitude/ Longitude	Overall Height Above Ground (AGL)
1049679	Constructed	Block Island Power Company	41-10-28.0N 071-34-18.0W	76.5
1204467	Dismantled	Astro-Telecommunications Corp.	41-10-30.4N 071-34-08.2W	51.0
1211820	Constructed	Verizon New England	41-10-21.3N 071-33-50.1W	50.9

Table 3: FCC Tower Data for Block Island

In addition to the two cellular communications towers, there is a 40 foot tower at the police station and at least two private large radio antennas on the island. The police station tower appears to be used for two way public safety radio traffic. The private radio antennas stand approximately 20 feet tall and are similar in appearance to structures used to track migratory birds along the east coast.[9] It is likely that these antennas serve a research purpose.

Figure 4: Private Research Antenna

The figure below shows the locations of these tower assets as well as the approximate cellular data coverage on the island. Significant coverage gaps exist at the northern and south eastern ends of the islands. Note that cellular data signals degrade over water due to reflection. So it is unlikely that islanders will receive service from the mainland.

[9] http://scienceandnatureforapie.com/an-antenna-on-napatree-what-is-this-neighborhood-coming-to/

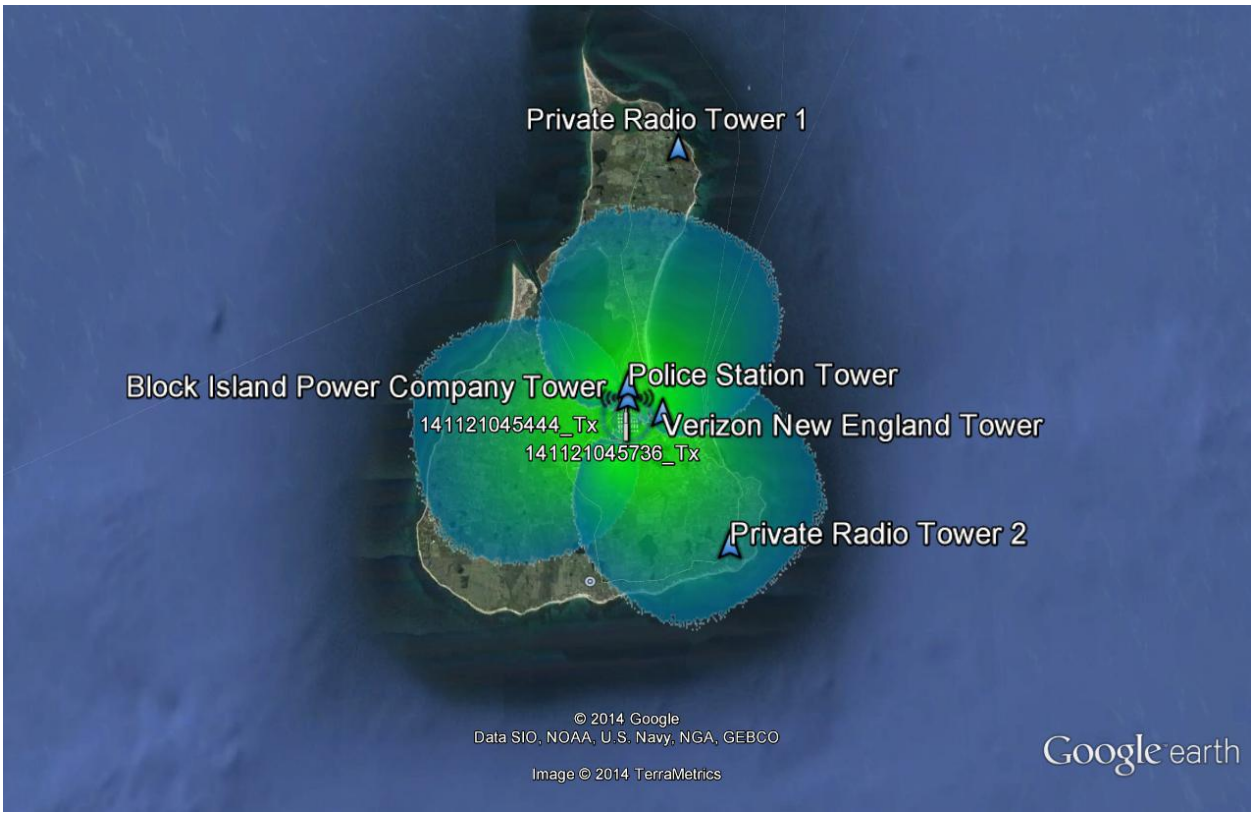

Figure 5: Tower Locations and Cellular Coverage on Block Island

New Shoreham is the only town in Rhode Island without a cable provider. This is significant because most residential customers in the U.S. purchase their high-speed broadband service from cable companies like Comcast, Cox Communications, and Time Warner Cable. New Shoreham residents are a step behind the rest of the country in this regard. Businesses are similarly disadvantaged. Even if a hotel or restaurant owner wanted to purchase a high speed broadband connection, the service is not available to buy on the island. The Block Island Cable Company used to provide service to the island but shut down several years ago. The loss of the cable company did, however, leave open space on the utility poles for stringing fiber optic cable.

The offshore wind developer, Deepwater, proposes to connect their development with Block Island and the mainland via submarine transmission cable. In exchange for easements to public land, the cable owner, National Grid, has offered the Town a lease of four to eight strands of fiber (the final number is still under negotiation) for the lifespan of the cable. Although this is not yet built, it represents an important piece of telecommunications infrastructure that should become available in the short to midterm. The cable will allow the Block Island Power Company to purchase wholesale electricity from the grid and retire the diesel generators that currently provide the island's power. After including a diesel surcharge, Block Island residents currently pay four times higher retail electric rates than mainland Rhode Island. The proposed cable will make landfall at Fred Benson Town Beach. It will be buried and unnoticeable. It will then follow Corn Neck Road south, turning right on Beach Avenue, and then left on Ocean Avenue before terminating at the power company's location. The map below

illustrates this route and an extension to the Town hall, which is also under discussion. The Town can splice into this cable at any place along the route and construct a lateral to a head end location. The head end location represents the point of demarcation from a National Grid owned asset to a Town-owned asset. From this point, the Town can operate one of the proposed networks.

Figure 6: National Grid Fiber Route

It must be reemphasized that even if this fiber is not built, the Town can still proceed with one of the network builds and utilize redundant 10 gigabit microwave links for connection to the internet, which would provide adequate backhaul service. There are options for connecting to the mainland with or without this fiber.

Network Design – Fiber to the Premise

The Town of Block Island can provide universal fiber to the premise service for an estimated capital cost of $4.3 million. This includes all design, engineering, make ready costs, splicing, equipment, and traffic control costs associated with construction. The figure below shows the major fiber routes necessary to serve every home on the island. All of the Town fiber originates from the head end location, which this design contemplates as the police station. Backbone cables with 288 fiber optic stands run from that location and split to a 144 count cable. These cables split further to 24 count cables that feed the multiport service terminals (MST). The MST is the point at which a residential or business customer connects to the network. Each MST has the capacity for twelve connections and this design cited the locations of 430 such devices.

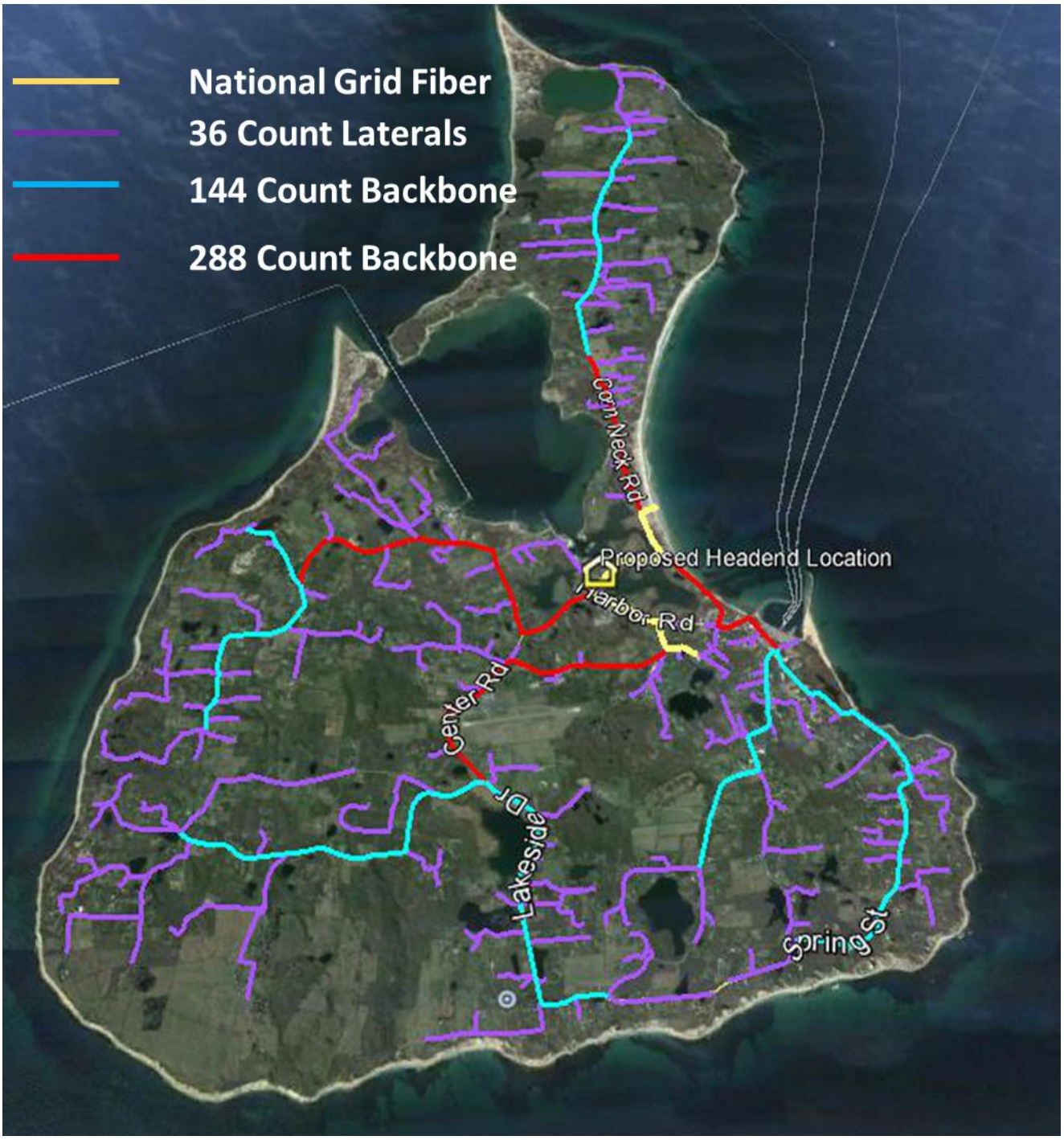

Figure 7: Block Island Fiber to the Home Design

The figure below shows a detailed view of the FTTP design for the northern extent of the island. The placemarks denote MST locations and the expected number of residential users at each location.

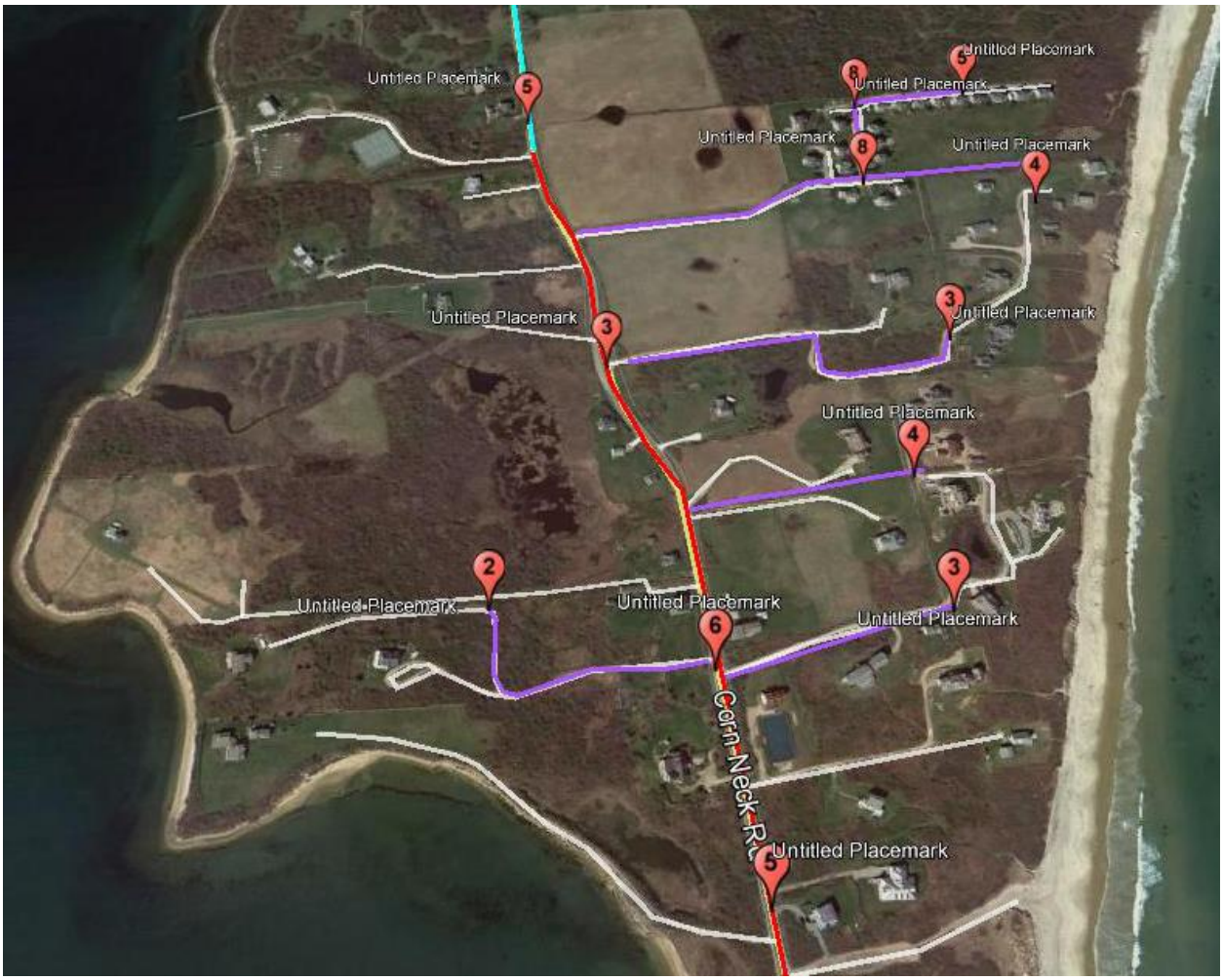

Figure 8: FTTH Design Detail

The FTTP design also connects the following community anchor institutions (CAIs) identified by the Town. Networking these facilities entails numerous benefits in addition to superior bandwidth. These facilities can share security feeds, pool internet usage, and share large GIS or research files seamlessly. If the Town elects to build the network with public funds, it can require the operator to provide dedicated service between these facilities and lite the circuits at little or no cost.

Rescue Barn	Town Hall
Sewer system	Dock Master
Police and Fire shared dispatch station	Library
K-12 School	North Light House
Block island medical center	University of RI Research Station
	Harbor Masters Office

Table 4: Community Anchor Institutions

Network Design – Hybrid Fiber Wireless

A less expensive alternative to the FTTP solution is wireless broadband. Wireless technology can achieve speeds in excess of the thresholds outlined in the standard. Under this option, wireless broadband would be delivered to homes and businesses using open or licensed spectrum. Due to the lack of available towers throughout most of the island, at least four new towers would need to be erected in order for this solution to be viable. A substantial backbone fiber optic cable connects these towers to the internet via the National Grid fiber or a microwave link. This design contemplates towers 75 feet tall, or about the same height as the Block Island Power Company tower. This is tall enough to rise above trees and other obstructions, but no so tall as to interfere with aviation. The design also includes two utility pole mounted small cell sites that provide service to the isthmus between the northern neck and the main body of the island.

Figure 9: Hybrid Fiber Wireless Solution Design

The towers are labeled by their compass direction. The pink areas represent the coverage of each tower. Note that each tower requires a substantial footprint. There are numerous potential sites that provide universal coverage to the island. The locations cited here illustrative and are not intended to reflect a commitment by landowners to lease property. Furthermore, this design does not consider any home ownership association, zoning, or other restrictions that might prohibit tower construction.

Head End Location

The key piece of infrastructure that transitions the national grid fiber to local fiber is a head end location. This can take one of two forms. One, a standalone shelter or two, a climate controlled and secure room in an existing building. The standalone shelter is a hardened, high reliability telecommunications building that can contain commercial telecommunications equipment for local distribution. This shelter is usually made of precast concrete, and includes battery backup, a generator, and climate control. A small fenced gravel compound contains the facility. An example of the standalone shelter is listed below.

Figure 10: Fiber Optic Head End Location

A headend facility installed in an existing building shares many of the same properties. The enclosure must be climate controlled with a generator back up and CO2-based fire suppression systems. Water-based fire suppression systems are just as damaging to telecommunications gear as a fire.

This head end houses the equipment (optronics, switches, and cards) that allows the networked residences and business to connect to other networks, and the internet. This is the point at which the National Grid fiber would terminate and where the Towns' fiber would begin. If the Town were to utilize point-to-point microwave instead of fiber for backhaul, this would be the point where fiber running from the tower site would connect with fiber running to residential and business customers. Key characteristics of a good head end site include:

1) Isolated from flood
2) Road access
3) One pole distance to power lines
4) Within one quarter mile of the proposed fiber route.

There are several potential sites on the island. Should the Town chose to pursue a municipally owned network, the police station offers many desirable features. The site's 24 hour access, backup generator, elevation, and proximity to the currently contemplated National Grid fiber route make it highly advantageous place.

Business Model

Tilson envisions six potential business models for addressing the residential and business service gap on the island and meeting the broadband standard of universal 30 mbps+ symmetrical service.

1. The Town partners with the incumbent service provider, Verizon, to upgrade existing facilities on Block Island to serve all premises on the island at faster speeds. Verizon would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. The Town would purchase bandwidth utilizing the National Grid fiber lease and resell that to Verizon at cost. Verizon would likely require some capital subsidy in order to build the network.

2. The Town partners with another existing commercial internet service provider, to build a fiber-to-the-home network on Block Island serving all premises on the island. The service provider would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. This carrier would likely need some additional external investment to proceed.

3. A private community-oriented non-profit builds a fiber-to-the-home network to all premises on the island.[10] The entity would construct, maintain, and operate the network. The entity could partner with a private internet service provider to offer service to customers. The entity would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions. The entity would be structured as a 501(c)3 and governed by a board of directors comprised of government employees, funders, and community stakeholders.

4. The Town pursues a joint venture with a private carrier to build a fiber-to-the-home network to all premises on the island. The venture would construct, maintain, and operate the network. The venture could partner with a private internet service provider to provide service to customers. The venture would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions. This entity might be an LLC jointly owned by the Town and private investors from the community.

[10] By "community-oriented entity", we mean an entity consisting of individuals with personal or business connections to Block Island.

5. The Town builds a fiber-to-the-home network serving all premises on the island. The Town could partner with a private internet service provider to provide retail service to customers on a fee for service basis. The Town would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

6. The Town builds a FTTH network to all premises on the island utilizing public funds (possibly from general obligation bonds). The Town leases the network to an internet service provider who operates, maintains, and provides internet service. The Town pays this operator on a cost plus fixed fee and bonus basis. Residual profits are held in a municipal escrow account to pay for future network upgrades and repairs.

The table below summarizes the business model options. It is advantageous to partner with a private carrier to utilize their poll attachment agreements. These agreements give them the right to secure fiber to utility poles and can be time consuming and/or expensive to secure. Also note, that Tilson recommends that the Town consult with municipal counsel before making conclusions regarding tax policy.

#	Who funds	Structure	Who owns facilities	Taxes	Who operates facilities	Who takes operating risk	Who gets revenue
1	Verizon and Town	Corporate ILEC	Verizon	Yes	Verizon	Verizon	Verizon
2	Private Carrier and Town	Corporate	Private Entity	Yes	Private Entity	Private Entity	Private Entity
3	Town and Non-Profit	501(c)3 or equivalent	Non-Profit	No	Contractor	Private Entity	Town after non-profit and contractor costs
4	Town and Private Carrier	Public Private Partnership (e.g. LLC or S-Corp)	PPP	Maybe	Private Carrier	Private Carrier	Private Carrier
5	Town	Municipal	Town	No	Contractor	Town	Town
6	Town	Capital Lease	Town	Maybe	Private Carrier	**Either** Private Carrier **or** Town	Revenue share commensurate with risk

Capital Cost Estimate

Fiber to the Premise Network

In this FTTP design 20% of the route will be buried cable with the remaining 80% deployed aerially. This swells the costs significantly because trenched construction is six times more expensive than aerial construction. Reducing the buried cable proportion to 10% would save $675,000 in capital costs. Trenched construction is a method of burying fiber where the ground layer is opened up and a fiber cable is laid in the gap. By contrast, directional boring is a method whereby fiber is deployed horizontally without breaking the surface. This is twice as expensive as trenching. Tilson believes that the 20% trenching estimate may be high. Network deployments tend to favor aerial construction whenever possible, due to the schedule and cost advantages. The only reason to bury fiber is when aerial deployment is unavailable.

Fiber Cable (all counts)	$214,775
Aerial Construction	$706,244
Under Ground Construction	$1,583,700
Splicing	$278,232
Make Ready	$267,110
Professional Services	$325,006
Contingency	$371,257
Customer Installation (Year 1)	$577,125
Total	**$4,323,449**

Table 5: FTTH Capital Costs

Notably, the actual cost of the fiber only represents five percent of the total capital costs. Make ready represents the costs associated with the movement of other cables on utility poles. Usually, a new network builder is required to pay the costs of moving existing equipment. However, the removal of the Block Island Cable Company's equipment likely creates an opening for the fiber deployment without significant make ready costs. Therefore this make ready estimate is likely conservative. Professional services include engineering and legal fees associated with the network build. The customer installation costs represents the cost of installing the equipment on a customer's home necessary to transmit and receive signal over fiber optic cable. Tilson estimated that 50% of households would sign up for the service in the first year. The Town can decided whether this cost is part of the capital cost or the responsibility of the customer.

Hybrid Fiber – Wireless Network

New tower construction will be necessary in order to serve all of the areas of the Island. The current tower infrastructure is consolidated in one area. Therefore, this solution's implementation requires the construction of at least four 75 foot towers in the island's four quadrants. The actual costs of engineering and erecting towers is the largest share of the capital costs.

Fiber Backbone	$227,449
Tower Construction	$636,000
Small Cell Construction	$67,000
Professional Services	$113,045
Contingency	$104,349
Customer Site Installation	$252,000
Total Capital Costs	**$1,399,844**

Table 6: Hybrid Fiber - Wireless Network Capital Costs

Wireless network capital cost partially depends upon subscribership. The more people sign up, the higher the net installation costs. Tilson estimates the total cost of installing a wireless receiver and mount to be $280 per premise. If 80% of Block Island's 1800 residential buildings subscribed to the service, the total cost of installation would be $403,200. If the Town proceeds with this option, it will need to decide if equipment costs are included in the capital costs of the network. Note that this capital cost estimate does not account for the cost of acquiring land on which to build.

Operating Cost Estimate

Fiber to the Premise Network

Tilson estimates that the total costs for operating the network will range between $355,000 and $652,000. They are shown in the table below.

Operating Expenses	Low	Best	High
Pole Attachment Fees	$30,000	$39,000	$48,000
Maintenance & Repair	$45,000	$67,500	$90,000
Bandwidth	$72,000	$90,000	$108,000
Fixed G&A	$89,250	$119,000	$148,750
Variable G&A	$118,800	$198,000	$257,400
Total	**$355,050**	**$513,500**	**$652,150**

Table 7: FTTH Operating Costs

Pole attachment fees are essentially rent paid to the pole owners, Verizon New England or Block Island Power Company. Tilson estimated 50 poles per mile of road and mapping showed there to be 60 miles of roads on the islands. Fees typically range between $10 and $16 per pole depending on the utility. These costs may be mitigated by burying cable for some customer drops, although the capital costs are higher. Maintenance and repair represent the ongoing costs of maintaining the network. These typically range between 1.5% and 3% of the total capital costs. Bandwidth represents the costs of wholesale data. This is necessary to connect the island network to the internet. Networks of this size typically require between two and three gbps of bandwidth. Tilson assumed a price of $3.0 per mbps, which is based on a recent quote. Fixed general and administrative costs include items such as electricity, rent, technician wages, and legal expenses. Once the final network design and business model are selected, these costs tend to remain fairly constant. Variable general and administrative costs scale with customer sign ups. Every internet customer costs their ISP approximately $220 per year in service time, billing, and other administrative expenses.

Hybrid Fiber – Wireless Network

Tilson estimates that the operating costs for the hybrid fiber-wireless network to be in line with those of the fiber to the premise network. Pole attachment fees and maintenance are significantly less expensive for this network for reasons of scale. This solution utilizes one sixth as many poles as the FTTP solution. The lower capital costs also drive maintenance costs lower, as maintenance is calculated as a percentage of total capital expenditure. However towers require more maintenance than fiber, so the percentage ranges from 3% to 5%. The remaining costs are the same for this solution.

Operating expenses	Low	Best	High
Pole Attachment Fees	$5,000	$6,500	$8,000
Maintenance & Repair	$27,913	$37,218	$46,522
Bandwidth	$72,000	$90,000	$108,000
Fixed G&A	$89,250	$119,000	$148,750
Variable G&A	$118,800	$198,000	$257,400
Total	**$312,963**	**$450,718**	**$568,672**

Table 8: Wireless Operating Costs

In addition to these operating costs, Tilson recommends an intensive customer service exercise for several months following network go live. Wireless broadband is a new technology to many users. Maintaining a customer service technician on site for real time service visits can help build customer satisfaction and ensure long term network viability. This would consist of two technicians residing on Island for a period of four months and responding to, and resolving, every service request.

Customer Service Costs	
Labor	$153,600
Travel Costs	$3,600
Accommodations	$9,600
Per-diem	$16,800
Total Customer Service Costs	$183,600

Table 9: Customer Service Costs

Network Concept – Hybrid Fiber Coaxial Cable

Another option for improving broadband on Block Island at little to no risk to the Town would be to incentivize a company such as Comcast, Time Warner, or Cox Communications to provide their normal suite of internet, television, and phone services on the island. Comcast provides service on both Martha's Vineyard and Nantucket. If the new fiber optic cable is available to provide backhaul, a cable provider may be interested in establishing service on island for low or no capital investment from the town.

The hybrid fiber coaxial cable technology that cable companies utilize costs approximately $45,000 per mile to build on the mainland. Assuming an island premium of 15% and 60 road miles on Block Island, this yields a total capital cost estimate to the company of $3.1 million. Some cable providers may seek a capital subsidy to build their network. The broadband technology used by cable companies does not meet the standard described by the Town. However, it is capable of providing speeds up to 30 mbps and

also includes service offerings that an ISP cannot provide, such as video (television). Tilson recommends that the town consider this option as a potential third solution.

Goal Two: Improved Wireless Service

As a summer colony situated between Boston and New York, Block Island sees many seasonal visitors. The Town estimates that the population can swell from 1000 to over 20,000 on busy weekends from June through August. Many of these visitors carry multiple internet enabled devices. User reports suggest that the Town's single cellular tower cannot provide robust signal to all of these users during these peak periods. Tilson recommends that that the town take the following steps to support improved cellular service.

1) Facilitate Zoning and Permitting Approval for Cellular Carriers

The major cellular carriers have historically utilized antennas mounted on towers for providing data service to data-enabled devices. Over the next several years, Tilson expects these carriers to shift their capital investments from building these macro sites to installing more discrete microsites. This new technology provides the same 4G LTE service but is much smaller and can be mounted on a building corner or telephone pole. Deployed in sufficient density, these can provide a large group of users low latency data service where a larger site would have been overloaded. Verizon Wireless has expressed an interest in securing lease agreements to the utility poles on Block Island. The more streamlined the zoning process, the more likely Block Island is to see improved cellular service in the near future.

2) Make Fiber Available to Cellular Providers

Assuming the Town elects to proceed with one of the Tilson proposed solutions, fiber will be deployed throughout the island. This fiber will be essential for connecting any cellular site to the internet. Keeping the network available to carriers on an open access or wholesale basis, allows them to meet their backhaul needs without going through their own fiber build. This reduces their costs of providing service tremendously.

3) Provide a WiFi Solution

The easiest solution for the Town to improve data coverage is to provide free WiFi to the downtown area and possibly the beaches. Smart phones and tablets could utilize this network in the event that the cellular data networks become oversaturated. The tower assets described in the hybrid wireless-fiber design could also be utilized for this purpose.

Economic Impact of Block Island Network

Research has shown that investments in broadband infrastructure can dramatically improve economic development in rural communities. Broadband enhances productivity, makes firms more efficient, facilitates commerce, attracts jobs, increases consumer options, and saves residents money.

The economy of coastal Rhode Island and Massachusetts has contracted in real terms over the past ten years. According to the US Bureau of Economic Analysis, the region experienced a net average annual real GDP decrease of 0.34% between 2003 and 2013. The US economy as a whole, by contrast, grew at an average annual rate of 1.6% over the same period.[11] Without conducting an extensive survey of spending trends on island over the past ten years, it is impossible to precisely estimate the economic product of Block Island alone. Therefore, Tilson used the economic data of Barnstable County as a corollary. Barnstable County shares many of the same characteristics of Block Island. Tourism constitutes a large component of economic activity and the region is home to many seasonal residents.

Tilson used "value transfer method" to conduct this analysis. This consists of borrowing the research contained in peer reviewed studies of the economic impact of broadband and applying local data to the same models. Tilson first gathered census data for Block Island and Bureau of Economic Analysis data for Barnstable County to establish the economic baseline. Then the team ran those estimates through economic models that forecast the impact of new broadband infrastructure on increasing gross domestic product (GDP), creating jobs, and enhancing consumer well-being on Block Island. Tilson believes developing universally-available, world class broadband infrastructure on the island has the potential to increase GDP growth to 3.7% by 2019.

This estimate represents $23.7 million in additional goods and services sold on the island over ten years. This figure is open to debate. However, a large increase in broadband penetration usually results in a significant increase in output. In a study of 22 Organization for Economic Cooperation and Development (OECD) member countries, Koutroumpis et al. (2009) found that an increase in broadband penetration of 10 percent added 0.25 percent to GDP growth on average.[12] In a similar study, Czernich et al. (2009) found that an increase in broadband penetration of 10 percent added 0.73 percent to GDP growth on average.[13]

A pertinent case study in the U.S. is Lake County, Florida. A rural area north of Orlando, the county saw its economic output double relative to its neighboring counties within five years of a major broadband build out to the county's community anchor institutions (Ford and Koutsky, 2005).[14] Therefore, Tilson believes that its estimate for Block Island may be conservative. As shown in the figure below, the positive impact of broadband development on Block Island's economy compounds year after year while

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[11] U.S. Bureau of Economic Analysis, 2014. These values account for inflation by keeping all figures in 2009 dollars.

[12] Koutroumpis, P. 2009. The economic impact of broadband on growth: A simultaneous approach. *Telecommunications Policy*. Vol:33, Pages: 471-485.

[13] Czernich, N., Falck, O., Kretschmer, T. & Woessman, L. 2009. Broadband Infrastructure and Economic Growth. *The Economic Journal.* Vol: 121, Pages: 505-532.

[14] Ford, G. and Koutsky, T. 2005. Broadband and Economic Development: A Municipal Case Study from Florida. *Review of Urban & Regional Development Studies. Vol: 17, Pages: 219-229.*

there is fixed upfront cost to deploy the network. The additional capital costs after year one represent new customer sign ups.

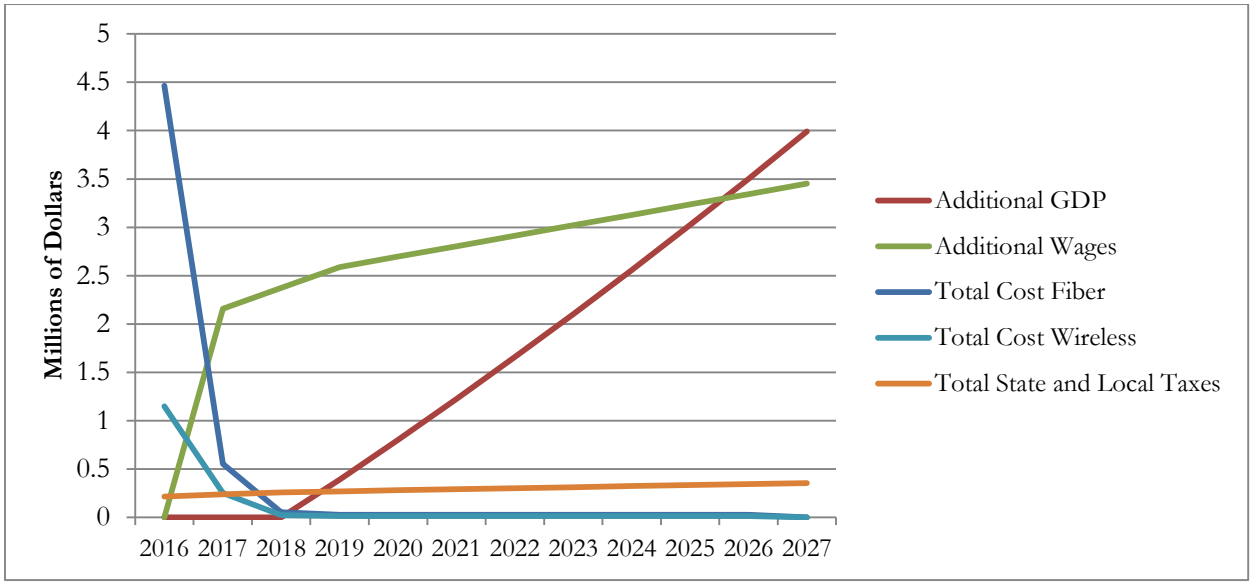

Figure 11: GDP, Wage, and Tax Impact of Broadband Investment

In addition to increasing local GDP, broadband development also creates jobs. Unlike economic output, which typically takes at least two years for communities to begin reaping the full effects of an investment, job creation occurs immediately. Broadband investments affect employment in three ways.

- Direct Jobs (telecommunications technicians, construction workers, and manufacturers of telecom equipment)
- Indirect Jobs (upstream suppliers and sellers of raw materials)
- Induced Jobs (from the household spending resulting from the new direct and indirect jobs)

These jobs tend to be higher paying, technology-oriented jobs, some of which are temporary but many are stable and more or less permanent improvements to the region's economy. A study of broadband development in rural Kentucky found that every 1 percent increase in broadband adoption yielded a 0.14 percent increase in employment (Shideler et al. 2007).[15] This factor suggests that 45 new jobs will be created in on the Island by 2027 under one of the solutions considered. Assuming these jobs pay Barnstable County's median wage, Tilson estimates approximately $3.5 million in state and local tax revenue will be generated over the next ten years.

Lastly, broadband investments improve consumer wellbeing. Consumers are not necessarily better off just because economic output increases. An increase in GDP just means that they are spending more. That being said, broadband access empowers consumers to both pay less for goods than they otherwise would have purchased and to purchase goods and services that were not available before. For example, broadband allows consumers to enjoy almost limitless video content for little or no cost. Without it,

[15] Shideler, D., Badasyan, N. & Taylor, L. 2007.The Economic Impact of Broadband Deployment in Kentucky. *Regional Economic Development*. Vol: *3*, Pages: 88-118.

consumers pay more to rent films and or subscribe to satellite television. In economic lexicon this phenomenon is known as “consumer surplus”.

For the purposes of this exercise, consumer surplus is defined as the amount that consumers benefit from purchasing a product for a price that is less than what they would be willing to pay. In a study of 40 million U.S. households with access to broadband, Greenstein and McDevitt (2009) found that broadband access increased consumer surplus by between $120 and $167.50 per household, per year.[16] Tilson’s economic analysis assumes that year-round Block Island residents would enjoy this full benefit, while seasonal residents would enjoy 30 percent of consumer surplus benefit. This translates to a total increase in surplus of between $885,000 and $1,235,000.

Overall, Tilson believes that investment in broadband on Block Island would be a strong contributor to economic development in the community that offers a range of public benefits. Improving broadband access would supplement Block Island’s traditional economic activities, while also supporting conditions for new enterprises. Due to these added public benefits, Tilson recommends that investment in broadband infrastructure is considered not only through a lens of the network’s profitability, but also as a long-term investment in the sustainability of the community and economic development on the island.

[16] Greenstein, S. and McDevitt, R. 2009. The Broadband Bonus: Accounting for Broadband Internet Impact on U.S. GDP. NBER Working Paper No. 14758.

Conclusion

The Block Island community has several options available for improving broadband service. The Fiber to the Premise solution has the potential to provide a generation of world class broadband service. The hybrid fiber-wireless option can provide excellent broadband at a lower capital cost. However, the new tower assets have the potential benefit of improving cellular communications on the island in addition to providing broadband service. While the fiber network offers superior service, the cellular network offers lower capital costs. It is also worth noting that the antiquated state of Block Island's telecommunications infrastructure may make the community eligible for federal subsidy to offset some of the capital costs of the construction.

As the Town continues to contemplate its broadband future it will face several decision points. In the short term, Tilson recommends that the Town contemplate the following next steps.

1) Finalizing negotiations with National Grid to define the Town's right of use to the fiber optics. Four or eight strands can meet any network backhaul needs. The most important outcome from the negotiations is ensuring unrestricted access. Even if the fiber does not become available, the island can utilize microwave links for backhaul.
2) Determine Town preferences. Tilson recommends that the Town circulate the findings of this report with the broadband committee and determine preferences among the three solutions and six business models presented.
3) Issue a request for information to the service provider community. The Town can invite service providers to describe their approach to bridging Block Island's service gap. Their solution description can include technical approach (fiber, wireless, coaxial), experience, pricing structure, and business model. The results of this solicitation can provide the Town with an actionable proposal from a vendor to fill the identified broadband gap.

Aquidneck Island

Broadband Analysis and Recommendations

January 2015

Report prepared by:

On behalf of:

BBRI is a project of the Rhode Island Department of Administration Office of Digital Excellence in partnership with Rhode Island Commerce Corporation and is funded by the US Department of Commerce National Telecommunications and Information Administration (NTIA)

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Note

Cost information included in the following report is an estimate based on recent quotes, historical data, certain assumptions about the project scope and approach, the regulatory environment and market conditions at a fixed point in time. Given these variables, we recommend updating the estimate as time passes, and allocating sufficient contingency to allow for inevitable but unpredictable changes in the cost environment if the project moves forward.

Table of Contents

Executive Summary 3
Defining Broadband 5
Future Broadband Speed Projections 7
Telecom Inventory 9
- Verizon 9
  - Commercial 9
  - Key Assets: 9
- Cox Communications 9
  - Residential: 9
  - Commercial: 10
  - Key Assets: 10
  - Recent Announcement: 11
- Towerstream 11
  - Commercial 11
  - Key Assets: 12
- OSHEAN 12
- Last Mile Resellers 13
- Wireless Phone Providers 14
- Existing Tower Assets on the Island 14
- Summary of Broadband Service Offerings on Aquidneck 15
- Pricing of Broadband Service Offerings 16

Future Service Providers 17
  - Aquidneck Broadband LLC 17

Gap Analysis and Report 18
  - Note on Wireline TV/Broadband Provider Competition 18
  - Speed Tests by County 19
  - Speed Tests Distributions, Aquidneck vs all of Rhode Island 20
  - Speed Tests Results for Cox-only Users, Aquidneck vs the Rest of Rhode Island 21
  - Summary of Gap Analysis 22

High Level Solution Designs and Cost Estimates 23

Operating Models 24
Network Options 26
Economic Benefits 30
Conclusion 34
Appendix A 35
Appendix B 36
Glossary 37
Acknowledgements 39

Executive Summary

Broadband Rhode Island (BBRI), part of the Rhode Island Office of Digital Excellence (ODE) has engaged EA Engineering Science, and Technology, Inc. (EA) to perform data collection and broadband mapping for Rhode Island as part of the State Broadband Initiative (SBI), a federally-funded NTIA grant. As part of that work, EA engaged Tilson to survey broadband assets on Aquidneck Island, conduct a needs analysis of the community, articulate gaps in service, and provide high-level solutions and cost estimates for closing the gap.

Several entities in the community have expressed interest in analyzing Aquidneck's broadband services and diagnosing performance gaps. Interested constituencies include the Newport IT Working Group, the Newport County Chamber of Commerce, the Aquidneck Island Planning Commission, and the city and town governments on the island.

Tilson understands that Aquidneck Island, and its communities of Middletown, Newport and Portsmouth are a key region to the state's economic health and viability.

The key findings of the study are as follows:

1. There is abundant fiber and tower infrastructure in close proximity to businesses on the island.

2. Web-surfing capable service is offered everywhere, however realized speeds, reliability and pricing is widely perceived to be insufficient.

3. Newport County is the only county in the state with only one cable TV provider. All other counties are served by at least two providers (e.g. Cox, Full Channel, Verizon FiOS). Since cable TV providers are well positioned to offer broadband with their current infrastructure, a dearth of competition in wireline cable providers negatively affects broadband competition.

4. BBRI's previously collected speed test data support a slower-than-norm download speed for both Newport County as a whole, and the three towns on Aquidneck. Further, it appears that Cox customers on Aquidneck Island experienced slower speeds than Cox customers elsewhere in Rhode Island.

5. Aquidneck's dense commercial settlement pattern combined with recent OSHEAN footprint make for a relatively low capital cost to improve service to businesses on the island.

6. Tilson's high-level capital cost estimate for a wireless infrastructure that covers the entire island is between $1.6 and $3.2 million. This would provide an alternative broadband service that would surpass current service offerings.

7. A fiber to the premise (FTTP) infrastructure for the entire island would cost between $70.1 and $106.4 million. This network would provide state of the art technology that would meet the broadband needs of every resident on the island for a generation. This network could also be deployed incrementally at lower costs.

8. Tilson estimates that it would cost $3.4 to $7.9 million annually to operate a FTTP network and between $2.4 and $4.1 million to operate the wireless network. It is extremely difficult to accurately estimate these costs without a final business model that defines ownership rights, taxes, revenue sharing, and cost of capital. These estimates represent a best effort utilizing comparable figures.

9. Proven business models have the potential to dramatically reduce the cost of high speed broadband. High end broadband service currently costs several hundred to several thousand dollars. Gigabit Ethernet service is offered in select cities throughout the country for as low as $70 per month.

10. Numerous studies have established a link between broadband investments and economic growth. Broadband access increases productivity, creates jobs and enhances consumer well-being. Extrapolating from existing studies, Tilson estimates the total 10 year benefit of a new island-wide network to be between $525 million and $2.020 billion.

11. Tilson identified four potential business models for improving broadband service. They are:

    - Private Model. An Internet Service Provider (ISP) uses its own capital to build its own broadband network using a combination of OSHEAN fiber, wireless assets, and/or new fiber. The ISP operates its network in competition with current providers.
    - Public Model. Local or regional government funds, builds and operates broadband network. This would likely require the hiring of new government staff or contractors.
    - Public/Private Partnership. A local or regional government entity funds and builds broadband network. A private ISP operates network.
    - Non-Profit OSHEAN Reseller. A non-profit resells OSHEAN internet access service to commercial customers within OSHEAN's distance parameters. Non-profit may consider offering wireless-based broadband to residential customers based on a more involved model.

Defining Broadband

It is important to note that the term "broadband" does not refer to any technology in particular. Rather it refers to data transmission through a medium in excess of certain threshold. From an information technology perspective, it represents the amount of data that a consumer can download or upload from the internet in a given second. This is the measurement known as bandwidth. Greater bandwidth is analogous to a faster connection. Connection speeds are generally measured in kilobits per second (Kbps), megabits per second (Mbps) or gigabits per second (Gbps).[1]

In the U.S., broadband standards are defined by the Federal Communications Commission (FCC), which regulates interstate and international communications by radio, television, wire, satellite and cable. The FCC uses a tiered approach to define broadband based on download and upload speeds for wireline and wireless technologies:

FCC Speed Tier	Download Speeds	Upload Speeds
1st Generation Data	200 Kbps to 768 Kbps	200 Kbps to 768 Kbps
Tier 1	768 Kbps to 1.5 Mbps	768 Kbps to 1.5 Mbps
Tier 2	1.5 Mbps to 3 Mbps	1.5 Mbps to 3 Mbps
Tier 3	3 Mbps to 6 Mbps	3 Mbps to 6 Mbps
Tier 4	6 Mbps to 10 Mbps	6 Mbps to 10 Mbps
Tier 5	10 Mbps to 25 Mbps	10 Mbps to 25 Mbps
Tier 6	25 Mbps to 100 Mbps	25 Mbps to 100 Mbps
Tier 7	> 100 Mbps	> 100 Mbps

Table 1: FCC Speed Tiers

The FCC currently defines 4 Mbps downstream and 1 Mbps upstream as the minimum threshold speeds for broadband. As shown in the table above, the current standard translates to a minimum Tier 3 download and Tier 1 upload connection to qualify as broadband service. In July of 2014, the FCC announced that it planned to increase the download threshold to 25 Mbps. They have yet to issue a position on the upload threshold.[2] This redefinition has the potential to dramatically increase the number of communities in the U.S. eligible for subsidy.

The rapid advancement of delivered data speeds in the U.S. is causing the FCC to recently change the definition of broadband. In 2000, only 4.4 percent of American households had a broadband connection (as currently defined) in their homes. By 2010, that number had jumped to 68 percent. Moreover, since 2010, average delivered speeds in the U.S. have doubled overall, and today roughly 94 percent of Americans have access to wireline or wireless broadband speeds of at least 10 Mbps downstream. As a result, the FCC raised the minimum threshold for download speeds from Tier 1 to Tier 3 in 2010, and is now considering increasing the downstream threshold to Tier 5.[3] This evolving baseline reflects a

[1] 1 Gbps = 1000 Mbps = 1,000,000 Kbps.

[2] As this document was going to publication, the FCC increased its broadband definition to 25 Mbps download, 3 Mbps download. http://www.fcc.gov/document/fcc-finds-us-broadband-deployment-not-keeping-pace

[3] Pg. 4. *Four Years of Broadband Growth*, June 2013. The White House Office of Science and Technology Policy & The National Economic Council.

growing need for higher bandwidth as Americans increasingly use the internet and communications technologies in all aspects of their lives.

In terms of functionality, the following table shows download speeds required for a range of common internet-based activities:

	Basic Use (Email, Web Surfing Basic Video)	Moderate Use (Basic use plus high demand functions i.e. gaming, conferencing, HD video)	Heavy Use (Basic use plus multiple high demand functions)
1 user on 1 device (laptop, tablet, gaming console)	1 – 2mbps	1 – 2mbps	6 – 15 mbps
2 users on 2 devices at a time	1 – 2mbps	1 – 2mbps	6 – 15 mbps
3 users on 3 devices at a time	1 – 2mbps	2 – 5 mbps	15 mbps or more
3 users on devices at a time	2 – 5 mbps	6 – 15 mbps	15 mbps or more

Figure 1: Minimum Download Speed for Common Activities[4]

[4] FCC, Household Broadband Guide.

Future Broadband Speed Projections

Future demand for increased download speeds is projected to grow dramatically as adoption of existing services grows, as consumers continue to increase the number of connected devices,[5] and as new services, such as monitoring and surveillance applications, are introduced.

One extensive study commissioned by Cable Europe and NLkabel forecasted the future average sufficient provisioned residential broadband speed in the EU given factors of adoption rates, connected devices, urgency of traffic (the tolerance for time required to transmit data), and future services.[6] Download speeds increase rapidly are were forecasted to be at Tier 5 in 2015. Average sufficient upload speed demand grows more slowly as this type of traffic typically has less urgency for the residential user (i.e. placing large files in cloud storage versus downloading a movie). Business users using the internet for tasks like cloud computing, real time backup and video conferencing require faster upload speeds and demand symmetrical connections.

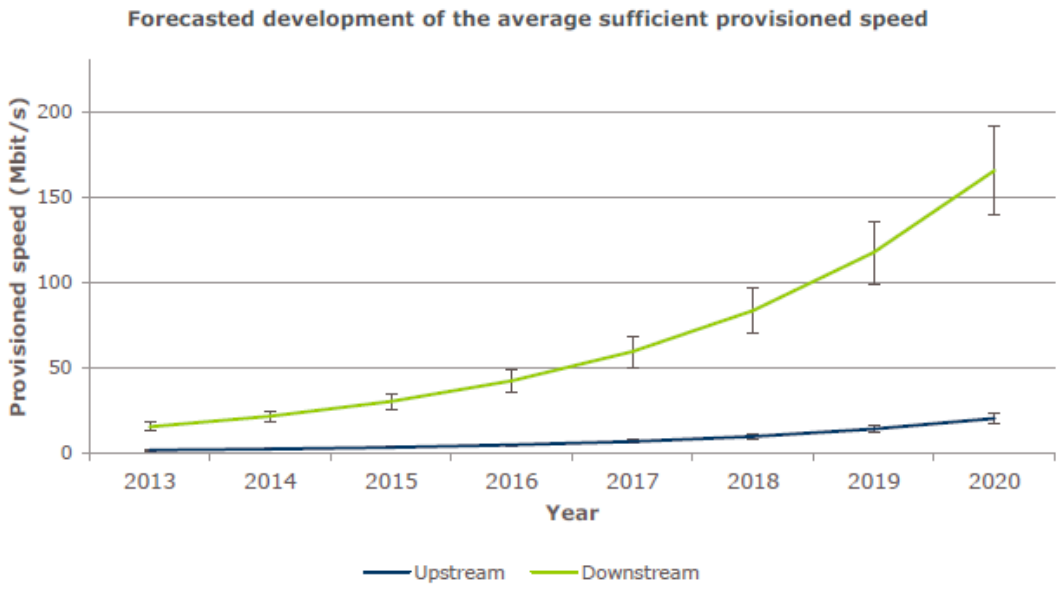

Figure 2: Forecasted Demand of Average Residential Broadband Connection Speed

Download and upload speed capability depend on the type of technology service providers utilize. There are a number of different technologies currently available to residential and business users, which offer varying bandwidth capabilities. As users demand increasingly fast connection speeds, the technology used to deliver those speeds will shift towards the bottom of the following table:

[5] Annual Cisco Visual Networking Index Forecast: In North America, there will be 9.3 networked devices per capita in 2018, up from 5.3 per capita in 2013.

[6] "Fast Forward: How the Speed of the Internet will Develop Between now and 2020", June 2014, van der Vorst et. Al.

Technology	Download & Upload Speeds
Dial-up	Up to 56 Kbps
2G Mobile	Up to 100 Kbps
3G Mobile	384 Kbps – 2 Mbps
4G Mobile[7]	2 Mbps – 18 Mbps
Satellite[8]	200 Kbps – 2 Mbps
T-1	1.5 Mbps
DSL	768 Kbps – 7 Mbps
Traditional Cable	1 Mbps – 10 Mbps
DOCSIS 3.0 Cable	1 Mbps – 150 Mbps
Fixed Wireless[9]	1 Mbps – 1.5 Gbps
Fiber Optic	Up to 1,000 Gbps. Effectively infinite

Table 2: Technological Speed Capabilities[10]

[7] AT&T Wireless currently has the highest tested capacity at 18 Mbps.

[8] Current satellite service may achieve broadband level speeds, but the excessive latency or delay precludes the use of many broadband applications.

[9] The Rhode Island company Towerstream offers up to 1.5Gbps.

[10] The speeds are typical ranges achieved for each technology. Higher speeds will be possible for certain technologies given future innovation. The top ranges represent optimal network layout and user saturation. For example, DSL users close to a network node during a period of low network use will obtain higher connection speeds. Outside of one mile from a network node, it is very difficult to achieve a broadband connection over DSL.

Telecom Inventory

This section details the assets and services of facilities-based carriers providing broadband service. Most municipalities in the U.S. have broadband options from an incumbent local exchange carrier (phone) and cable company (TV) for broadband service. On Aquidneck Island, these providers are Verizon and Cox Communications respectively. They offer a suite of business and residential internet and voice products. Cox offers video products. In addition to these options, Towerstream provides a wireless broadband option to businesses on the island and the publicly funded OSHEAN network connects educational, public safety, non-profit, and government institutions.

Verizon

Residential: Verizon offers copper-based DSL to most or all addresses on the island. The fastest residential advertised (and available) DSL promotion is 3.1 to 7 Mbps download, 768 kbps upload. Speeds are not guaranteed, and are a function of distance to the central office, the size and type of copper, and the condition of the copper infrastructure. Verizon does not offer its FiOS Service on the island and has no plans to expand service. [11] [12]

Commercial: In addition to DSL, Verizon will supply fiber-based connections, up to 1 Gbps of symmetrical service[13], anywhere on the island. The price and time required to provision are on a case-by-case basis. In most cases, a fiber lateral is built from a network Point of Presence (POP) in the street to the customer premises. Verizon's quote for this service appears in the Pricing of Broadband Service Offering summary table below. [14]

Key Assets: The Verizon network covers the majority of the island servicing residential customers with copper wired line Telephony and DSL data services. The Verizon fiber network is not visible throughout the island and appears limited in many areas. Verizon has large fiber sheaths along sections of East Main Street (RT 138), some fiber along portions of West Main St (RT 114) and along some commercial areas, albeit limited. It appears that there is fiber connecting Verizon's central offices, which transports telephony and DSL between central offices.

Cox Communications

Residential: Cox offers a self-described best efforts[15] service to all addresses on the island using its DOCSIS 3 hybrid fiber/coaxial cable network. According to a Middletown-based Cox customer service representative, Cox's network was upgraded from DOCSIS 2.0 in the summer of 2014. Top advertised

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[11] FiOS is a fiber to the premises service offering symmetrical broadband speeds of up to 500 Mbps, voice, and TV programming. It is offered in the nearby mainland community of Narragansett.

[12] Conversation with Tom Kogut, RI PUC 11.18/2014; and http://consumerist.com/2014/03/12/dont-count-on-verizon-fios-coming-to-your-town-anytime-soon/

[13] Symmetrical service is where download and upload speeds are the same. E.g. 50 Mbps symmetrical means that the customer will be able to both upload and download data at 50Mbps.

[14] A Verizon business sales representative quoted fiber-based 50Mbps/50mbps service to the Aquidneck Corporate Park in Middletown, for $1800/mo, no installation fee, and a three year term.

[15] As described by Cox account representative. Terms on website include: "Cox cannot guarantee uninterrupted or error-free High Speed Internet service or the speed of your service. Actual speeds vary."

speeds on the upgraded DOCSIS 3.0 network are 150 Mbps download, 20Mbps upload. Actual speeds are determined by network configuration, data traffic congestion, the condition of the copper facility, and customer premise equipment.

One aspect of network configuration is how many subscribers are served from a fiber-fed node. As data demands have increased over time, the number of active subscribers designed into a typical cable provider's network have decreased from 500+ to 250, to as few as 125 today. The optimal number of users per node is dependent on subscriber rates. Another aspect is how the nodes are combined and routed in the Cox network's head end, where the fiber from the nodes terminates.

Data traffic congestion is the term for multiple simultaneous data demands that results in slower speeds. This is directly related to user demand and network configuration. Many cable modem customers experience congestion in the evening, when users are home from school and work. On Aquidneck, users complain of evening slowdowns and added seasonal slowdowns during the summer tourist season. [16] [17]

The condition of the network for the best efforts service refers to the coaxial cable and amplifiers between the node and subscribers' cable modems. Coaxial cable is a cable with a copper clad center conductor which the signals travel on, surrounded by foam dielectric, covered with an aluminum sheath and then covered by a PVC jacket. The coaxial cable performance diminishes in wet conditions. Salt water exposure corrodes the cable and diminishes performance further. This weathering tends to be one of the biggest maintenance issues for cable companies as their coax plant ages.

Customers require a DOCSIS 3.0 compatible modem, which they can rent or buy, in order to achieve advertised speeds.

Commercial: In addition to its DOCSIS 3.0 hybrid fiber/coax network business offerings, Cox offers business optical fiber service. The local Cox sales representative did not return requests for comment. However, Tilson believes that Cox has fibers available for dedicated customer connections along the OSHEAN route[18], plus in several other locations, such as to the Navy property in Newport. The Pricing of Broadband Service Offering summary table below contains a quote made for this service in 2013 that was made available to Tilson.

Key Assets: The Cox network covers the majority of the island in both residential and commercial business locations. This coverage is in the form of fiber to the node with a hybrid fiber/coaxial (HFC) cable network architecture providing DOCSIS 3.0 data transfer rates (see table in "Defining Broadband" section above). Cox's fiber feeding its HFC network is ubiquitous on the island. Fiber from this network can also be seen running to individual businesses subscribing to optical services, e.g. A2B Solutions. Cox also has a backbone fiber network that consists of and an overlay on the OSHEAN network,[19] and some

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[16] Stoneacre Pantry, Newport. Restaurant pays $160/month for fastest best efforts Cox Service. During weekends internet connection slows, and web-dependent functions like credit card transactions take as long as 15 minutes to process, and streaming music stops. Per phone conversation with David Crowell, owner of Stoneacre Pantry in Newport on 11/19/2014

[17] Ron Corriveau, conversation on 10/27/2014; Susan McDonald email 11/18/2014; Jim Egan 12/05/14.

[18] Cox won the contract to build the OSHEAN network, and during construction laid its own cable along much of the OSHEAN route.

[19] Cox built the OSHEAN network, and during that process built an overlay network of its own fiber. Cox's fiber is actually lashed to the OSHEAN fiber along the OSHEAN route.

below-ground fiber near the Navy facility in Newport. The figure below show's Cox's backbone fiber as well as large count laterals connecting the Navy facilities and running up Route 114. In addition to this backbone fiber, Cox has numerous fiber laterals running throughout the three Aquidneck Island communities. Tilson's field survey found the Cox fiber running along most every street on the island. Cox will sell fiber connections utilizing this infrastructure on a site by site basis. The Cox backbone fiber network can be seen juxtaposed against the OSHEAN network in Appendix A.

Recent Announcement: On December 18, 2014, the Newport Daily News reported that a spokesman for Cox stated that the company is planning to bring high-speed fiber-optic broadband Internet service to homes across Aquidneck Island by the end of 2016. See article in Appendix B.

Figure 3: Cox Backbone Fiber Network

Towerstream

Commercial: Towerstream provides digital microwave (wireless)-based service to customers that have line-of-sight to its two towers on the island. According to a Towerstream representative, line of sight is

available to customers on flat, treeless expanses like office parks and customers in tall buildings with a profile that accommodates an antenna that is clear of interference. Towerstream will provision one receiver to serve multiple tenants in a building by running fiber from the receiver to the customer premises. Towerstream can provide this service at a lower average cost per customer, and in fact the company provides discounts to customers in multi-tenant locations. Symmetrical speeds are available up to 1.5 Gbps. Towerstream uses licensed spectrum, and must apply for an FCC license for connections greater than 20 Mbps. Prices are lower than Cox or Verizon in terms of price per mbps for dedicated symmetrical internet access. See Broadband Service Offering summary table below for sample price points. Note that Towerstream may be a potential operator of the wireless broadband network described in the Network Design section.

Key Assets:

Towerstream's key assets on Aquidneck are two towers, one in the northern part at Bay View Apartments, 2121 West Main Road Portsmouth, RI 0287. The second covers much of the southern geography of Aquidneck from the Newport Hospital, 11 Friendship St, Newport, RI 028401. The map below shows the coverage delivered by Towerstream's two towers on the island.[20]

Figure 4: Towerstream Network

OSHEAN

OSHEAN is a consortium of universities, hospitals and government agencies that operates a 450 mile fiber optic network to serve nonprofits, health-care organizations, and educational institutions. These customers are known as "Community Anchor Institutions" (CAIs). OSHEAN offers connection speeds of up to 1Gbps.

Although OSHEAN's lit network is only open to a limited class of organizations, it does offer indirect options for expanding service on the island to private businesses and homes. OSHEAN's fiber is available

[20] Towerstream website.

for wholesale lease, and OSHEAN will resell its internet access service to a non-profit or government entity. These possibilities will be discussed later in the report.

Figure 5: OSHEAN Fiber Network on Aquidneck Island

Last Mile Resellers

Verizon and Cox supply local loops to other carriers without last mile infrastructure on the island. For example, Earthlink does not have fiber on the island, but is able to quote prices for its IP-based services using fiber to the premises that it buys from either Verizon or Cox, and resells as a bundled offering to its customer. In most cases, the provision of resold optical services requires running fiber between the Verizon or Cox POP to the customer premises. Earthlink representatives are able to identify local loop

providers and quote the price of optical services using a desktop tool. Provision of service often takes several weeks.[21]

Wireless Phone Providers

Of the four providers on the island, Verizon, AT&T, and Sprint advertise 4GLTE network on Aquidneck Island. 4GLTE networks are capable of replacing wired networks when users configure phone as a hotspot. Maximum signal strength on AT&T's network has been tested at 18.5/9 Mbps.[22] However, speed varies as a function of distance to towers and traffic congestion. The cellular antenna and radio equipment performance suffers when servicing more than a few hundred users. Verizon is currently planning the deployment of a new network of "small cells" in Rhode Island that will dramatically improve cellular performance.

Mobile 4GLTE service does not support business broadband needs. This is because mobile device generated network congestion varies widely, especially in a town like Newport with seasonal and event-driven cell phone usage.

Existing Tower Assets on the Island

Aquidneck Island has five towers that are utilizing spectrum registered with the FCC. These towers are used for mobile phone networks and the Towerstream network. They have the potential to be used for an additional wireless broadband network on the island. If these towers have space for additional antenna arrays (known as "rad sectors" in the industry), they may be an option for a wireless residential and business broadband solution. The figure below shows the locations of tower assets on Aquidneck

[21] Conversation with Earthlink Business Technology Consultant on 10/14/2014

[22] http://www.cnet.com/news/at-t-outshines-verizon-in-4g-lte-speed-tests/

Island and their approximate service range, assuming 5.8 ghz spectrum. The major cellular carriers utilize frequencies that propagates farther than 5.8 ghz, so these radiuses are conservative.

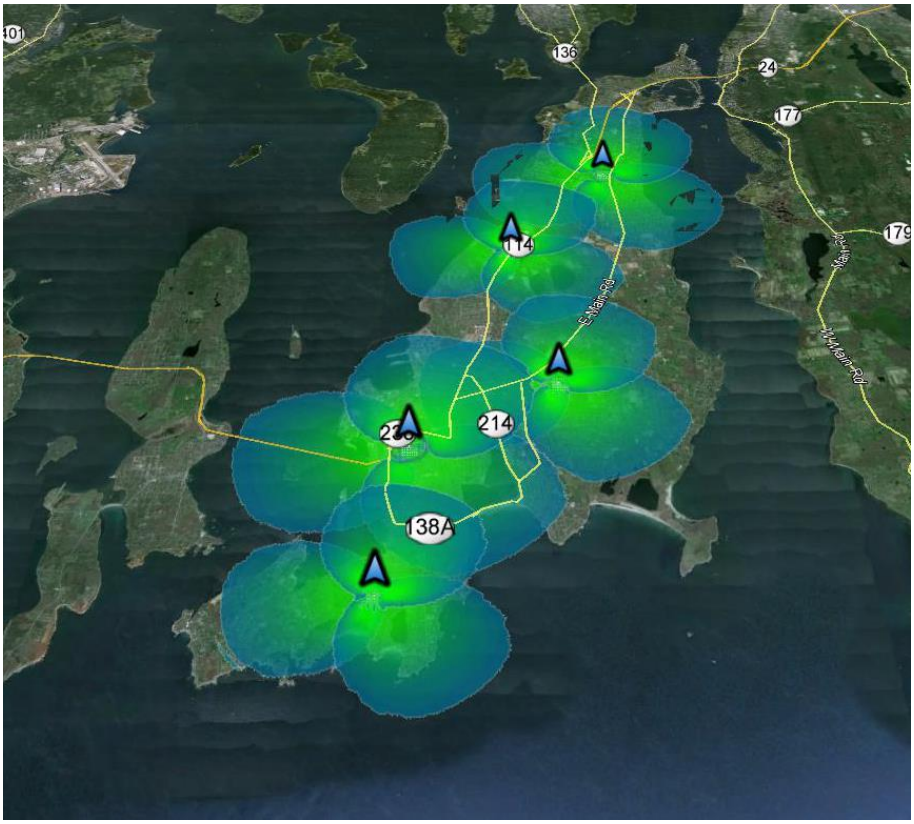

Figure 6: Existing Tower Assets and Approximate Service Range

Summary of Broadband Service Offerings on Aquidneck

Below is a table of the providers discussed above. It is important to note that the only commercial entities served by OSHEAN are healthcare providers, and Towerstream is a wireless service.

	Verizon	Cox	Towerstream	OSHEAN	Mobile Wireless
Commercial > 100 Mbps	x	x	x		
Education, Medical, Non-Profit, Gov > 100 Mbps	x	x	x	x	
Commercial 10> <100 Mbps	x	x	x		
Residential > 10 Mbps		x			
Roaming > 10 Mbps					x

Table 3: Facilities-Based Broadband Speed Offerings by Carrier on Aquidneck

Pricing of Broadband Service Offerings

Tilson was able to obtain pricing from various sources including websites, sales reps, and prospective customers. Tilson was not able to obtain OSHEAN pricing, and excluded wireless plans due to their limited relevance.

Cox Business	Speeds (down/up)	Delivery Method	Monthly Price	Notes
	15/5		n/a	
	30/10	best efforts	$75	+ installation and modem, 2 yr term
	60/15	best efforts	$135	+ installation and modem, 2 yr term
	100/20		n/a	
	2/2	optical	$460	3 yr term, bid dated Sept. 2013
	up to 10 Gbps	optical	n/a	

Cox Residential	Speeds (down/up)	Delivery Method	Monthly Price	Notes
	5/1	best efforts	$35	2 yr term, price increases $10 in year 2
	50/5	best efforts	$50	2 yr term, price increases $10 in year 2
	100/10	best efforts	$70	2 yr term, price increases $12 in year 2
	150/20	best efforts	$80	2 year term, price increases $20 in year 2

Verizon Residential	Speeds (down/up)	Delivery Method	Monthly Price	Notes
	5/.768	dsl	$30	plus installation and router

Verizon Business	Speeds (down/up)	Delivery Method	Monthly Price	Notes
	50/50	dedicated fiber	$1,800	quote from rep to Aquidneck Office Park

Towerstream	Speeds (down/up)	Delivery Method	Monthly Price	Notes
	100/100	wireless	$1,800	single tenant
	100/100	wireless	$700	10 tenants on premise

Table 4: Advertised and Quoted Broadband Prices by Carrier on Aquidneck

Tilson conducted a limited survey of ISP pricing for dedicated, symmetrical bandwidth outside of Aquidneck. That survey included two services in downtown Boston, and Google Fiber, Taunton Municipal Lighting Plant (TMLP), and Verizon FiOS residential and small business. Downtown Boston, like Aquidneck Island, is not served by FiOS, Google or a municipal utility offering like TMLP.[23]

[23] Towerstream pricing for a premise with 10+ customers decreases to $700/mo for 100Mbps. One, two or three year terms apply for most offerings.

The discrepancy in prices, shown in the table below, was big enough to necessitate a logarithmic scale to depict graphically.[24] The lowest prices are for services like FiOS, municipal utility offerings, and Google Fiber where concentrated deployment within "fiber hoods" took place. Boston, like Aquidneck, does not have Verizon FiOS. Wicked Bandwidth is a startup ISP with 10 buildings on-net.

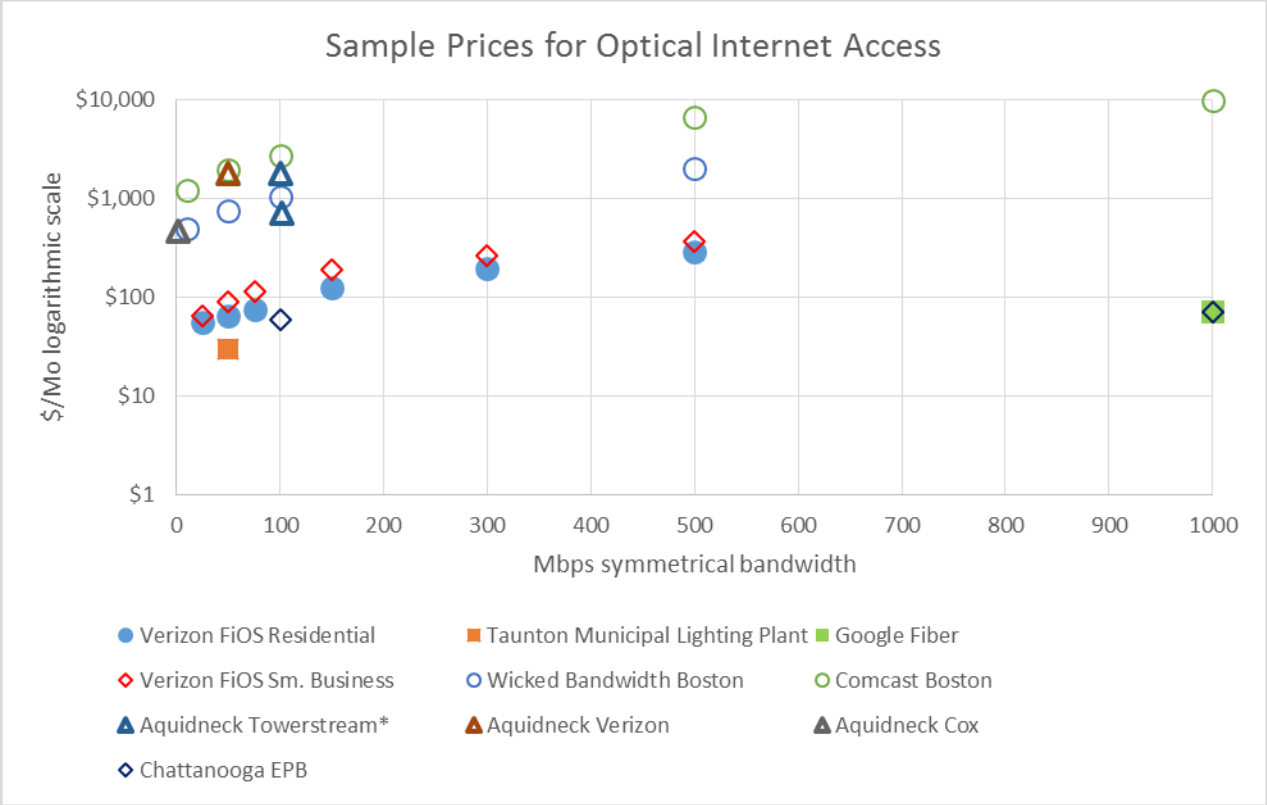

Figure 7: Advertised and Quoted Optical Internet Access Prices by Carrier[25]

Future Service Providers

Aquidneck Broadband LLC

Aquidneck Broadband LLC is a partnership that intends to announce an open access network[26] on Aquidneck Island during 1Q 2015.[27] A few details were made available to Tilson: Aquidneck Broadband will be an open access network, meaning that it will not provide services like internet access and cloud storage directly. Rather, ISPs will provide these services on leased capacity from Aquidneck Broadband.

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[24] i.e. price differences are larger than they appear. E.g. the 50 Mbps price of Wicked Bandwidth is more than 10x the price of Verizon FiOS residential.

[25] * Towerstream's service is not optical, but served over a wireless microwave connection that is intended to compete with optical service. They charge a lower price if the premise has 10 or more tenants.

[26] See Glossary for definition and brief discussion of open access networks

[27] Phone conversation with Andrew Cohill, CEO Wide Open Networks, 11/17/14

The ISPs would provide retail services to end users. The partnership plans to combine OSHEAN middle-mile fiber and newly-constructed routes to create the physical layer of its backbone.[28]

Tilson has not spoken to Aquidneck Broadband LLC principals since Cox's December 18 announcement stating a future fiber rollout in the area, and therefore cannot comment on the effect of Cox's statement on Aquidneck Island LLC's ability to raise capital or on their outlook for the Middletown/Newport/Portsmouth market.

Gap Analysis and Report

As part of this exercise, Tilson analyzed extensive survey data of end user speed tests compiled by Broadband Rhode Island. Broadband Rhode Island, working with vendor Brave River Solutions, set-up a speed test that launched from the Broadband Rhode Island website and pinged a server in Providence, RI. Over 6,000 samples were collected from about 2300 unique business and residential tester addresses. While speed tests are not taken in a perfectly controlled environment, and the voluntary nature of the survey design may introduce bias, numerous speed tests measured by a single vendor using a consistent protocol are perhaps the best measure of experienced speeds across the state. [29] [30]

Note on Wireline TV/Broadband Provider Competition

Wireline TV providers are regulated by the RI PUC for their "basic cable" services. These providers offer unregulated add-on services like enhanced channel offerings, DVRs and broadband services. Cox Communications and Verizon FiOS are the predominant wireline TV providers in Rhode Island, and they co-exist and compete for broadband services in many markets. There are other providers too, like Full Channel in the East Bay area that offers bundled TV/broadband/phone.

Newport County, comprised of Newport, Portsmouth, Middletown, Jamestown and Little Compton, is the only county in Rhode Island that has a single wireline TV provider.[31] [32] While Verizon offers DSL in Newport County, that service doesn't support TV, and is not a viable broadband competitor to Cox's DOCSIS based service.

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[28] Phone conversation with Jack Maytum, Wide Open Networks, 11/19/14

[29] All speed tests are subject to exogenous factors. Examples affecting speed tests results include spyware and viruses installed on end user equipment, proxy server use in a business setting, and other factors like network congestion that may change the route packets take between the speed test server and the end user. It is not uncommon for two sequential speed tests to have slightly different results. It is very common to have consistently different results on reported speeds between separate speed test vendors.

[30] Speed test data is comprised of all tests taken between 3/23/10 and 8/3/14 on BRRI's server. Brave River utilizes a VMWare server partitioned with 2 dedicated Intel Server CPU's Xeon E5-2603 and 8 GB. The server has unrestricted access to entire Prov.net network Internet hub which runs at up to 500 MB/Sec. Previous to 2013, the server had a 75MB connection to the Prov.net network.

[31] Tom Kogut, Rhode Island PUC. Phone conversation on 11/18/2014

[32] The RI PUC's structure that enables multiple wireline providers can operate in a given market also means that franchise agreements don't expire. Therefore, as long as Cox continues to meet its service obligations for basic cable TV, it will maintain its franchise.

Speed Tests by County

The speed tests collected by BBRI show that median broadband speeds were slower in Newport County (served only by Cox wireline TV), than in Bristol County (served by Cox and Full Channel) or Washington County (served by Cox and Verizon FiOS).

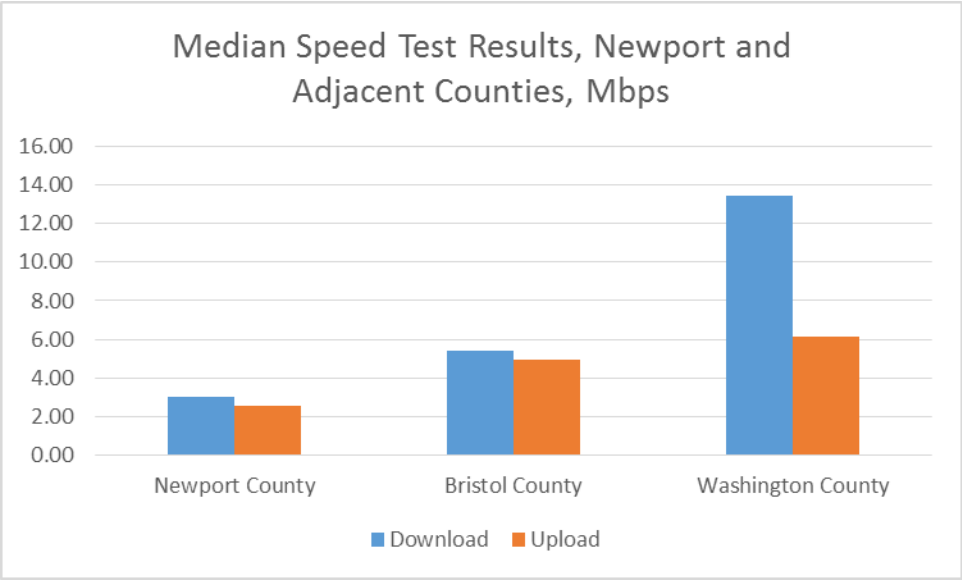

Figure 8: Median Speed Test Results by County, All Providers

In addition to looking at the median speed test results by county presented above, it's also useful to examine the distribution of test speeds on Aquidneck, and compare those speeds to another community. In this case, Tilson decided to compare the speeds on Aquidneck to all of Rhode Island in order to maximize sample size.

Speed Tests Distributions, Aquidneck vs all of Rhode Island

In the first analysis, Tilson looked at all Aquidneck testers' results (i.e. subscribers of ISPs Verizon, Cox, OSHEAN and Towerstream) and compared them to the results of all of RI. The results suggest that testers on Aquidneck experienced download speeds skewed towards the slower speeds, and a smaller percentage of testers experienced speeds in ranges needed by businesses.

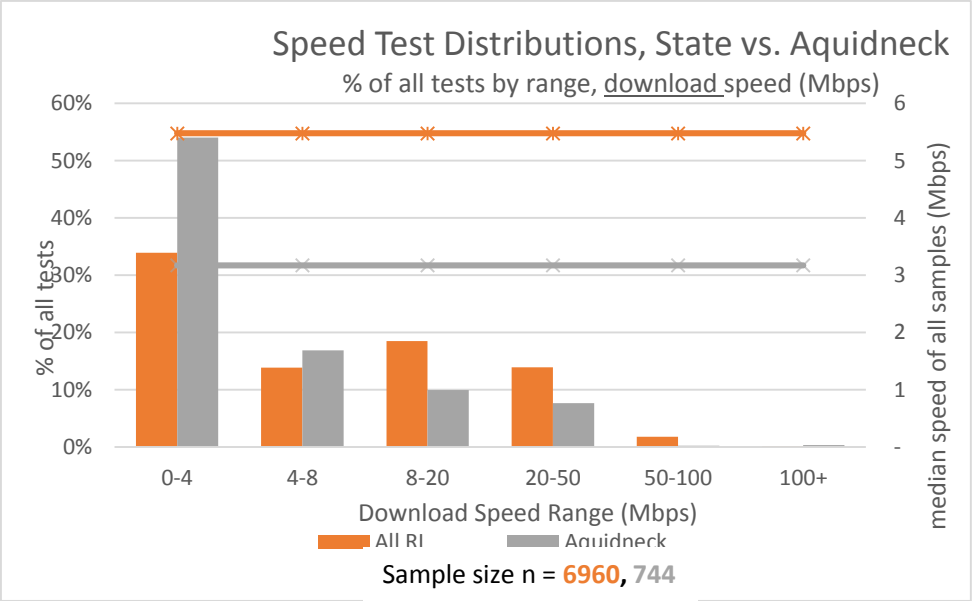

Figure 9: Comparative Speed Test Distributions, RI vs Aquidneck, Download, All Providers

Median upload speeds on Aquidneck were roughly on par with state speeds. Tilson believes this is most likely because of the way the ISPs' networks are (or were) configured on the island. Very few users Tilson spoke to subscribed to symmetric services, so a high proportion of symmetric subscribers is unlikely the underlying cause.

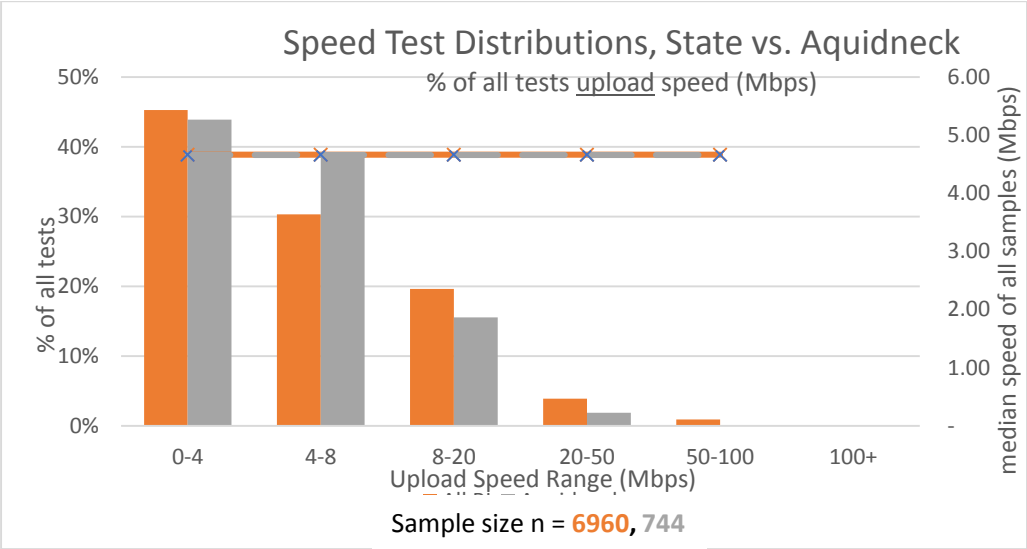

Figure 10: Comparative Speed Test Distributions, RI vs Aquidneck, Upload, All Providers

Speed Tests Results for Cox-only Users, Aquidneck vs the Rest of Rhode Island

In the second analysis, Tilson looked at Aquidneck testers that were Cox Communications customers only, and compared those test results with all Cox Communications testers elsewhere in the state. These results showed that Cox testers on Aquidneck experienced significantly slower download speeds than testers elsewhere in the state. The gap in upload speeds within the Cox tester base was narrower.

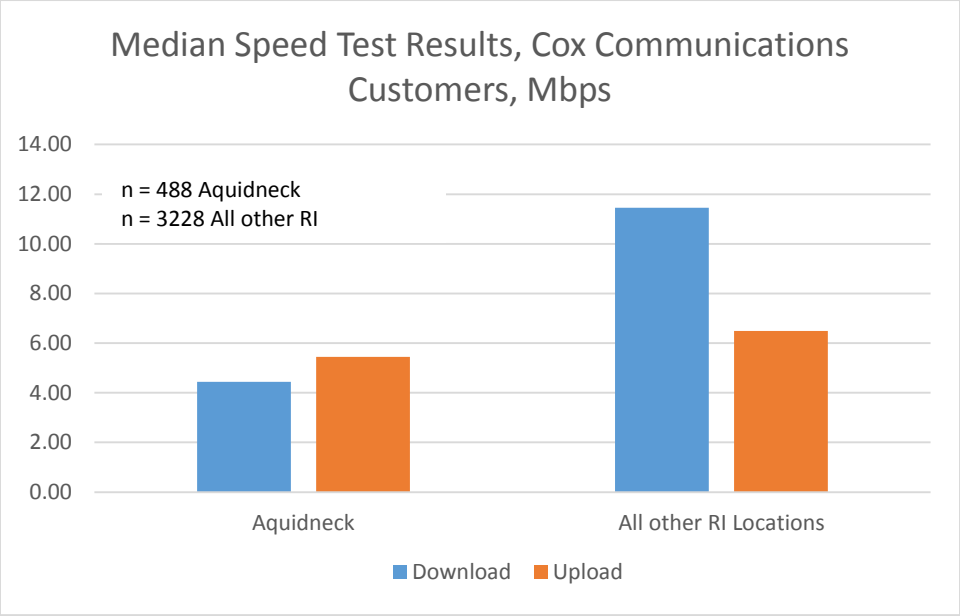

Figure 11: Comparative Speed Test Results, Cox Customers on Aquidneck vs All Other RI Locations

Summary of Gap Analysis

BBRI's speed test results suggest that Aquidneck Island experienced slower broadband speeds than the rest of Rhode Island during the test period. Newport County experienced slower speeds than adjacent counties,[33] and Cox customers on Aquidneck experienced slower speeds than Cox customers elsewhere.

Anecdotal evidence suggests that Cox's HFC "best efforts" service has dominant combined residential and business market share for broadband on the island. Interviews with stakeholders revealed persistent dissatisfaction with service reliability and actual speeds. Tilson believes that while some dissatisfaction with Cox stems from customers' sense of being captive to a single provider, that the data suggests that Cox's service on Aquidneck and in Newport County was inferior to that experienced in the rest of Rhode Island.

The analysis of the existing data has raised questions, and may contribute to existing theories about broadband performance throughout Rhode Island. Tilson believes this analysis will place a lot of scrutiny on the speed test process – e.g. who took it, what protocol was used, and whether the sample represents a relatively uniform distribution of subscribed speeds. Another important variable is when the speed tests were taken, particularly important if Cox's network upgrades on Aquidneck Island were recent (see date distribution graph below). With this in hand, the next logical step may be a separate speed test survey dedicated to resolving the question of relative performance of Aquidneck vs the rest of Rhode Island.

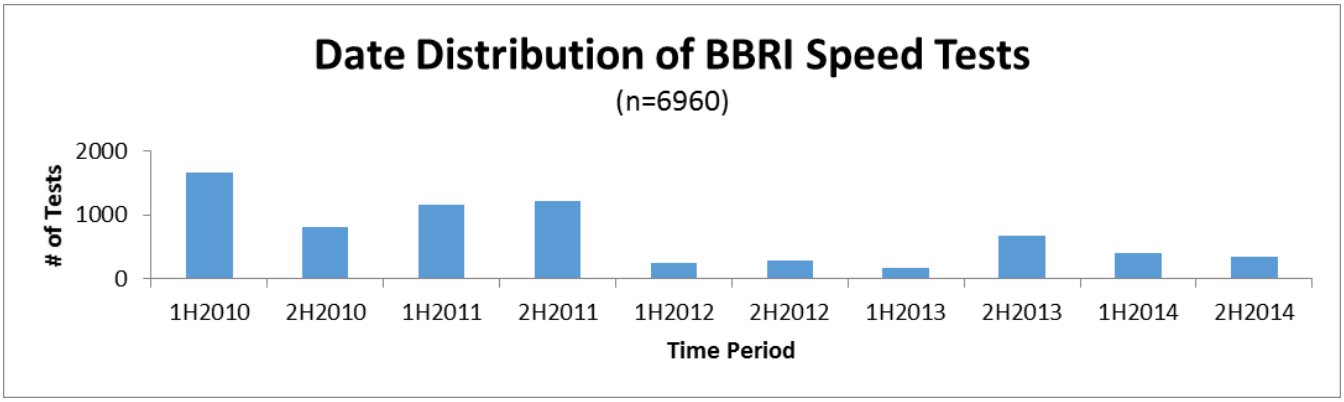

Figure 12: BBRI Speed Test Dates by Half Year Periods

[33] The three Aquidneck Island towns have faster median speed test results than all Newport County towns as a whole.

High Level Solution Designs and Cost Estimates

The 2013 completion of OSHEAN's Beacon 2.0 fiber optic network delivered significant middle-mile infrastructure on Aquidneck Island with good proximity to many of the island's businesses and tower assets (see Figures below). Tilson has leveraged this infrastructure to provide two high-level technical designs – a Fiber to the Premise design (FTTP) and a wireless design.

Figure 13: OSHEAN Network and Newport Chamber of Commerce Business Locations

Figure 14: OSHEAN Network and Existing (blue) and Proposed (white) Towers for Wireless Network

Operating Models

Tilson envisions four potential operating models for addressing the residential and business service gap on Aquidneck. These models are a not an exhaustive list of options to improve broadband access in the state, but rather build on the technical solutions described above. For example, they do not contemplate legislative action or the possibility that a new provider will seize the market opportunity and enter and disrupt the market for internet access on Aquidneck Island.

1. Private Model. The towns of Newport, Portsmouth and Middletown partner with an incumbent ISP (either Verizon or Cox) or a new ISP (e.g. Aquidneck Broadband LLC), to upgrade existing facilities and/or build new facilities on the island. These upgraded and/or new facilities would offer faster, more reliable speeds. The private provider would construct, maintain, operate, and

provide service on the network and would cover all ongoing operating costs. It is possible that the provider would require some capital subsidy in order to build/upgrade the network to reach all addresses in Newport, Portsmouth and Middletown.

Pros (Incumbent): Use existing, proven technology and leverage existing assets.

Cons (Incumbent): Likely a higher price for consumers than alternate options. No guarantee of future upgrades in absence of a competitive environment. Reduced likelihood of a future competitive environment (i.e. new entrants will find it more difficult to enter this market).

Pros (New ISP): Consumer and regional economic development benefits associated with an improved competitive environment (i.e. increases in domestic and business productivity resulting from lower price and faster broadband connections).

Cons (New ISP): Performance risk associated with partnering with a new, relatively lightly capitalized service provider.

2. Public Model. The towns of Newport, Portsmouth and Middletown fund, build and operate a broadband network. This model could work with either the FTTP or wireless solutions described above.

   Pros: Leverage municipalities' lower cost of capital. Ensures municipal control over network. Exempts network owners from paying state telecommunications infrastructure tax. Likely a lower price for consumers. Potential operating income.

   Cons: Requires that municipal governments become an internet service provider, an area in which they likely have little expertise. Requires close alignment of municipalities. Operating loss risk if venture loses money.

3. Public/Private Partnership. Newport, Portsmouth and Middletown pursue a joint venture with a private carrier to build a network to all premises on the island. The municipalities fund the network (either FTTP or wireless), and a private partner constructs, maintains and operates the network. There are a variety of ways to structure the partnership. For example, a joint venture with combined town/private ownership could fund, build and own the network. Alternatively, the municipalities could fund the network, hire a third party EPC to build the network, and work with an ISP to maintain and operate the network. If a municipality retains control over the network, it could have the right to replace the ISP in the event of non-performance.

   Pros: Leverage municipalities lower cost of capital. Ensure municipal control over network while leveraging the expertise and assets of an ISP. May exempt network owner from paying state telecommunications infrastructure tax. Likely a lower price for consumers.

   Cons: Requires close alignment of municipalities and ISP. Initial partnership structure must reflect community needs, risk tolerances, and ISP competencies. Complex deal structure. ISP will likely require customer guarantees or operating capital subsidy.

4. Non-Profit OSHEAN Reseller. A non-profit is formed to resell OSHEAN internet access to commercial customers within a given distance parameter. This model is within OSHEAN's charter parameters, and OSHEAN is willing to consider the model whereby it provisions and serves individual customers via a reseller.[34] While OSHEAN is willing to consider this model for businesses, provisioning and serving individual residences would be complex, and OSHEAN is not equipped to serve this market. If the non-profit were to service this market, it would have to take on virtually all operational responsibilities and use OSHEAN as a wholesale provider.[35]

   Pros: Low initial capital investment. Gets business access to the OSHEAN network's low cost bandwidth.

   Cons: Requires close alignment of municipalities, OSHEAN, and non-profit. May necessitate serving the residential market as a second phase contingent on the success of the business-only model.

Model	Who Funds	Who Builds	Who Owns	Who Operates	Who Takes Revenue Risk	Taxes? (Y/N/?)
1a. Private - Incumbent	Carrier – possilbe coverage subsidy	Carrier	Carrier	Carrier	Carrier	Yes
1b. Private – New ISP	Carrier – possible coverage subsidy	Carrier	Carrier	Carrier	Carrier	Yes
2. Public	Municipalities	Municipality / Contractor	Municipality	Municipality	Municipality	No
3. Public Private Partnership	Municipalities	Municipality/ Contractor	Municipality	Carrier	Structured commensurate with risk	tbd
4.Non Profit OSHEAN Reseller	Non-Profit (Donations, Bonds, Grants)	Non-Profit/Contractor	Non-Profit	Non-Profit	Non-Profit	No (probably)

Table 5: Business Model Options

Network Options

Tilson Identified three high level network solutions to close the identified broadband service gap. The first option is a coaxial cable infrastructure investment. Under this scenario Cox or another cable provider works in partnership with the three municipalities to replace derelict copper, split nodes, and make fiber more available to customers. The second option is a new fiber to the premise network that can be operated and funded on a public, private, or hybrid basis. A third option is to use deploy a more extensive wireless broadband network to serve the island. Using 4G LTE equipment or fixed wireless

[34]Conversation with David Marble, President of OSHEAN on 11/4/14.

[35] The residential reseller/OSHEAN reseller model would be similar to the structure between Taunton Municipal Lighting and Plant and OSHEAN. See http://www.tmlp.net/#&panel1-1 for customer-facing details.

installed on five existing and five new towers in the area, the network could provide fast broadband to every home on Aquidneck.

Option 1. New hybrid fiber coaxial networks cost approximately $45,000 per mile to build. The comprehensive plans for Newport, Middletown, and Portsmouth indicate that the island has approximately 206 miles of roads. This implies a total capital cost of $9.3 million to build the new network. This model does not place any operating cost burden on the municipal governments because a third party assumes all business responsibilities.

Option 2. According to the U.S. Census there are approximately 35,000 housing units and business on Aquidneck Island. Experience with fiber to the premise projects indicates that capital costs run in the range of $2000 to $3000 per premise, depending on population density, take rate, and the division of costs between customers and providers. Assuming this range of prices, Tilson estimates that a new FTTP network with the potential to serve every home and business on Aquidneck would cost between $70.9M and $106.4M. The line item estimates are imputed from similar cost estimates based on the total cost.

Cost Per Premise	Low $2,000	Mid $2,500	High $3,000	Share of Total Cost
Fiber Cable (all counts)	$4,067,428	$5,084,285	$6,101,142	6%
Aerial Construction	$13,374,919	$16,718,648	$20,062,378	19%
Under Ground Construction	$29,992,291	$37,490,364	$44,988,437	42%
Splicing	$5,269,197	$6,586,497	$7,903,796	7%
Make Ready	$5,058,558	$6,323,197	$7,587,836	7%
Professional Services	$6,155,002	$7,693,752	$9,232,502	9%
Contingency	$7,030,913	$8,788,642	$10,546,370	10%
Total Capital Cost	$70,948,308	$88,685,385	$106,422,462	

Table 6: FTTP Capital Cost Estimate

Without a business plan in place, it is impossible to precisely estimate what the operating costs of such a network would be. These costs are highly dependent upon the scale of the operator, take rate, and the fee structure of the network. The operating costs listed below give the components of operating a FTTP network and a range from $3.4M to $7.9M.

Operating expenses	Low	Mid	High
Pole Attachment Fees	$103,050	$133,965	$164,880
Maintenance & Repair	$1,064,225	$1,995,421	$3,192,674
Bandwidth	$360,000	$360,000	$360,000
Fixed G&A	$1,100,000	$1,100,000	$1,100,000
Variable G&A	$780,431	$1,951,078	$3,121,726
Total	**$3,407,706**	**$5,540,465**	**$7,939,279**

Table 7: FTTP Operating Cost Estimate

Pole attachment fees are paid to the owner of the utility poles on which the fiber is mounted. On Aquidneck Island, National Grid and Verizon own over 90% of these poles. Fees usually range between $10 and $16 per pole. Tilson estimates that there are 50 utility poles per road mile, which yields an estimated total of 10,305 poles. Maintenance and repair ranges from 1.5% to 3.0% of the capital costs of the network. These maintenance estimates are equal to 1.5%, 2.25%, and 3.0% of the corresponding capital costs. Fixed G&A reflects costs such as rent, electricity, field technician labor, and legal advisory this is based on previous network designs. These do not scale significantly as the network grows. Fixed G&A costs include all the customer service, billing, and administration associated with each customer. Tilson estimated a per customer cost of $220 and take rates of 10% to 40% to obtain the variable G&A estimates. Considering all of these variables, Tilson estimates that a fiber optic network covering all of Aquidneck Island would cost between $3.4 and $7.9 million to operate annually. For comparison, if the network operator obtained 9000 customers, or about 27% of all premises, at an average monthly subscription price of $70, the business would generate $7.5 million in revenue. The experience of similarly disruptive FTTP networks suggests that such figures are attainable.

	Take Rate	Gigabit Price
Chattanooga, TN	40%	$70
Leverett, MA	65%	$80
Kansas City, MS	75%	$70

Table 8: Take Rates and Corresponding Prices of FTTP Broadband Projects

Chattanooga EPB was the nation's first municipal gigabit network and took several years to achieve its market share. However, the new Google Fiber project in Kansas City and municipal broadband network in Leverett Massachusetts quickly reached their take rates. The projects in Chattanooga and Kansas City have succeeded despite crowded markets with strong cable and telecom providers offering broadband products. This success appears to be replicable.

Option 3. In this model new antennas and radios are installed on towers throughout the area to provide LTE-equivalent service to homes and businesses. Tilson identified five existing towers that can serve as potential sites. The map below also identifies five additional sites that would fill the current gaps in coverage. The route utilizes OSHEAN fiber where possible for connection to the internet via a nonprofit reseller. Model includes the cost of installing equipment at customer homes. The map below shows the tower locations and coverage footprint of a potential wireless broadband network. Blue triangles indicate existing towers while white triangles denote proposed towers.

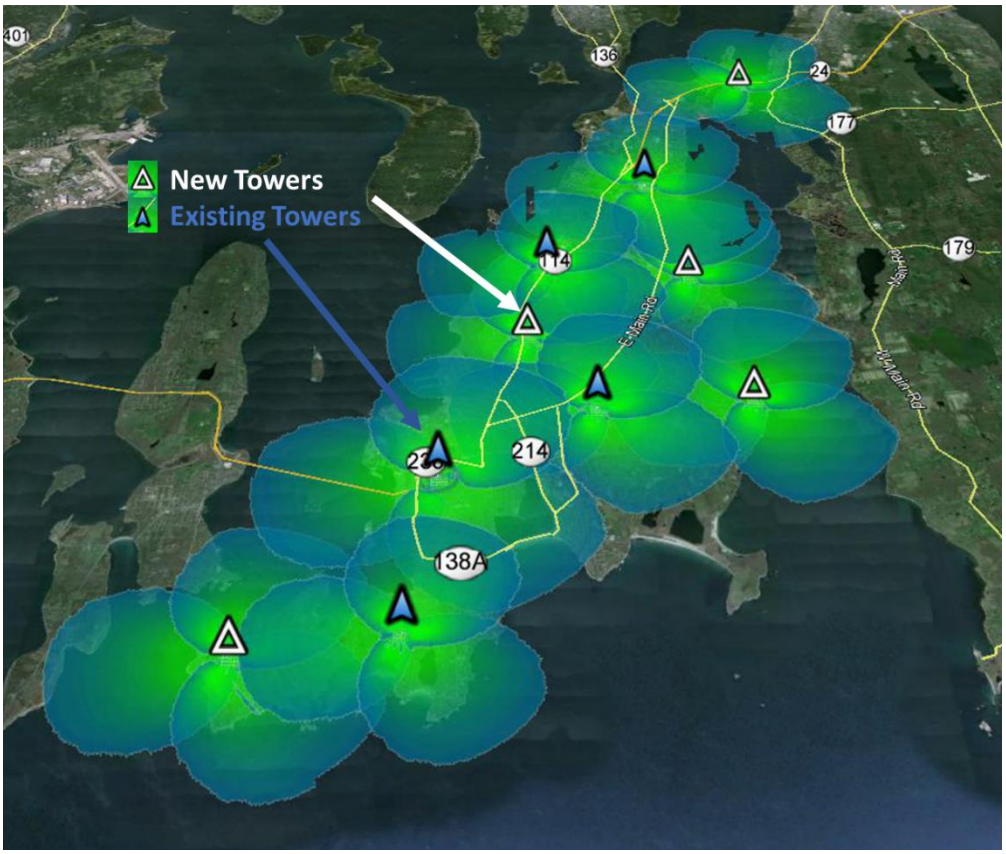

Figure 15: Wireless Broadband Coverage Area

Tilson estimates that the macro sites will entail construction costs of between $1.5 and $2.3 million including new tower erection, antenna installation, fiber construction, legal services, engineering, and permitting, and a 10% contingency. Major cost variables include the number of sites required and fiber construction costs. The major capital cost is installation of the customer's equipment, which can cost as much as $280 in labor and material per site. If 30% of premises take the service, the total cost of installation will be approximately $2.4 million. If the municipal governments pursue a public operating structure and public subsidy, they will need to decide whether or not to capitalize this large expense or leave it as the customer's responsibility.

	Low	Mid	High
Tower Construction	$1,140,000	$1,340,000	$1,740,000
Fiber Construction	$75,000	$125,000	$200,000
Professional Services	$120,000	$120,000	$120,000
Contingency (10%)	$133,500	$158,500	$206,000
Total Capital Costs	**$1,468,500**	**$1,743,500**	**$2,266,000**
Take Rate	20%	30%	40%
Customer Installs	$1,621,885	$2,441,547	$3,255,396

Table 9: Wireless Capital Cost Estimate

The operating costs of this network are difficult to estimate in the absence of a finalized business model. That being said, Tilson estimates that this network could be operated for between $2.4 and $4.0 million per year. Tilson's estimates are based on previous experiences and recent quotes. Most of the operating cost estimates resemble those of the FTTP network. While the technology is different in each case, the actual service to the customer is very similar, and entails similar costs. Variable G&A is lower due to lower forecasted take rates. Wireless internet service providers seldom see take rates over 20% in their communities. Fixed G&A is higher due to added technician costs associated with working on towers. Electricity and rent are similar. Pole fees are significantly lower due to the small number of poles needed to connect to the OSHEAN backbone.

Operating expenses	Low	Best	High
Pole Attachment Fees	$1,500	$3,250	$6,400
Maintenance & Repair	$44,055	$69,740	$113,300
Bandwidth	$360,000	$360,000	$360,000
Fixed G&A	$1,244,000	$1,250,000	$1,262,000
Variable G&A	$780,431	$1,560,863	$2,341,294
Total	**$2,429,986**	**$3,243,853**	**$4,082,994**

Table 10: Wireless Network Operating Cost Estimate

Economic Benefits

Research has shown that investments in broadband infrastructure can dramatically improve economic development in rural communities. Broadband enhances productivity, makes firms more efficient,

facilitates commerce, attracts jobs, increases consumer options, and saves residents money. Recent research has shown that faster broadband also improves GDP growth rate (Rohman and Bohlin, 2011).[36]

By transferring values from peer-reviewed economic valuations of the impact of broadband on communities, Tilson estimated the impact of improved broadband infrastructure on Aquidneck Island. This focuses on increasing gross domestic product (GDP), creating jobs, and enhancing consumer well-being on the Island.

The economy of coastal Rhode Island and Massachusetts has contracted in real terms over the past ten years. According to the US Bureau of Economic Analysis, the region experienced a net average annual real GDP decrease of 0.34% between 2003 and 2013. The US economy as a whole, by contrast, grew at an average annual rate of 1.6% over the same period.[37] Without conducting an extensive survey of spending trends on island over the past ten years, it is impossible to precisely estimate the economic product of Aquidneck Island alone. This is because some economic data, such as productivity and output, are not tracked on the local level. Therefore, metrics for GDP growth in Portsmouth, Newport, and Middletown were not available. These metrics are, however, tracked at the metropolitan statistical area (MSA) level. The most comparable of which, in terms of its profile of economic activity, is Barnstable County in Massachusetts. Barnstable is similar in terms of its economic dependence on tourism, military installations, seasonal residents, and coastal environment.

This analysis assumed the US ten year GDP real growth rate of 1.6% as the baseline growth rate for Aquidneck. The baseline growth rate is crucial to estimating the economic impact of the new network, because the economic community widely agrees that broadband affects economies by boosting the GDP growth rate. In the case of Aquidneck, the mechanism for this impact is boosted productivity and innovation through faster connections. While it is impossible to know exactly how much connection speed will improve, we modeled the impact of a 50% to 200% average increase in speed. Note that a fiber to the premise network gives the user the option of speed several orders of magnitude faster than what is commercially available in Aquidneck, at least for small businesses and residences. This analysis assumes that for the next ten years the average user will only demand speeds two to four times greater than their current usage.

Using Rohman and Bohlin's results (2011), we estimated that a new network has the potential to increase the economic output of the three municipalities by between $247 million and $1.0 billion over ten years. The lower benefit estimate is over 2.5 times greater than the total cost of the FTTP network. Because broadband boosts GDP growth rate, the investment behaves like compound interest. For example, in the second year of the network, Tilson estimates that a major broadband investment will increase economic output by $8.1 million. Ten years later, the model shows network contributions to GDP equaling $106 million. This is because as tech businesses and knowledge workers move to the area or grow, they tend to attract additional services and improve their productivity.

There are numerous case studies that illustrate the transformative impact of broadband. Lake County, Florida, a rural area north of Orlando, saw its economic output double relative to its neighboring

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[36] Rohman, Ibrahim Kholilul and Erik Bohlin. 2001. "Does Broadband Speed Really Matter for Driving Economic Growth: Investigating OECD Countries." Department of Technology Management and Economics, Chalmers University of Technology, Gothenburg, Sweden.

[37] U.S. Bureau of Economic Analysis, 2014. These values account for inflation by keeping all figures in 2009 dollars.

counties within five years of a major broadband build out to the county's community anchor institutions (Ford and Koutsky, 2005).[38]

In addition to increasing local GDP, broadband development also creates jobs. Unlike economic output, which typically takes at least two years for communities to begin reaping the full effects of an investment, job creation occurs immediately. Broadband investments affect employment in three ways.

- Direct Jobs (telecommunications technicians, construction workers, and manufacturers of telecom equipment)
- Indirect Jobs (upstream suppliers and sellers of raw materials)
- Induced Jobs (from the household spending resulting from the new direct and indirect jobs)

These jobs tend to be higher paying, technology-oriented jobs, some of which are temporary but many are stable and more or less permanent improvements to the region's economy. A study of broadband development in rural Kentucky found that every 1 percent increase in broadband adoption yielded a 0.14 percent increase in employment (Shideler et al. 2007).[39] We assume that job growth parallels GDP growth at a rate of one job per $93,000 of additional output. This reflects the current GDP to job ratio in the area. This factor suggests that between 500 and 2000 new jobs will be created in the Aquidneck area (not all of these will be in on the island itself) by 2026 as a result of major broadband investment. Assuming these jobs pay a technology industry salary of $73,000, Tilson estimates that they will receive between $235 and $959 million in additional wages over ten years.

Lastly, broadband investments improve consumer wellbeing. Consumers are not necessarily better off just because economic output increases. An increase in GDP just means that they are spending more. That being said, broadband access empowers consumers to both pay less for goods than they otherwise would have purchased and to purchase goods and services that were not available before. For example, broadband allows consumers to enjoy almost limitless video content for little or no cost. Without it, consumers pay more to rent films and or subscribe to satellite television. In economic lexicon this phenomenon is known as "consumer surplus".

For the purposes of this exercise, consumer surplus is defined as the amount that consumers benefit from purchasing a product for a price that is less than what they would be willing to pay. In a study of the 40 million U.S. households with access to broadband, Greenstein and McDevitt (2009) found that broadband access increased consumer surplus by between $120 and $167.50 per household, per year.[40] The analysis used the Census figure of 29,000 housing units on Aquidneck as a proxy for the total number of households. This translates to a total increase in surplus of between $41.8 and $58.4 million over ten years.

The table below illustrates the economic impact on Aquidneck Island's communities of a major broadband investment in the year 2020 in terms of GDP, wages, and consumer surplus.

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[38] Ford, G. and Koutsky, T. 2005. Broadband and Economic Development: A Municipal Case Study from Florida. *Review of Urban & Regional Development Studies. Vol: 17, Pages: 219-229.*

[39] Shideler, D., Badasyan, N. & Taylor, L. 2007.The Economic Impact of Broadband Deployment in Kentucky. *Regional Economic Development*. Vol: *3*, Pages: 88-118.

[40] Greenstein, S. and McDevitt, R. 2009. The Broadband Bonus: Accounting for Broadband Internet Impact on U.S. GDP. NBER Working Paper No. 14758.

		Additional Economic Activity - 2020		
		GDP	Wages	Consumer Surplus
Speed Improvement	1.5X	17,086,386	17,106,820	3,487,924
	2X	34,248,506	34,314,814	4,178,243
	4X	68,800,840	69,036,115	4,868,561

Table 11: Annual Economic Benefit

The table below shows the estimated ten year economic impact of a major broadband investment.

		Ten Year Total Economic Improvement		
		GDP	Wages	Consumer Surplus
Speed Improvement	1.5X	247,145,875	236,271,539	41,855,092
	2X	496,525,296	474,920,086	50,138,913
	4X	1,002,065,110	959,444,550	58,422,733

Table 12: Ten Year Net Economic Benefit

Using data on the effective state and local tax rates for residents of the state of Rhode Island, we can estimate the approximate increase in tax revenue from the jobs created by the network.[41] Approximately 10% of the wages from the network build will be paid in state and local income, sales and property taxes. Note that this only accounts for the tax increase associated with new jobs. It does not account for the property tax increase resulting from appreciating land and buildings, which is likely to happen. The table below shows annual additional tax revenue from the network construction. Tilson estimates that a broadband investment has the potential to increase state and local tax revenue by between $500K and $2.0 million per year.

		Speed Improvement		
		1.5X	2X	4X
Tax Level	Sales	533,047	1,069,253	2,151,197
	Property	518,241	1,039,552	2,091,441
	State Income	503,434	1,009,850	2,031,686

Table13: Annual Additional Tax Revenue 2020

Overall, Tilson believes that a broadband investment on Aquidneck would be a strong contributor to economic development in the region and offer a range of public benefits. Improving broadband access would supplement the region's traditional economic activities, while also supporting conditions needed to foster small business growth. Due to these added public benefits, Tilson recommends that investment in broadband infrastructure is considered not only through a lens of the network's profitability, but also as a long-term investment in the sustainability of the community and economic development in the region.

[41] Institute on Tax and Economic Policy. 2009. "Who Pays: A Distributional Analysis of the Tax System in all 50 States."

Conclusion

The communities of Middletown, Newport and Portsmouth on Aquidneck Island are underserved relative to state norms for broadband access. This can be measured in several ways: the number of wireline TV providers offering broadband speeds over 10Mbps across Aquidneck; BBRI's speed test data showing median speeds below state and adjacent county numbers; the relatively high prices quoted for dedicated, optical service;[42] and the feedback from business leaders and residents on Aquidneck.

The notable exception to the underserved on Aquidneck is the education, government, non-profit and healthcare sectors, which are served by the recently deployed OSHEAN network. While OSHEAN is precluded from serving the residential and business sectors directly by its charter, it is capable of serving these sectors indirectly via a wholesale or resale arrangement. Tilson's high-level network designs leverage the OSHEAN infrastructure to reduce the cost of deploying a broadband network for the island.

As the state of Rhode Island continues to contemplate the broadband future of Aquidneck, Tilson recommends that it should consider these issues:

1) To what extent is the Aquidneck market ripe for a self-sustaining for-profit entity to disrupt the market for internet access? Is that entity likely to meet economic development goals on the island?
2) Will an increased network investment by Cox that yields better service (higher realized speeds, greater reliability) suffice for Aquidneck's economic development goals? Or does the island need another high speed provider with a similarly broad footprint to ensure a competitive environment in the long term.
3) Given the unregulated nature of broadband, is it imperative to Aquidneck's economic development goals that municipalities play an active role in the delivery of the service to ensure adequate coverage, speeds, reliability and pricing? If so, Tilson recommends exploring options 2-4 outlined in the Operating Models section above.

[42] See prices above for Leverett, MA and Chattanooga, TN. Also, see like Taunton Municipal Light and Power, $29.95/month for 50/50 dedicated optical broadband. http://www.tmlp.net/page.php?content=highspeed_home

Appendix A

Cox Network (Orange) Superimposed on OSHEAN Network (Blue)

12/18/2014 Print

The Newport Daily News Newport Daily News 12/18/2014 Local (0-ndn_a_1_12182014_a_03.pdf.0) Page A03

Cox to bring high-speed to island by '16

By Matt Shelvy
Staff writer

Cox Communications is planning to bring high-speed fiber-optic broadband Internet service to homes across Aquidneck Island by the end of 2016.

In response to a recent story in The Daily News about efforts to bring the broadband service to the island, Cox spokesman Eric Wagner said the communications company already manages about 200 miles of the high-end service in Newport, Middletown and Portsmouth.

Wagner would not disclose how many business and residential customers tap into the network on the island, saying that is proprietary information. He said the cost of the service varies, but is far less than the thousands of dollars a month that has been quoted to those involved in the effort locally.

As part of a statewide initiative, Aquidneck Island customers could expect to see 1 gigabit (Gb) per second service available to their homes within two years, Wagner said.

> 'According to Broadband RI, Rhode Island ranks No. 1 in Internet speed and No. 3 in Internet coverage. Our 200-plus miles of fiber on the island contribute to this.'
>
> ERIC WAGNER
> Cox Communications spokesman

"Broadband Internet has become essential to compete as a business and even as an individual navigating a crowded job market," Wagner said. "It is necessary for education and communication, and Cox is committed to helping our customers make life's most important connections."

Dissatisfied with the speed, cost and quality of the Internet service available locally, officials, business leaders and residents have been discussing ways to address the issue, which is seen as essential to attracting and retaining businesses.

Fiber broadband is billed as being 50 to 60 times faster than traditional Internet service. The higher the speed, the better the quality of the experience and lower the likelihood of blurry, slow loading pictures.

The matter is the subject of a study by a consultant working through the state's economic development agency, Commerce RI. That report is expected to be completed by the end of the year or in the first quarter of 2015.

The town of Middletown's Economic Development Advisory Committee has scheduled an informational briefing on Tuesday, Jan. 13, at 4:30 p.m. at Town Hall to learn more about the lack of high-speed service, seen by some as a major impediment to growing the local economy. Matthew Waln wright, Middletown's technology director, and members of the Aquidneck Island Broadband Project are scheduled to speak. Newport and Portsmouth officials have been invited to attend.

Wagner said fiber-based Internet has been available to Aquidneck Island since 1999. Although he would not name specific organizations, Wagner said there are local hospitals, universities, government groups and commercial businesses in the area that use the service.

According to Cox, more than 90 percent of the businesses on Aquidneck Island are located within 1,500 feet of the fiber network.

"We are not aware of any companies that have left Aquidneck Island due to insufficient Internet bandwidth," Wagner said. "In fact, according to Broadband RI, Rhode Island ranks No. 1 in Internet speed and No. 3 in Internet coverage. Our 200 plus miles of fiber on the island contribute to this, as does 1 gigabits per second to 10 gigabits per second speeds for businesses."

Cox Communications applaude municipal officials and others for working on the issue, Wagner said, and welcomes further discussions in the future.

"Cox believes governments can play a positive role in providing communications services in truly unserved areas where no private alternative is available," he said. "Public-private partnerships and government-owned networks can fill gaps in coverage, but we do not believe Aquidneck Island falls into this category.

"We welcome the discussion and look forward to educating Middletown and Aquidneck Island leaders about Cox's existing network capacity and future plans."

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Glossary

Data Over Cable Service Inteface Specification (DOCSIS) – A telecommunication standard developed by CableLabs that permits the transmission of broadband data over existing HFC infrastructure. DOCSIS 2.0 was released in 2001, and increased upstream speeds. DOCSIS 3.0 was released in 2006, and significantly increased down- and upstream transmission speeds. A DOCSIS 3.1 standard was released in 2013, and promises to significantly increase speeds if adopted by cable companies.

Digital Subscriber Line (DSL) – a technology that transmits data signals over traditional phone lines (twisted pair) without interfering with voice calls.

Fiber to the Premise (FTTP) - a local loop architecture that uses optical fiber as a physical medium

Hybrid Fiber Coaxial Network (HFC) – A network design used by cable companies that is comprised of a combination of optical fiber and coaxial cable in different portions of the network. Typically the fiber optic cable runs from the cable head-end to serving nodes. Coaxial cable runs between the nodes and end user homes and businesses.

Internet Service Provider (ISP) - A firm that provides services for using the internet. These services include internet access, domain name registration and web hosting.

Last Mile – the final (or first) leg of a telecommunications network that reaches the customer. Local loops are often provisioned over the last mile of a network, which can be twisted pair, coaxial cable, optical fiber or a wireless signal.

Local Loop – The circuit that connects the demarcation point of the customer premise to the edge of the service provider's network. The edge of the service provider's network can be the phone company's central office, the cable company's head end, or any location with networking gear.

Open Access Network (OAN) – A network that provides wholesale access to network infrastructure or services at fair and reasonable prices, and on non-discriminatory and transparent terms. Open access arrangements are used in dark fiber networks, mobile networks, undersea cables, etc. OANs are intended to promote competition, maximize consumer choice, and lower prices in a scenario where a shared network infrastructure is more affordable and less risky than building networks from scratch.

In the context of municipal broadband networks, an Open Access Network separates the network owner from the retail service provider. The network owner does not provide retail services. There are two primary OAN business models: Two-Layer and Three-Layer OANs.

In a Two-Layer OAN, the network owner manages and maintains the network's physical assets. Multiple retail service providers sell services like internet access, private data networking and voice calling by purchasing wholesale access from the owner/manager. This model is most commonly deployed in dark fiber networks, where the owner is managing a passive network. If the network is lit, the Two-Layer OAN necessitates that the owner-operator manage and maintain network electronics as well.

In a Three-Layer OAN, network ownership and management is split. The network owner, usually a public or public/private entity, owns the assets. A network manager, under contract to the network owner, maintains the network's physical assets and electronics. Multiple retail providers sell IP-enabled services to end users by purchasing wholesale access from the network manager.

Point of Presence (POP) – An interface point on a telecommunications network, where interconnections are made between multiple carriers, or between a carrier and its customer.

Verizon FiOS – A bundled communications service offered by Verizon that offers voice, internet access and TV programing over a FTTP infrastructure

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Islesboro Broadband Study

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Note

Cost information included in the following report is an estimate based on recent quotes, historical data, certain assumptions about the project scope and approach, the regulatory environment and market conditions at a fixed point in time. Given these variables, we recommend updating the estimate as time passes, and allocating sufficient contingency to allow for inevitable but unpredictable changes in the cost environment if the project moves forward.

Table of Contents

Executive Summary 3

Current State of Broadband on Islesboro 6

- Comparing Local, State and National Averages 7
- Community Broadband Census 12
- Economic Impact of Broadband on Islesboro 18

Strategies for Improving Broadband on Islesboro 21

- Market Survey 23
- Business Model Considerations 25
- Business Model Case Studies: Chattanooga, TN and Leverett, MA 29

Investment Required to Improve Broadband on Islesboro 34

- Fiber-to-the-Home Cost Estimate 35
- Fiber-to-the-Home Network Design 36

Conclusion 48

Appendix 49

Executive Summary

The Town of Islesboro engaged Tilson to evaluate current broadband availability on the island for homes and businesses. The Town Selectmen have expressed concern that existing internet access may be insufficient, and poses a critical challenge for sustaining the island's year round community. The Selectmen believe that it will be difficult to retain and attract young residents, families, and businesses if high-speed, reliable internet connectivity is not universally available on Islesboro.

As part of the engagement, Tilson focused on three topics:

1. Analysis of the current state of broadband availability on Islesboro.
2. Strategies for improving broadband availability on Islesboro.
3. Investment required for improving broadband infrastructure on Islesboro.

By measuring current service access and consumer satisfaction on the island through a survey, reaching out to commercial internet service providers to gauge interest in pursuing a project on the island, and conducting sufficient engineering and cost estimation to understand the capital expenditure needed to improve broadband facilities on the island, Tilson has developed the following report to help the Town explore possible options for improving broadband Islesboro.

The key findings of the report are as follows:

- Based on a comparison of local broadband availability to state and national levels, a survey of Islesboro residents and businesses, and an evaluation of potential economic impact of improved broadband on the island, Tilson agrees that improved broadband infrastructure on Islesboro would benefit the Town.

- Tilson does not believe there is a viable market-based business case for an existing commercial internet service provider to invest the full amount required to improve broadband facilities on the island. In other words, the incumbent service provider, FairPoint Communications, or a new service provider would need some external investment to be enticed to pursue a project on Islesboro. This investment could come from a number of different public and private sources.

- There are six potential strategies for the Town to improve broadband availability on Islesboro:

1. The Town partners with the incumbent service provider, FairPoint, to upgrade existing facilities on Islesboro to serve all premises on the island at faster speeds. FairPoint would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, FairPoint would need some additional external investment of an as yet undetermined amount to do so.

2. The Town partners with Time Warner Cable to build a new DOCSIS 3.0 cable network on Islesboro, which would be the same technology that Vinalhaven and North Haven have, and provide internet, voice, and video service to all premises on the island. Time Warner Cable would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, Time Warner Cable would need some additional external investment of an as yet undetermined amount to do so.

3. The Town partners with another existing commercial internet service provider, such as Axiom, GWI, OTT or Tidewater Telecom, to build a fiber-to-the-home network on Islesboro serving all premises on the island. The service provider would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, these carriers would need some additional external investment of an as yet undetermined amount to do so.

4. A private community-oriented entity builds a fiber-to-the-home network to all premises on the island.[1] The entity would construct, maintain, and operate the network. The entity could partner with a private internet service provider to provide service to customers. The entity would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

5. The Town pursues a joint venture with a private community-oriented entity to build a fiber-to-the-home network to all premises on the island. The venture would construct, maintain, and operate the network. The venture could partner with a private internet service provider to provide service to customers. The venture would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

[1] By "community-oriented entity", we mean an entity consisting of individuals with personal or business connections to Islesboro.

6. The Town builds a fiber-to-the-home network serving all premises on the island. The Town could partner with a private internet service provider to provide retail service to customers.[2] The Town would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

- For Options 1-3, Tilson estimates an investment of $1.24 million to $2.48 million will be required, which would be paid directly to the commercial internet service provider with which the Town partners.

- For Options 4-6, Tilson estimates a total investment of $2.48 million will be required, with a fixed cost of $1.6 million and the rest being deployed over a number of years on a success basis. In each of these options the network owner would also be responsible for covering annual operating costs, which Tilson estimates would be approximately $206,000 per year.

- For Options 4-6, a fixed and total investment amount are identified because network construction costs would contain two components: a fixed capital expenditure needed to construct facilities that pass each premise on the island and a variable cost for connecting homes and businesses with service from the street curb. An investment covering the fixed amount would be required upfront, whereas the variable cost of customer connections could be phased over time based on customer uptake. As properties across the island have varying driveway lengths, individual household connections will cost different amounts.

- For next steps, the Town needs additional information from the commercial internet service provider community to effectively evaluate the value of all possibilities. Tilson recommends that the Town proceeds into a formal request for information (RFI) process to get specific information from service providers about the required amount of investment needed to pursue a commercial initiative. With this information in hand, the Town will be able to better understand the needs for network construction, maintenance, network operation, and service provision moving forward.

[2] By "retail service", we mean internet, voice, and potentially video content delivery.

Current State of Broadband on Islesboro

Over the last twenty years, the internet and communications technologies have fundamentally transformed Americans' lives. Between 2000 and 2010, the number of Americans with broadband access at home grew from eight million to nearly 200 million. Today, it is hard to imagine life without these technologies, as they have reshaped the ways in which we interact and do business.

Recognizing this tectonic shift, the U.S. Congress directed the Federal Communications Commission (FCC) in 2009 to develop a National Broadband Plan with the goal of ensuring that every American gains access to broadband capability. In the report's opening lines, the FCC recognizes the economic importance of broadband in today's hyper-connected world:[3]

> Like electricity a century ago, broadband is a foundation for economic growth, job creation, global competitiveness and a better way of life. It is enabling entire new industries and unlocking vast new possibilities for existing ones. It is changing how we educate children, deliver health care, manage energy, ensure public safety, engage government, and access, organize and disseminate knowledge. (xi)

However, the FCC recognizes that broadband remains inaccessible to many Americans, especially when compared to availability in other developed countries:

> Approximately 100 million Americans do not have broadband at home. Broadband-enabled health information technology can improve care and lower costs by hundreds of billions of dollars in the coming decades, yet the United States is behind many advanced countries in the adoption of such technology. Broadband can provide teachers with tools that allow students to learn the same course material in half the time, but there is a dearth of easily accessible digital educational content required for such opportunities. A broadband-enabled Smart Grid could increase energy independence and efficiency, but much of the data required to capture these benefits are inaccessible to consumers, businesses and entrepreneurs. And nearly a decade after 9/11, our first responders still lack a nationwide public safety mobile broadband communications network, even though such a network could improve emergency response and homeland security. (xi)

In light of these findings and the Town's concerns that existing broadband availability on Islesboro is insufficient, Tilson evaluated the current state of broadband on the island in three ways:

[3] Federal Communications Commission. 2009. *Connecting America: National Broadband Plan.* Available at http://www.broadband.gov/plan/.

1. Comparison of broadband availability on Islesboro to local, state, and national averages using publically-available data.
2. Survey of Islesboro residents and businesses to measure current access and consumer satisfaction.
3. Evaluation of potential economic impact of improved broadband availability on Islesboro using existing academic literature.

Overall, Tilson agrees that improved broadband infrastructure would benefit the Town. At present, broadband availability on Islesboro lags behind national averages and goals for future access. In the survey, residential and business respondents expressed strong interest in improved internet service. Lastly, based on academic studies of other broadband initiatives in the U.S. and internationally, Tilson believes improved broadband availability would have a positive economic impact on Islesboro.

Comparing Local, State and National Averages

To benchmark current broadband availability on Islesboro, Tilson examined local, state, and national broadband data. Overall, access to broadband in any form on the island is on par with other communities in mid coast Maine, but average delivered speeds on Islesboro lag behind other towns in Maine, and Maine lags behind the national average. However, with the recent installation of the Three Ring Binder dark fiber network along Lincolnville's and Northport's Route 1, the island is in proximity to relatively inexpensive access to internet backhaul among others options (FairPoint, Time Warner Cable, Tidewater, other Competitive Local Exchange Carriers) that can be leveraged to improve service.

Local Broadband Data

In Maine, the ConnectME Authority has developed the most comprehensive database of municipal broadband availability to date. As part of its recent Broadband Mapping and Inventory Project, the agency mapped broadband penetration throughout the state using data reported by internet service providers. The findings were published in the Authority's *Developing Broadband in Maine: Needs Assessment*, which details download speeds on Islesboro and in surrounding communities:[4]

[4] Report is available at http://www.sewall.com/files/connectme_na_v2.pdf. Broadband availability is measured by road mileage, as communications facilities are located on roadside poles to be able to pass households.

Figure 1: Community Broadband Access by FCC Speed Tier

	Broadband Tier								
Town	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**<null>**
Belfast				24.4%	13.3%	50.9%	11.4%		
Camden				2.6%	1.9%	0.3%	46.5%	48.7%	
Islesboro	0.6%	0.2%			0.5%		98.7%		
Lincolnville		5.3%	2.1%	0.0%	0.4%		92.1%		
North Haven				1.8%	2.3%		95.9%		
Northport	0.1%	4.9%	3.5%		22.0%	3.6%	65.6%		0.2%
Vinalhaven	0.2%	14.2%		35.4%			45.4%		4.9%
Road Footprint	**0.1%**	**3.6%**	**0.8%**	**10.9%**	**5.9%**	**11.3%**	**59.8%**	**6.7%**	**0.7%**

While the Authority's data enables comparison of broadband availability throughout mid coast Maine, Tilson believes the underlying methodology for data collection produces an overstatement of broadband availability on the island. More specifically, the primary source of data the Authority uses in determining broadband levels is advertised connection speeds that are self-reported by internet service providers. In this method, maximum advertised connection speeds in a census block are applied to the entire block, even if only some individuals in a service area are actually able to obtain such speeds.

On Islesboro, the Authority's data suggests 99 percent of the island has access to Tier 6 download speeds (between 25 Mbps and 100 Mbps). Broadband "tiers" are defined and explained on page 36. As detailed in the next section, Tilson surveyed island residents and businesses and asked respondents located on the island to use an online tool that measures connection speed. Of the 58 responses (46 residential and 12 business), which represent 7.5 percent of occupied properties on the island, no respondent registered a Tier 6 download speed. In fact, only one respondent measured a download speed above 8 Mbps. The average download and upload speeds reported on the island were 3.74 Mbps and 0.62 Mbps respectively. This average translates to a Tier 3 download speed and an upload speed less than Tier 1. While reported speeds depend on two factors, availability of service and customers' willingness to subscribe to higher speeds, these low reported averages seem to suggest that access to faster speed tiers is an obstacle to broadband adoption on Islesboro.

As a number of Tilson's field technicians have worked on telecommunications infrastructure in mid coast Maine, they were asked to provide an overview of local broadband availability based on their experience in the area:

Figure 2: Community Broadband Access Summary – Tilson

Town	Local Service Provider(s)	Cumulative Coverage Footprint	Technologies Utilized	Average Connection Speed in Town
Camden	FairPoint/Lincolnville Telco/Midcoast-GWI/Time Warner Cable	90%+	Cable/DSL/Wireless/Fiber	10Mbps+
Belfast	FairPoint/Lincolnville Telco/Midcoast-GWI/Time Warner Cable	80%+	Cable/DSL/Wireless	4Mbps+
Lincolnville	Midcoast-GWI/Tidewater	95%+	Wireless/DSL	3Mbps+
Northport	FairPoint/Midcoast-GWI	60%+	Wireless/DSL	3Mbps+
Vinalhaven	FairPoint/Midcoast-GWI/Time Warner Cable	85%+	Wireless, DSL, Cable	6 Mbps+
Northaven	FairPoint/Midcoast-GWI/Time Warner Cable	85%+	Wireless/DSL/Fiber	10 Mbps+

The table identifies which service providers are present in each town and how much of each town has at least one service option. The average connection speed represents the average level available to the town as a whole.

Historically, a primary obstacle preventing faster connection speeds from competitive internet service providers in mid coast Maine has been a lack of inexpensive internet backhaul. A broadband network has two primary components: middle mile service and last mile service. Middle mile service is the backhaul bandwidth that enables customers to connect to the internet. Last mile service includes the facilities that connect end user premises to the middle mile facilities via an aggregation point at the town level commonly known as a central office (CO).

With prohibitively expensive backhaul bandwidth costs due to a lack of competitive fiber-based middle mile facilities, last mile service in mid coast Maine has not been able to be economically advanced. However, with the completion of Maine Fiber Company's Three Ring Binder network in 2012, improvements to FairPoint's interoffice fiber facilities, and local network investments by Time Warner Cable and Lincolnville/Tidewater telecom, the region now has several competitive options for internet backhaul.

The Three Ring Binder was publically funded as part of the 2010 American Recovery and Reinvestment Act (ARRA), and has a requirement that network capacity is available to users on a non-discriminatory, open-access basis. In other words, customers cannot be prohibited access if there is unused fiber and all are charged the same amount for access. The Three Ring Binder is a middle mile network and runs along Route 1 in Lincolnville and Northport, and, in conjunction with Central Maine Power's proposed subsea fiber cable to be installed between

Northport to Islesboro, offers a relatively inexpensive alternative option for middle mile backhaul that has previously not existed for Islesboro. The middle mile fiber can be leased by any party, and requires a service provider to light the fiber to provide a backhaul service.

State Broadband Data

In addition to surveying municipal broadband availability, the ConnectME Authority's *Needs Assessment* aims to measure overall broadband availability in Maine. The average statewide download speed in Maine is 4.8 Mbps, compared to 6.4 Mbps nationally. Maine ranks 49th nationally in speeds greater than 10 Mbps, with Tier 5 download and upload speeds only available at roughly one-fifth of street locations across the state:

- 93 percent of street locations in Maine have access to Tier 1 download and upload speeds from at least one service provider.
- 85 percent of street locations in Maine have access to Tier 3 download and upload speeds from at least one service provider.
- 21 percent of street locations in Maine have access to Tier 5 download and upload speeds from at least one service provider.

For adoption, 90 percent of Maine households have some form of internet connection, with 75 percent of households subscribing at broadband levels. 94 percent of Maine businesses have some form of internet connection, with 93 percent of businesses subscribing at broadband levels.

Considering Islesboro in the context of statewide broadband availability, Islesboro's average download and upload speeds appear to lag behind the statewide average, which in turn lag behind the national average. Tilson's surveyed town average of 3.74 Mbps downstream is less than the statewide average of 4.8 Mbps, and the town average of 0.62 Mbps upstream is less than Tier 1.

National Broadband Data

At the national level, the FCC has conducted several initiatives focused on measuring broadband access nationwide and targeting future goals for availability and adoption. In its *National Broadband Plan,* the FCC sets two primary goals for future broadband access in the U.S.:[5]

1. The United States must lead the world in the number of homes and people with access to affordable, world-class broadband connections. As such, 100 million U.S. homes should have affordable access to actual download speeds of at least 100 Mbps and actual upload speeds of at least 50 Mbps by 2020.

[5] Pg. 9. *Connecting America: National Broadband Plan.* Federal Communications Commission. Available at http://www.broadband.gov/plan/.

2. As a milestone, by 2015, 100 million U.S. homes should have affordable access to actual download speeds of 50 Mbps and actual upload speeds of 20 Mbps.

At present, current service options on Islesboro do not meet these goals.

In addition to the FCC's work, the White House Office of Science and Technology Policy and the National Economic Council have worked to measure current broadband availability in the U.S. In their 2013 report *Four Years of Broadband Growth,* the portion of the American population with access to advertised download speeds is higher than the averages for Maine and Islesboro:[6]

Figure 3: Percentage of U.S. Population with Access to Various Advertised Broadband Download Speeds (Mbps)

	>3Mbps	>6Mbps	>10Mbps	>25Mbps	>50Mbps	>100Mbps	>1Gbps
All Broadband	98.18%	96.17%	94.39%	78.51%	75.15%	47.09%	3.17%
Wireline	93.41%	92.81%	90.91%	78.11%	74.85%	46.87%	3.17%
Wireless	94.37%	84.17%	80.66%	4.94%	3.03%	1.80%	0.00%

As with the ConnectME Authority's data, one must be cautious when drawing conclusions based on advertised speeds reported by service providers. That being said, the disparity between national and state data seems to support Maine's low national ranking in availability of Tier 5 and higher connection speeds.

On Islesboro, the primary type of communications technology utilized in homes and businesses is DSL. The following table shows how technology selection relates to delivered connection speeds nationally, based on the portion of the U.S. population with access to advertised download speeds:[7]

Figure 4: Percentage of U.S. Population with Access to Broadband Speeds by Technology Type

	>3Mbps	>6Mbps	>10Mbps	>25Mbps	>50Mbps	>100Mbps	>1Gbps
Cable	86.92%	86.95%	86.15%	76.42%	72.63%	44.20%	0.00%
DSL	73.51%	64.60%	47.39%	7.21%	0.11%	0.01%	0.00%
Fiber	20.20%	20.00%	19.86%	18.72%	18.25%	6.79%	3.16%
Fixed	34.33%	25.81%	10.89%	4.88%	2.99%	1.78%	0.00%
Mobile	91.81%	80.58%	78.67%	0.00%	0.00%	0.00%	0.00%
Copper	43.25%	15.37%	14.59%	1.46%	0.27%	0.12%	0.01%

[6] Pg. 5. *Four Years of Broadband Growth*, 2013. The White House Office of Science and Technology Policy & The National Economic Council.

[7] Pg. 6, *Four Years of Broadband Growth*, June 2013. The White House Office of Science and Technology Policy & The National Economic Council.

Lastly, it is interesting to compare broadband availability and adoption in urban and rural regions of the U.S. Nationally, urban areas have a 72 percent broadband adoption rate compared to only 58 percent in rural areas. The following table shows the availability of broadband access by street location:[8]

Figure 5: Broadband Availability by Urban and Rural U.S. Populations

	>3Mbps	>6Mbps	>10Mbps	>25Mbps	>50Mbps	>100Mbps	>1Gbps
Rural	91.1%	81.8%	74.3%	40.8%	37.6%	22.8%	1.2%
Urban	99.9%	99.6%	99.1%	87.5%	84.0%	52.9%	3.6%

As noted in the following sections, this is an important factor to consider when contemplating customer uptake and long term financial sustainability of the network.

Community Broadband Census

In order to better understand the current state of broadband availability on Islesboro, Tilson surveyed island residents, businesses, and schoolchildren to gather the following information:

1. Services that residents are currently using and how much they are paying.
2. An assessment of the adequacy of current service.
3. Service options residents would like to have to meet their current and projected needs.

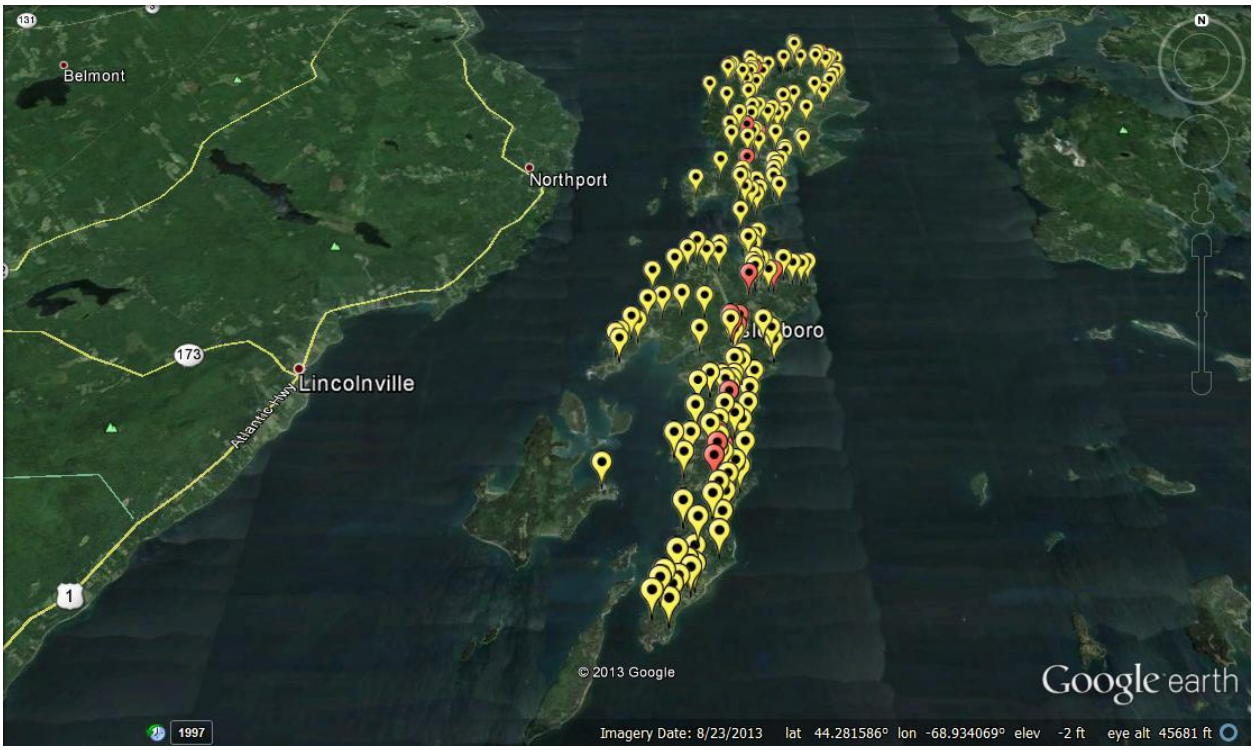
Respondents had the choice to complete Tilson's survey online or to submit a hard copy. 773 surveys were mailed in total, including 291 surveys to addresses on Islesboro for year-round residents, 411 surveys to off-island addresses for seasonal residents, and 71 surveys to on-island businesses. Tilson received 227 responses, 204 residential and 23 business, for an overall response rate of 29.4 percent. Tilson also collaborated with the Islesboro Central School to survey current high school students on their opinion of internet options on the island. Tilson received 24 student responses from 9th to 11th graders.

The geographic distribution of residential and business responses is fairly even across the island:[9]

[8] Pg. 11, *Four Years of Broadband Growth*, June 2013. The White House Office of Science and Technology Policy & The National Economic Council.

[9] Residential responses are shown in yellow and business responses are shown in red.

Figure 6: Geographic Distribution of Survey Responses

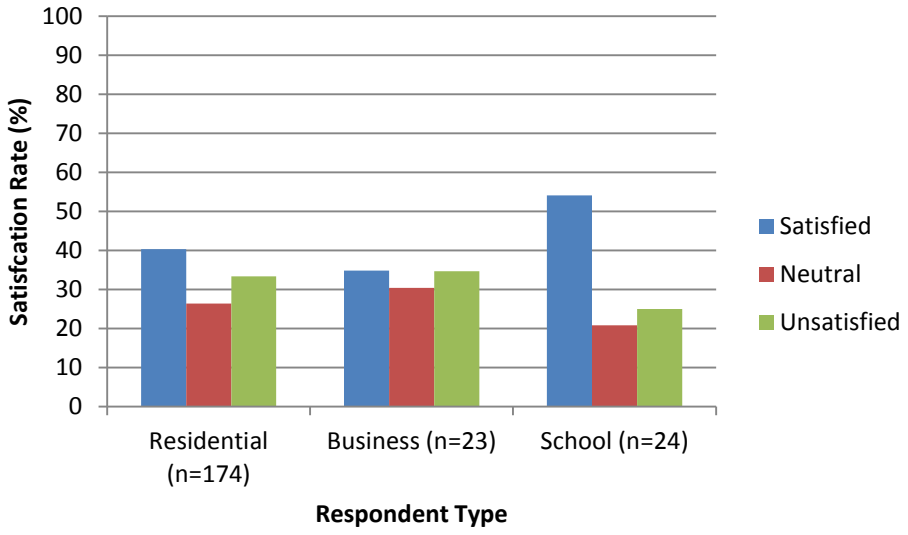


Copies of the residential, business, and school surveys are presented in the attached appendix, which include full survey results. For analysis purposes, all skipped questions by respondents were classified as "No response", and are not included in the percentages cited below.

There were several key findings in the survey:

- Overall, respondents reported higher satisfaction levels with current phone and video service than with current internet service.
- Both residential and business respondents expressed strong interest in improved internet service.
- Residential respondents did not indicate an overall willingness to pay more for improved internet service compared to current service pricing. Business respondents expressed a higher willingness to pay more for improved service, but not significantly.
- Survey responses seem to suggest market uptake of new phone and video services could be low.
- A majority of surveyed schoolchildren perceive internet options on the island to be high speed, but reported mixed satisfaction levels with current service.

Figure 7: Respondent Satisfaction with Speed of Current internet Service[10]



Residential Survey Results

As stated above, Tilson received 204 residential survey responses. 38 percent of respondents are year-round residents and 62 percent are seasonal residents. Respondents are generally older in age, with 65 percent over 60 years old compared to 31 percent between 40 and 59 years old and 5 percent between 20 and 39 years old.

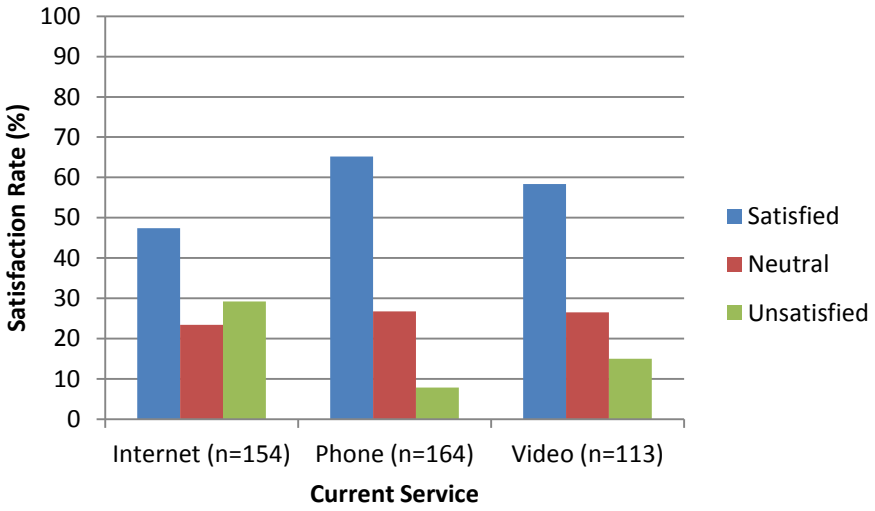
For subscription, 81 percent of residential respondents have an internet connection in their home on Islesboro. A majority subscribe to FairPoint's DSL service (88 percent), while some instead subscribe to Midcoast/GWI's fixed wireless service (12 percent). Half of those who do not have an internet connection in their home use a cellular hotspot for internet access. For use, respondents most commonly average between 1 and 3 hours per day (60 percent) using the internet at home. For price, two-thirds of respondents reported paying between $26 and $50 per month for internet service.

For phone and video, 82 percent of residential respondents subscribe to a phone service in their home on Islesboro and 56 percent subscribe to a video service. Of these households, 94 percent subscribe to FairPoint's phone service, whereas video subscription is divided between Dish (21 percent) and DirecTV (74 percent). Seasonal residents appear less likely to subscribe to video, as a majority of seasonal respondents (54 percent) do not currently have a video service in their home on Islesboro. For price, a majority of respondents (54 percent) pay between $25 and $50 per month for phone service. Video subscription costs vary, with 30 percent of respondents paying between $51 and $75 per month and 32 percent paying between $76 and $100 per month.

[10] Student satisfaction rates are based on connection speeds at students' homes.

Respondents reported higher satisfaction levels with current phone and video service than with current internet service. For phone, 65 percent of respondents expressed being satisfied with their current service, 27 percent are neutral, and 8 percent are unsatisfied. For video, 58 percent of respondents expressed being satisfied with their current service, 27 percent are neutral, and 15 percent are unsatisfied. For internet, 47 percent of respondents expressed being overall satisfied with their current service, 23 percent are neutral, and 29 percent are unsatisfied.

Figure 8: Satisfaction with Current Services among Residential Respondents



Year round and seasonal respondents produced relatively similar results for internet satisfaction: 43 percent of year round respondents are satisfied with current service, 22 percent are neutral, and 35 percent are unsatisfied. 51 percent of seasonal respondents are satisfied with current service, 24 percent are neutral, and 26 percent unsatisfied. Respondents were also asked if their satisfaction with the speed and reliability of current internet differed. 40 percent of respondents reported being satisfied with the speed of current internet service, 26 percent are neutral, and 33 percent are unsatisfied. 45 percent of respondents reported being satisfied with the reliability of current internet service, 20 percent are neutral, and 35 percent are unsatisfied.

When asked if they consider current internet service on the island to be high speed, respondents were almost equally split, with 52 percent believing current service qualifies as high speed. A majority of seasonal respondents (52 percent) did not believe current internet service is high speed, compared to 41 percent of year round respondents. For applications, respondents reported wanting to be able to do email (21 percent), web browsing (19 percent), streaming video (16 percent), peer-to-peer (12 percent), large file transfer (12 percent),

interactive video (7 percent), remote office connectivity (7 percent), and voice services (5 percent).

78 percent of residential respondents indicated that they are interested in an improved internet service, compared to 17 percent being neutral and 5 percent being uninterested. Of these respondents, 90 percent of year round respondents indicated being interested in an improved internet service, compared to 73 percent of seasonal respondents. When asked why they are interested in an improved service offering (if applicable), 41 percent of respondents cited the speed of current internet service, 32 percent cited reliability, 21 percent cited price, and 6 percent cited customer service. Overall, respondents did not indicate a strong willingness to pay more for an improved internet service compared to current service pricing, with 33 percent unwilling to pay any additional amount, 20 percent willing to pay up to $10 more per month, and 22 percent willing to pay an additional $11 to $25 per month.

Business Survey Results

As stated above, Tilson received 23 responses from businesses based on the island. Compared to residential respondents, business respondents were younger on average: 59 percent are between 40 and 59 years old and 41 percent are between 40 and 59 years old.

For subscription, all business respondents currently have an internet connection in their business. 83 percent of respondents work from home, 89 percent of who use the same internet connection for residential and business purposes. A majority subscribe to FairPoint's DSL service (91 percent), while some instead subscribe to Midcoast/GWI's fixed wireless service (9 percent). Business use varies, with 30 percent reporting average internet use between 0 and 1 hour per day, 26 percent reporting average use of 1 to 3 hours per day, and 35 percent reporting average use of more than 6 hours per day (35 percent). For price, a majority of respondents (53 percent) reported paying between $26 and $50 per month for service.

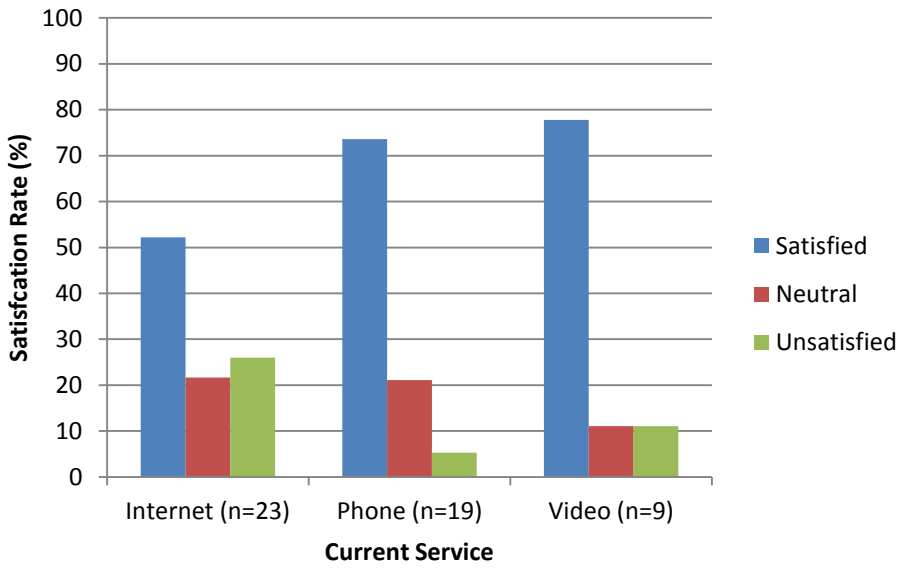
For phone and video, 70 percent of business respondents subscribe to a phone service and 46 percent subscribe to a video service. Of these, 90 percent subscribe to FairPoint's phone service and 75 percent subscribe to DirecTV's video service. For phone, 31 percent of respondents pay between $26 and $50 per month for phone service and 38 percent pay between $51 and $75. A majority of respondents (57 percent) pay between $76 and $100 for video service.

Like residential respondents, business respondents reported higher satisfaction with current phone and video service than internet service. For internet, 52 percent of respondents expressed being satisfied with their current service overall, 22 percent are neutral, and 26 percent are unsatisfied. For speed and reliability, 35 percent of respondents reported being satisfied with both aspects of current service, 30 percent are neutral, and 35 percent are unsatisfied.

For phone, 73 percent of respondents expressed being satisfied with their current service, 21 percent are neutral, and 6 percent are unsatisfied. For video, 78 percent of respondents

expressed being satisfied with their current service, 11 percent are neutral, and 11 percent are unsatisfied.

Figure 9: Satisfaction with Current Services among Business Respondents



When asked if they consider current internet service on the island to be high speed, respondents were almost equally split, with 52 percent believing current service qualifies as high speed. For applications, respondents reported wanting to be able to do email (18 percent), web browsing (18 percent), large file transfer (14 percent), streaming video (11 percent), peer-to-peer (11 percent), interactive video (11 percent), remote office connectivity (10 percent), and voice services (6 percent).

86 percent of businesses indicated that they are interested in an improved internet service, compared to 9 percent being neutral and 5 percent being uninterested. When asked why they are interested in an improved service offering, 37 percent of respondents cited the speed of current internet service, 26 percent cited reliability, 26 percent cited price, and 12 percent cited customer service. Overall, respondents indicated mixed willingness to pay more for an improved internet service compared to current service pricing, with 23 percent unwilling to pay any additional amount, 27 percent willing to pay up to $10 more per month, 14 percent willing to pay an additional $11 to $25 per month, and 14 percent willing to pay an additional $26 to $50 per month.

School Survey Results

Tilson received 26 responses from 9th to 11th graders currently attending Islesboro Central School. 39 percent of respondents are in 9th grade, 35 percent are in 10th grade, and 26 percent

are in 11th grade. Of these students, 18 live on the island full time, 1 lives on the island part time during the school week, and 7 commute daily from the mainland.

93 percent of respondents have an internet connection in their home, 74 percent of whom subscribe to FairPoint's DSL service. At home, 28 percent of respondents indicated they use the internet between 1 and 3 hours per day, 44 percent reported average use between 3 and 6 hours, and 24 percent reporting average use of more than 6 hours per day. At school, 19 percent of respondents indicated that they use the internet between 0 and 1 hour per day, 46 percent said between 1 and 3 hours per day, and 31 percent said between 3 and 6 hours per day. Respondents reported using the internet for web browsing (21 percent), email (20 percent), streaming video (18 percent), peer-to-peer (10 percent), online gaming (9 percent), large file transfer (9 percent), and interactive video (5 percent).

Respondents reported higher satisfaction with internet at school than service options available at their homes. 54 percent of respondents reported being satisfied with the speed of current internet service in their homes, 21 percent are neutral, and 33 percent are unsatisfied. By comparison, 67 percent of respondents are satisfied with the speed of current internet service at school, 21 percent are neutral, and 12 percent are unsatisfied. For reliability, 45 percent of respondents reported being satisfied with the reliability of current internet service, 20 percent are neutral, and 25 percent are unsatisfied. When asked if they consider current internet service on the island to be high speed, a majority of respondents (71 percent) believe current service qualifies as high speed. 75 percent believe current internet service at school is high speed.

Economic Impact of Broadband on Islesboro

Research has shown that investments in broadband infrastructure can dramatically improve economic development in rural communities. Broadband enhances productivity, makes firms more efficient, facilitates commerce, attracts jobs, increases consumer options, and saves residents money.

By transferring values from peer-reviewed economic valuations of the impact of broadband on communities, Tilson has developed estimates of the impact of the Town's proposed actions, with a focus on increasing gross domestic product (GDP), creating jobs, and enhancing consumer well-being on Islesboro.

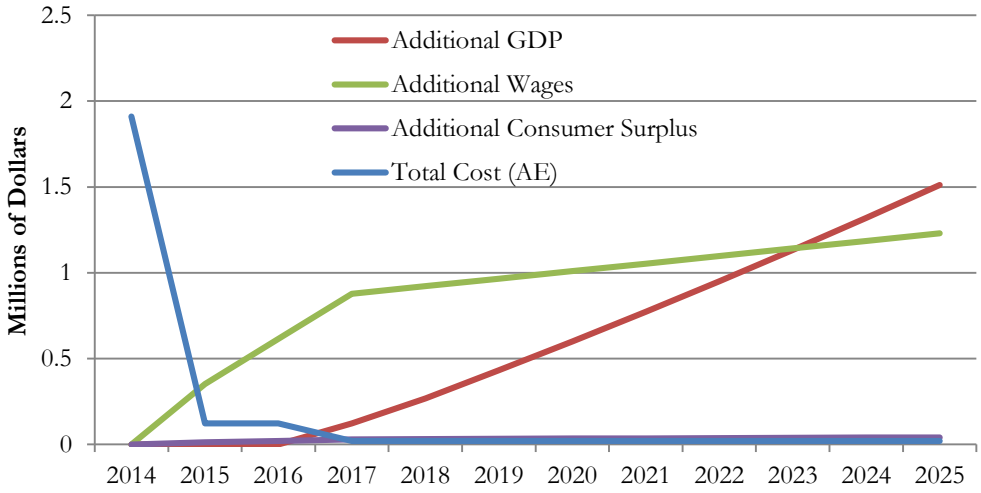
The economy of Waldo County, Maine has not grown substantially over the past ten years. While it is difficult to determine precisely how Islesboro's GDP has changed over this period, it likely has not deviated from the general trend of the area. Tilson believes developing universally-available broadband infrastructure on the island has the potential to increase GDP growth on the island from 0.3 percent to at least 1.2 percent in five years.

This estimate represents $8.8 million in additional goods and services sold on the island over ten years. This figure is open to debate. However, a large increase in broadband penetration

usually results in a significant increase in output. In a study of 22 Organization for Economic Cooperation and Development (OECD) member countries, Koutroumpis et al. (2009) found that an increase in broadband penetration of 10 percent added 0.25 percent to GDP growth on average.[11] In a similar study, Czernich et al. (2009) found that an increase in broadband penetration of 10 percent added 0.73 percent to GDP growth on average.[12]

A pertinent case study in the U.S. is Lake County, Florida, a rural area north of Orlando, which saw its economic output double relative to its neighboring counties within five years of a major broadband build out to the county's community anchor institutions (Ford and Koutsky, 2005).[13] Therefore, Tilson believes its estimates for Islesboro may be conservative. As shown in Figure 10 below, the positive impact of broadband development on Islesboro's economy compounds year after year while there is fixed upfront cost to deploy the network:

Figure 10: Additional GDP, Wages, and Consumer Surplus vs. Total Cost of Project



In addition to increasing local GDP, broadband development also creates jobs. Unlike economic output, which typically takes at least two years for communities to begin reaping the full effects of an investment, job creation occurs immediately. Broadband investments affect employment in three ways.

- Direct Jobs (telecommunications technicians, construction workers, and manufacturers of telecom equipment)
- Indirect Jobs (upstream suppliers and sellers of raw materials)
- Induced Jobs (from the household spending resulting from the new direct and indirect jobs)

[11] Koutroumpis, P. 2009. The economic impact of broadband on growth: A simultaneous approach. *Telecommunications Policy*. Vol:33, Pages: 471-485.

[12] Czernich, N., Falck, O., Kretschmer, T. & Woessman, L. 2009. Broadband Infrastructure and Economic Growth. *The Economic Journal.* Vol: 121, Pages: 505-532.

[13] Ford, G. and Koutsky, T. 2005. Broadband and Economic Development: A Municipal Case Study from Florida. *Review of Urban & Regional Development Studies. Vol: 17, Pages: 219-229.*

These jobs tend to be higher paying, technology-oriented jobs, some of which are temporary but many are stable and more or less permanent improvements to the region's economy. A study of broadband development in rural Kentucky found that every 1 percent increase in broadband adoption yielded a 0.14 percent increase in employment (Shideler et al. 2007).[14] This factor suggests that 30 new jobs will be created in the mid coast Maine region (not all on Islesboro) by 2025 as a result of the Selectmen's proposed actions. Assuming these jobs pay Waldo County's median wage, Tilson estimates approximately $1.1 million in state and local tax revenue will be generated over the next ten years.

Lastly, broadband investments increase consumer surplus. Consumers are not necessarily better off just because economic output increases. An increase in GDP just means that they are spending more. That being said, broadband access empowers consumers to both pay less for goods than they otherwise would have purchased and to purchase goods and services that were not available before. For example, broadband allows consumers to enjoy almost limitless video content for little or no cost. Without it, consumers pay more to rent films and or subscribe to satellite television. This phenomenon is termed "consumer surplus".

For the purposes of this exercise, consumer surplus is defined as the amount that consumers benefit from purchasing a product for a price that is less than what they would be willing to pay. In a study of the 40 million U.S. households with access to broadband, Greenstein and McDevitt (2009) found that broadband access increased consumer surplus by between $120 and $167.50 per household, per year.[15] Tilson's economic analysis assumes that year round Islesboro residents would enjoy this full benefit while seasonal residents would enjoy 30 percent of consumer surplus benefit. This translates to a total increase in surplus of between $330,000 and $460,000 for Islesboro.

Overall, Tilson believes that investment in broadband on Islesboro would be a strong contributor to economic development on the island and offers a range of public benefits. Improving broadband access would supplement Islesboro's traditional economic activities, while also supporting conditions needed to foster a new, low impact economy. Due to these added public benefits, Tilson recommends that investment in broadband infrastructure is considered not only through a lens of the network's profitability, but also through a long-term investment in the sustainability of the community and economic development on the island.

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[14] Shideler, D., Badasyan, N. & Taylor, L. 2007.The Economic Impact of Broadband Deployment in Kentucky. *Regional Economic Development*. Vol: *3*, Pages: 88-118.

[15] Greenstein, S. and McDevitt, R. 2009. The Broadband Bonus: Accounting for Broadband Internet Impact on U.S. GDP. NBER Working Paper No. 14758.

Strategies for Improving Broadband on Islesboro

Tilson is not aware of any privately-funded broadband upgrades being planned for Islesboro, and doubts that there is a business case in the future to do so. As there is not a viable market-based business case for an existing commercial internet service provider to invest the full amount required to improve broadband facilities on the island, the incumbent service provider, FairPoint, or a new service provider would need to receive an external investment to be enticed to pursue a project on Islesboro. This investment could come from a number of different private or public sources.

As the Town Selectmen have expressed that taking no action to improve broadband availability on the island is not viable, Tilson proposes the following strategies:

1. The Town partners with the incumbent service provider, FairPoint, to upgrade existing facilities on Islesboro to serve all premises on the island at faster speeds. FairPoint would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, FairPoint would need some additional external investment of an as yet undetermined amount to do so.

2. The Town partners with Time Warner Cable to build a new DOCSIS 3.0 cable network on Islesboro, which would be the same technology that Vinalhaven and North Haven have, and provide internet, voice, and video service to all premises on the island. Time Warner would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, Time Warner would need some additional external investment of an as yet undetermined amount to do so.

3. The Town partners with another existing commercial internet service provider, such as Axiom, GWI, OTT or Tidewater Telecom, to build a fiber-to-the-home network on Islesboro serving all premises on the island. The service provider would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, these carriers would need some additional external investment of an as yet undetermined amount to do so.

4. A private community-oriented entity builds a fiber-to-the-home network to all premises on the island. The entity would construct, maintain, and operate the network. The entity could partner with a private internet service provider to provide service to customers. The entity would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

5. The Town pursues a joint venture with a private community-oriented entity to build a fiber-to-the-home network to all premises on the island. The venture would construct, maintain, and operate the network. The venture could partner with a private internet service provider to provide service to customers. The venture would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

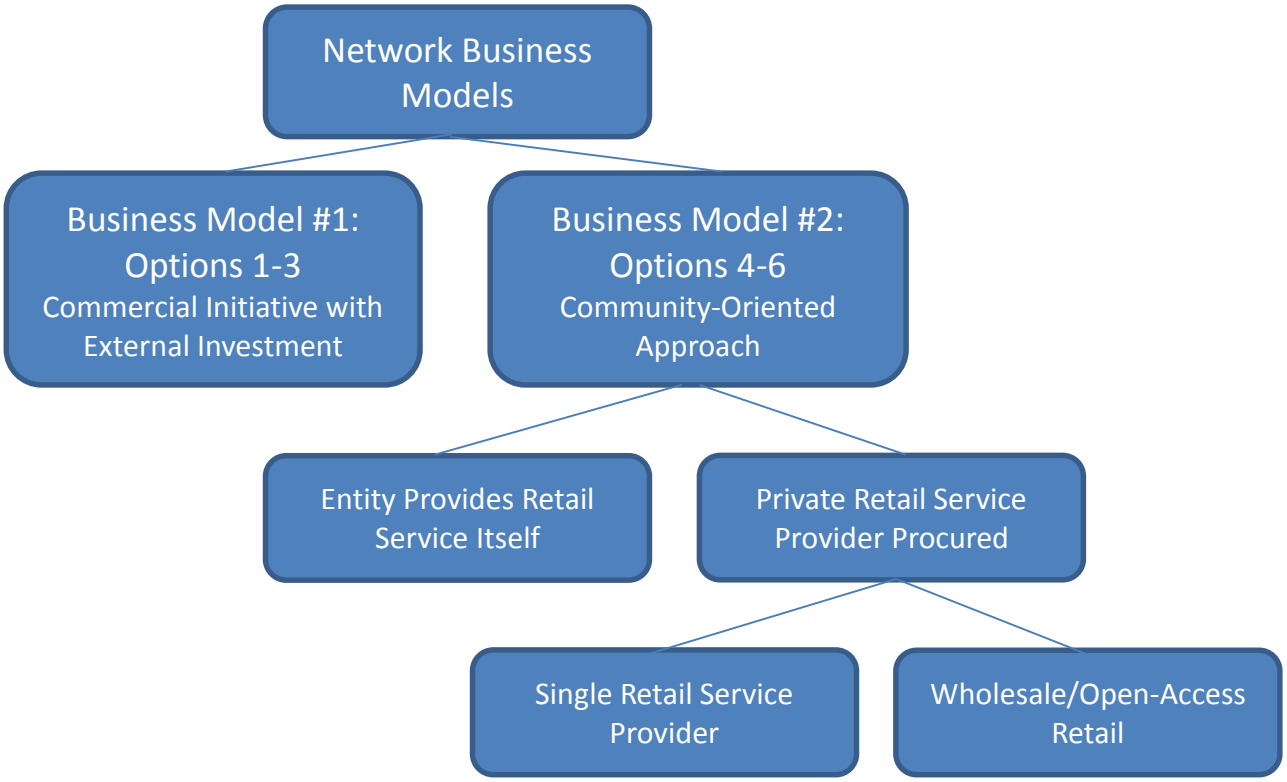
6. The Town builds a fiber-to-the-home network serving all premises on the island. The Town could partner with a private internet service provider to provide retail service to customers. The Town would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

As the Town explores these possible scenarios, Tilson believes the six options fall into two primary business models:

1. Business Model #1: Commercial Initiative with External Investment (Options 1-3)
2. Business Model #2: Community-Oriented Approach (Options 4-6).

As the Town evaluates which of the six options is best for residents and businesses moving forward, each business model has a number of factors the Town should consider. The following section details the feasibility of partnering with industry, considerations for each business model, and lessons learned from other municipal broadband projects to help steer the Town's decision making process:

Figure 11: Business Model Options



Market Survey

Tilson conducted a general market survey of six Maine-based commercial internet service providers and the incumbent service provider on the island, FairPoint, to gauge interest in collaborating with the Town:

The following service providers expressed interest in participating in the Town's initiative:

Business Model #1: Commercial Initiative with External Investment

- Potentially interested parties include Axiom Technologies, FairPoint Communications, GWI, Tidewater Telecom, and Time Warner Cable.

Business Model #2: Community-Oriented Approach

- Potentially interested parties include Axiom Technologies, GWI, OTT Communications, and Tidewater Telecom.

Axiom indicated interest in participating in either business model and has a track record for effectively advancing broadband in hard to serve coastal communities. The company is expanding its presence in the mid coast area with new operational support based in Rockland. However, Axiom currently provides service primarily using a fixed wireless technology, and does not have commercial experience providing fiber to the home. Tilson believes Axiom's potential

for contributing capital to a new build is limited, and the company could play a more effective role as a service provider on the network. Axiom does not have its own IP video product.

Tilson met with FairPoint to discuss the potential for upgrading existing service on the island. There are two potential ways to do so, both of which would utilize existing fiber infrastructure on the island to provide faster speeds. First, FairPoint could install additional remote terminals to provide fiber-to-the-node in neighborhoods with copper connections between the node and a customer premise for an advanced DSL service. Second, FairPoint could build a fiber-to-the-home (FTTH) network to every premise on the island. Tilson proposed these two scenarios during the meeting, and FairPoint was clear that external investment would be required to entice the company in either case. Tilson requested a range of external investment contribution for each option, and FairPoint indicated they would welcome a further conversation on that topic.

GWI indicated interest in participating in either business model. However, Tilson believes GWI's potential for contributing capital is limited, and the company could play a more effective role as a service provider on the network. GWI does have some limited experience providing fiber to the home. GWI does not have its own IP video product.

OTT Communications indicated interest in participating in the second business model as a service provider, as OTT currently has limited capital availability recently emerging from bankruptcy. Like GWI, OTT does not have its own IP video product; the company bundles internet and voice service with a satellite video provider.

Oxford Networks is not interested in participating in either business model. Oxford recently built a FTTH network in Lewiston, ME. However, due to slow customer uptake on the network, the company has shifted its efforts away from the residential market and is focusing all available new capital investments on business service.

Tidewater Telecom indicated interest in participating in either business model. Tidewater has its own IP video product. Tilson provided Tidewater's engineering team with road mileage, parcel lot, and premise location data to conduct further due diligence to be able to provide the Town with an understanding of the level of external investment might be required.

Time Warner Cable (TWC) indicated interest in participating in the first business model as a network owner. TWC was clear that external investment would be necessary for the company to build a DOCSIS 3.0 cable network on the island. Tilson provided TWC's engineering team with road mileage, parcel lot, and premise location data to conduct further due diligence to be able to provide the Town with an understanding of the level of external investment contribution required.

Business Model Considerations

In terms of service quality, FTTH would deliver a higher quality service than a DSL or cable system that uses a hybrid fiber/copper-based system. That being said, there are a number of other factors the Town needs to consider to determine which business model is the right fit for the community moving forward, including:

- Cost
- Competition
- Long-term financial sustainability
- Operational responsibility
- Customer service

Cost: Costs are more fully detailed in the next section. In Business Model #1: Commercial Initiative with External Investment, Tilson estimates between $1.24 million and $2.48 million of upfront investment would be needed to entice a commercial service provider, either FairPoint or another company, to construct, maintain, operate, and provide service on a network on the island.

In Business Model #2: Community-Oriented Approach, Tilson estimates $1.6 million would need to be raised to cover the fixed upfront cost of constructing the backbone fiber-to-the-curb (FTTC) network, and up to an additional $880,000 to construct customer connections to every premise on the island. The incremental investment range will depend on the type of FTTH technology the entity selects and how variable costs for customer connections are covered.

Comparing the two business models, Tilson appreciates the importance of cost and the difficulty in choosing a model without a more specific range for external investment contribution. However, it is difficult to confidently state a more specific amount at this point in time as a private company bidding on a competitive procurement would need to complete an in depth engineering analysis that models their construction and operating costs. Tilson recommends that the Town proceeds into a formal process to procure specific information from service providers about the required amount of investment needed to pursue a commercial initiative. With this information in hand, the Town will be able to better understand the needs for network construction, maintenance, network operation, and service provision moving forward.

Competition: In Business Model #1, the Town would maintain the current relationship structure that is has with an incumbent service provider if it chooses FairPoint to upgrade existing facilities or another company to construct a new network. By this, we mean that the Town will not have ownership of the network or operational responsibilities.

In Business Model #2, the network owner would operate the network facilities, and have the ability to select service provision through a competitive procurement process. This opens up potential opportunity to pursue an open-access, wholesale retail model where network customers could choose among multiple service providers. However, due to the small number of customers on Islesboro, Tilson does not believe the local retail market could effectively support a wholesale, open-access model with multiple service providers. While competition would benefit customers, the island does not have a sufficient customer base. Therefore, the network owner would either have to select a private service provider or provide service itself.

Partnering with other communities in a cooperative structure might help build economy of scale for a better broadband business model. However, Islesboro should carefully weigh that benefit against the potential 'deal complexity' that it might introduce. Such an analysis is beyond the scope of this report, but as part of the close out of this phase of planning, Tilson would be happy to facilitate a discussion about such a model, and then study it in greater detail as part of a follow-on engagement.

Long-term financial sustainability: In addition to the investment required to construct a network, maintaining, operating, and providing service on a network entails a number of ongoing expenses. Commercial network owners use revenues generated from customer subscriptions to cover these fees. Revenues are based on pricing for telephone, internet, and video service, which service providers offer as a single or bundled option.

In Business Model #1, the commercial service provider would cover these annual fees in the same way that FairPoint currently does. In other words, the Town would not have any long term financial risk in paying the network's ongoing operating expenses.

In Business Model #2, the network owner would be responsible for using the revenues generated by customer subscriptions to cover its operating costs. Tilson assumes that a community-oriented approach would include a basic phone and internet service offering on the network. As evidenced in the Town survey results, many residents currently subscribe to satellite video service as well, such as DirecTV or Dish. Provisioning video service would require IPTV technology on a FTTH network.

This is an important point to consider for two reasons. First, if video service is not offered on the network or customers do not want to switch from satellite service to IPTV, the network owner loses a substantial revenue stream. Without this revenue stream, the network owner must consider if revenues from phone and internet service can cover the annual operating costs of the network. Second, not all retail service providers are able to deliver IPTV service because doing so requires a significant investment in network head end equipment. These points are important to consider in the context of long-term financial sustainability and customer satisfaction.

Tilson estimates annual operating costs for a FTTH network would be approximately $206,000 per year: [16]

CMP & FP Pole Attachment Fees	$	31,500
CMP Dark Fiber Lease	$	8,200
State Telecom Taxes	$	21,700
Pole Work	$	10,500
Cable Replacement	$	5,000
Internet Uplink	$	39,000
General & Administrative	$	90,000

General and Administrative costs assume the network owner employs one full-time employee to perform necessary field services and back office administration during network operations, as detailed below. Tilson also estimates that the network owner would need to consider including some costs for marketing efforts on the island. This would be a non-recurring cost, and would not necessarily need to be spent all at once.

Operational responsibility: If the Town pursues a commercial initiative, the chosen partner would perform all the necessary responsibilities that go along with operating a network. If the Town pursues a community-oriented approach, there are a range of day-to-day responsibilities that would require staffing by the network owner. Operating a residential broadband network requires on-call maintenance services 7 days per week, 24 hours per day, and 365 days per year, which would necessitate hiring at least one full-time employee to perform service provisioning and troubleshooting, network maintenance, invoicing and collections, regulatory and contract compliance, and marketing.

Operational responsibilities include the following field services and back office administration:

- Add-move-change management. Management of all network moves, adds, and changes.
- Maintenance coordination. Route maintenance management, including coordination with the Dig Safe program to ensure that all locates are marked in a timely fashion.
- Department of Transportation (DOT) and local road job management. Processing of all road job notices, including identifying impacted facilities, managing contractors, ensuring timely transfers, performing road job impact evaluations, and reporting evaluation results.
- Management of a tree trimming program. Providing route patrolling, planning, and oversight of contractors, and manage third party tree trimming contractors when tree trimming is needed.

[16] GWI provided quotes for several tiers of internet backhaul. They recommended 500 Mb as sufficient bandwidth based on the number of customers on Islesboro, with a cost of $3,250 per month. GWI examined another network they operate with 1 Gb uplinks to 500 units (~2,000 customers), and peak utilization on the network is less than 200 Mb. For comparison, a 1 Gb uplink would cost $5,000 per month and a 2 Gb uplink would cost $7,750 per month.

- Restoration management. Management of all restoration activities following network damage (e.g., hurricane blow-down, pole strikes from cars, etc.), including notification and communication with customers and local management of restoration crews.
- ISP maintenance. Maintenance of networking equipment and mechanical systems in CO location(s).
- Contract administration. Includes license agreement management with pole owners.
    - Logistics support, inventory management (including critical spares), and warranty management.
- Insurance claim management. Administer insurance claims for casualty claims around matters such as pole strikes and fires.
- Regulatory matters. Perform required Public Utilities Commission reporting (annual, accident, etc.) and monitoring of relevant PUC rulemaking and other regulatory matters that affect the network.

This work can be contracted to outside parties; Tilson performs these activities for several clients. However, it is critical that the Town understands that a community-oriented approach entails a need for network owner to take a long term role in network operations.

Customer service: At the beginning of Tilson's engagement, the Town Selectmen expressed a concern that residents are not satisfied with current customer service by the incumbent service provider, in particular with prolonged, widespread service outages experienced after a recent storm.

In Business Model #1, customer service would depend on the company with which the Town chooses to partner. There are two primary components to customer service: field service and administration. For field service, the Town should consider if the company will have field staff located on the island full time or in close proximity to be able to perform troubleshooting and resolve customer problems quickly. For administration, the Town should consider if customers will be able to easily access support staff to resolve issues with billing or changing service.

In Business Model #2, a community-oriented approach would give the Town more local control of customer service. That is not to say that customer service would be inevitability better than under the commercial initiative; the network owner would have full responsibility for performing field service and administration. If the network owner decides to contract out facets of operations, the Town should consider where these resources are located and how their placement would affect response time and accessibility.

Business Model Case Studies: Chattanooga, TN and Leverett, MA

To date, the industry standard for FTTH has been Verizon FiOS. First announced in 2004, Verizon initially planned to invest $23 billion over ten years to construct FTTH facilities to 19 million homes throughout the Northeast U.S. The network offers customers a bundled service of internet, phone, and video with download speeds up to 50 Mbps, making FiOS internet approximately five times faster than the average Northeast cable company's service. [17]

During the network build out, Verizon's average fixed FTTC and variable costs were observed to be roughly $700 per premise and $650 per premise respectively, totaling $1,350 per premise. However, Verizon has struggled to recuperate its capital investment in the network due to slow service uptake, and, the company announced in September 2012 that it would discontinue FiOS deployment.[18] Today, FiOS is only available in the Northeast's primary metro areas, including Boston, New York City, Philadelphia, and Washington D.C.

Recognizing the public value of broadband access and the limited number of advanced projects undertaken by the private sector, a number of U.S. cities have initiated their own plans to develop broadband networks. New York City began planning the nation's largest outdoor WiFi wireless network in late 2013, which will cover 95 blocks in Harlem and will provide free 2 Mbps download speeds to the area's 80,000 residents.[19] Los Angeles is planning a fiber-based network to provide free internet service to its 3.5 million residents with download speeds between 3 Mbps and 5 Mbps.[20]

In addition to these ambitious plans in major urban centers, smaller cities and municipalities across the country have also undertaken initiatives to improve broadband access for citizens and local businesses. Two of these efforts by Chattanooga, TN and Leverett, MA are both pertinent to Islesboro's initiative and can provide important lessons learned and considerations for the island:

1. Chattanooga and Leverett both utilized municipal bonds to construct their FTTH networks.
2. Chattanooga and Leverett established municipally-owned entities to perform the range of responsibilities in network operations and assume financial risk of operations.
3. Leverett's network will not provide a video product, whereas Chattanooga's network delivers an IPTV service.
4. Chattanooga is served by a municipally-owned power utility, which decreased capital costs of constructing the network due to lower make ready expenditures.

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[17] Customers have the option to upgrade to 100 Mbps.

[18] http://www22.verizon.com/idc/groups/public/documents/adacct/goldman_vz_transcript_092012.pdf

[19] Story is available at http://mashable.com/2013/12/10/new-york-city-harlem-wi-fi-network/.

[20] Story is available at http://www.theverge.com/2013/11/5/5070520/los-angeles-planning-to-bring-free-fiber-based-internet-to-its-residents.

Chattanooga, TN

The Chattanooga Electric Power Board (EPB) is a municipally-operated power utility serving the City of Chattanooga, TN. EPB has been a national leader in using fiber infrastructure to improve power service and broadband availability for residents and businesses. After deploying fiber in pieces of its distribution system, EPB decided to undertake a citywide deployment to fully automate its infrastructure serving 170,000 homes, businesses, and devices (street lights, substations, etc.).[21]

As a power utility, EPB's primary goal was to install 1,200 switches throughout its distribution network and advanced metering infrastructure at all premises in the city. EPB designed an 8,000-mile fiber network passing all 170,000 service locations, which it planned to deploy over 10 years starting in 2008. However, in 2010, EPB received a $111 million federal ARRA grant from the Department of Energy, which enabled the organization to advance construction to be completed in three years. The total project cost approximately $340 million; the city passed a $229 million municipal bond to provide matching funds. The loan was structured so that EPB's electric division would loan the cable/internet division sufficient funds, and then the loan would be repaid using revenue generated from network subscriptions.

Now fully built, EPB's fiber network has been a resounding success. For power service, EPB's automated switches have cut outage durations by over 60 percent. Moreover, with fiber passing every home and business in the city, totaling roughly 150,000 premises, EPB created a division to provide retail internet, voice, and video services to customers.[22] EPB's FTTH network is a GPON design, meaning it has a passive architecture with bandwidth capabilities up to a Gigabit per customer.

For retail service, EPB initially offered three tiers of internet at symmetrical speeds of 15 Mbps, 30 Mbps, and 50 Mbps. However, after realizing it did not have to invest additional capital to advance service speeds, EPB has doubled delivered upstream and downstream speeds in each subsequent year. Today, EPB offers two tiers of internet service: symmetrical 100 Mbps for $57 per month and symmetrical 1 Gpbs for $69 per month.[23] Customers can also purchase bundled services: an internet and TV package costs $110 per month and a Triple Play package (internet, phone, and video) costs $125 per month. EPB has achieved market uptake above its initial projections, with 53,000 current residential customers and 4,500 business customers.

Like Islesboro, EPB had to initially decide if it wanted to own and operate a FTTH network and provide retail service. After deciding to pursue a FTTH solution, EPB was sued by Comcast and the Tennessee Cable Television Association.[24][25] Both parties claimed that EPB was improperly

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[21] Information on EPB's network was obtained in a phone interview with Danna Bailey, EPB's VP Corporate Communications (baileydk@epb.net).

[22] EPB purchased and operates its own IPTV head end, which has High Definition service capabilities.

[23] Basic VoIP phone service starts at $23 per month.

[24] *Comcast of the South v. Electric Power Board of Chattanooga.* Court of Appeals of Tennessee at Knoxville. Filed May 13, 2009. Available at http://www.leagle.com/decision/In%20TNCO%2020090513587.

using electric utility funds to subsidize its cable/internet venture. However, both lawsuits were dismissed on the basis that the case did not present a justifiable controversy and the parties did not have standing to bring the action.

In terms of operational responsibilities, EPB cited implementing business systems, adapting customer service culture to include a focus on marketing, and provisioning/troubleshooting service inside customers' homes as challenges to which the organization had to adapt when it became a network operator.[26]

Overall, EPB's efforts have provided a model for cities around the U.S. on how to effectively advance power and telecom service for residents.

Leverett, MA

The town of Leverett, MA is located roughly 30 miles north of Springfield, MA. Like Islesboro, the town's residents have limited access to broadband infrastructure, which currently consists of satellite service and limited DSL coverage with speeds in the single-digit Mbps range. To address the issue, a municipal bond issue was approved in April 2012 to finance the construction of a town-wide FTTH network.

This FTTH network will connect to the internet via the MassBroadband123 middle mile network, which, like the Three Ring Binder in Maine, was ARRA-funded.[27] The MB123 network offers open-access middle mile fiber throughout central and western Massachusetts, where there was previously minimal fiber-based communications infrastructure.

Leverett's proposed FTTH network is similar in scope to Islesboro's project. The network will have an Active Ethernet architecture that serves approximately 800 premises and covers 39 road miles. Once constructed, the network will be managed by a Municipal Lighting Plant (MLP) entity owned by Leverett.

In terms of service, the Town is planning for the network to provide broadband internet access and phone service to subscribing households and businesses, but no video service. The Broadband Committee has selected the following standards for the network:

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[25] *Tennessee Cable Telecommunications Association v. Electric Power Board of Chattanooga.* Court of Appeals of Tennessee at Nashville. Filed August 26, 2009. Available at http://www.leagle.com/decision/In%20TNCO%2020090827620.

[26] As a power company, EPB had previously only worked on the exterior of customers' homes. With telecom service requiring technicians to enter premises to install and repair service, EPB made a concerted effort to train field staff on best practices for working inside homes.

[27] MB123 is owned by the Massachusetts Broadband Institute, a state agency, whereas the Three Ring Binder is owned by Maine Fiber Company, a privately held company.

- The network will connect every household in Leverett, regardless of distance, household density, or service usage.
- The fiber count capacity will be enough to reach all developed and undeveloped parcels of Leverett and provide redundancy.
- The network will be built with the capacity to serve cell towers which could eventually be built near the network.
- Leverett will own the network infrastructure from the middle-mile nodes up to, and including, the optical network terminals at the customer premise.
- The network will provide a 1 Gbps symmetrical connection for every customer that orders service.
- There will be a private party who operates as a single point of contact for one-call trouble-shooting and customer service.
- The network will include the capability to support "smart-grid", medical monitoring operations, and other high-bandwidth/high-availability operations.
- The network will be serviced by third-party network maintenance, including routine and disaster-related services under contract with either the MLP or the service provider/operator contracted by the MLP.

Like Islesboro, the Town's efforts to date have been guided by the Town Select Board. The three-member board has been supported by a Broadband Committee composed of six volunteer residents with domain expertise. In November 2011, the group secured a planning grant of $40,000 from the Massachusetts Broadband Institute, the owner of the MB123 network, to design the network. The Town subsequently conducted a competitive procurement to select a firm to perform a detailed FTTC design.[28]

Following the completion of the design and approval of public funds, the Town released a Request for Information (RFI) in September 2012 to gauge industry interest in providing services as a construction, maintenance, network operator, or service provider vendor. A copy of the RFI has been attached as an appendix to the report.[29] The RFI provides a useful framework to understand the roles of various players involved in the construction and operations of the network:

> ***Construction***: Firms which provide fiber cable installation and required construction services including, but not limited to, digging trenches and duct banks, building conduit, pulling cable, erecting facilities, installing initial electronics, and other functions to connecting the network together or to users.
>
> ***Maintenance***: Firms who repair broken fiber cables, provide replacement fiber, fix broken aerial structures, replace compromised facility structures, and generally keep the network's physical elements in working order

[28] A copy of the Request for Proposals (RFP) is included as an attachment.
[29] Industry responses can be found on the Town's website: https://www.dropbox.com/sh/mh6fjdqqrx0fjwp/k9XUwh7Q31.

Network Operator: Firms responsible for the operation of the network including managing the performance of the switches, servers, software, and data traffic within the network. The Network Operator will have the relationship with the network hubs and interconnections, run the Network Operations Center, and dispatch maintenance and other technical resources to provision, maintain, and repair the network as needed

Service Provider: Firms who manage the customer relationship, either directly or white-labeled as the MLP. These firms handle billing, process payments, provide customer relations, provide technical support, undertake home installations, and serve as a customer service contact

In May 2013, the Town released a Request for Proposals (RFP) for FTTH installation, splicing, termination, testing, and maintenance services. The Town received eight responses and selected Millenium Communications Group, a New Jersey-based telecom firm, as the contractor to build the network. Millenium's bid amount was $2,275,731.

The Town has yet to release an RFP for providing service on the network. An important difference between Islesboro and Leverett to note is that there is state-led effort in Massachusetts to build last mile service off the MB123 network. The Commonwealth recently approved $40 million for the last mile effort. Therefore, municipalities in central and western Massachusetts face a different dynamic in terms of network operations and retail service than communities in Maine that have access to the Three Ring Binder.

The Town's primary point of contact for questions and issues related to the FTTH effort is the Leverett Town Administrator, Marjorie McGinnis (townadministrator@leverett.ma.us). Additional information on the Leverett Broadband Committee's work can be found on the Town's website: http://leverett.ma.us/content/broadband-committee.

Investment Required to Improve Broadband on Islesboro

As stated before, Tilson does not believe there is a viable market-based business case for an existing commercial internet service provider to invest the full amount required to improve broadband facilities on the island. As a result, the incumbent service provider, FairPoint, or a new service provider would need to receive external investment to be enticed to pursue a project on Islesboro.

In Business Model #1: Commercial Initiative with External Investment (Options 1-3), Tilson estimates between $1.24 million and $2.48 million of upfront investment would be needed to entice a commercial service provider, either FairPoint or another company, to construct, maintain, operate, and provide service on an improved network on the island. This amount covers a range of 50 percent to 100 percent of the estimated cost to construct a FTTH network on the island. Advanced DSL and DOCSIS 3.0 cable construction costs run approximately in the same range.

In Business Model #2: Community-Oriented Approach (Options 4-6), Tilson estimates a total investment of $2.48 million would be required to construct a new FTTH network on the island, with a fixed cost of $1.6 million. This capital amount could be raised through private contributions, a municipal bond, property taxes, or other means, depending on how the owning entity is structured and governed. Moving forward, the network owner would be responsible for covering annual operating costs, which Tilson estimates would be $206,000 per year.

For Business Model #2, Tilson developed a capital model that includes costs for the labor, materials, and professional services needed to construct an active or passive FTTH network on Islesboro and an active FTTH network on Seven Hundred Acre Island and Minot Island:

Figure 12: Cost Estimates of Network Options

	Islesboro AE	**Islesboro PON**	**700 Acre Island AE**	**Minot Island AE**
Total Cost	$ 2,477,341	$ 2,245,933	$ 113,890	$ 54,322
FTTC Cost	$ 1,603,720	$ 1,606,245	$ 95,514	$ 49,195
Per Mile Cost (FTTC)	$ 37,858	$ 37,920	$ 33,686	N/A
Per Mile Cost (FTTC+Variable)	$ 58,481	$ 53,018	$ 40,167	N/A
FTTC Cost Per Premise	$ 2,127	$ 2,130	$ 6,368	$ 12,229
Variable Cost Per Premise	$ 1,159	$ 848	$ 1,225	$ 1,282
Total Cost Per Premise	$ 3,286	$ 2,987	$ 7,593	$ 13,511

Fiber-to-the-Home Cost Estimate

The total cost of each FTTH design includes the following components, which are detailed in the attached appendix:

- Construction
  - Make ready
  - Aerial installation
  - Conduit installation[30]
  - Fiber cable
  - Splicing
  - Traffic control
- Professional Services
  - Project management/engineering
  - Legal and regulatory
- Network Gear
- Microwave Links (only applicable for Seven Hundred Acre Island and Minot Island)
  - 1 Gbps FDX equipment
  - Installation
- Customer Connections/Service Drops
- Bonding
- 10% Overall Contingency

As stated in the Executive Summary, the network costs contain two components: a fixed capital expenditure needed to construct facilities that pass each premise on the island and a variable cost for connecting homes and businesses with service from the street curb. The fixed FTTC amounts presented above include all costs for construction, professional services, microwave links (for Seven Hundred Acre Island and Minot Island), bonding, project contingency, and fixed network gear. Variable costs include service drops and variable network gear. Network gear is broken out into fixed and variable components because certain equipment must be installed to serve the first network customer (cabinet and chassis), while other equipment (cards and SFP) can be purchased and installed as additional customers subscribe to the network.

Tilson's cost estimates assumed that all service drops from the FTTC network are aerial connections. The Selectmen have indicated that some service drops will be underground, so Tilson has included an option in its model for installation of new conduit for service drops. As properties across the island have varying driveway lengths and visual preferences, individual household connections will cost different amounts and the network owner must consider how these variable costs will be covered. In a desktop survey, Tilson estimated an average 250 foot service drop length per premise for the island. Average connection costs are estimated to be $1.67 per foot for aerial installation. Estimated underground costs for service drops in new conduit would be $2.79 per foot.

[30] Since there are no utility poles on Minot Island, Tilson assumed fiber would be installed in conduit that would be laid directly on the ground, not buried.

In Business Model #2, the network owner will need to obtain regulatory approval as a competitive local exchange carrier (CLEC) from the Maine Public Utilities Commission. CLEC status is required to execute a pole attachment agreement with CMP and FairPoint, the owners of existing utility poles on the island, which is needed to be able to install fiber cable in the public right-of-way.

Fiber-to-the-Home Network Design

Tilson believes the FCC's Tier 5 threshold for both download and upload speeds (10 Mbps), with scalability to 1 Gbps service without major recapitalization, is well suited to be a universal service standard on Islesboro. Tier 5 speeds will provide the island with sufficient bandwidth for internet, video, and voice applications for the foreseeable future, including those activities survey respondents want to be able to do. This standard enables the Town to pursue either of Tilson's proposed business models.

The following section provides an overview of two types of FTTH network architecture, active and passive, and contemplates a high level FTTH design for Islesboro, Seven Hundred Acre Island, and Minot Island. For the purposes of the study, Tilson assumed a technology solution for Seven Hundred Acre Island and Minot Island that is consistent with Islesboro's solution.

Defining Broadband

Broadband is defined by the amount of data that a consumer can download or upload from the internet in a given second. This measurement is known as bandwidth, and the greater a consumer's bandwidth is, the faster the connection. Connection speeds are generally measured in kilobits per second (Kbps), megabits per second (Mbps) or gigabits per second (Gbps).[31]

In the U.S., broadband standards are defined by the FCC, which regulates interstate and international communications by radio, television, wire, satellite and cable. The FCC uses a tiered approach to define broadband based on download and upload speeds for wireline and wireless technologies:[32]

[31] 1 Gbps = 1000 Mbps = 1,000,000 Kbps.

[32] Pg. 5. The ConnectME Authority, 2012. *Developing Broadband in Maine: Strategic Plan.* Available at http://www.maine.gov/connectme/grants/ntia/planning.shtml.

Figure 13: FCC Speed Tier Upload and Download Speeds

FCC Speed Tier	Download Speeds	Upload Speeds
1st Generation Data	200 Kbps to 768 Kbps	200 Kbps to 768 Kbps
Tier 1	768 Kbps to 1.5 Mbps	768 Kbps to 1.5 Mbps
Tier 2	1.5 Mbps to 3 Mbps	1.5 Mbps to 3 Mbps
Tier 3	3 Mbps to 6 Mbps	3 Mbps to 6 Mbps
Tier 4	6 Mbps to 10 Mbps	6 Mbps to 10 Mbps
Tier 5	10 Mbps to 25 Mbps	10 Mbps to 25 Mbps
Tier 6	25 Mbps to 100 Mbps	25 Mbps to 100 Mbps
Tier 7	> 100 Mbps	> 100 Mbps

The FCC currently defines 3 Mbps downstream and 768 Kbps upstream as the minimum threshold speeds for broadband, with some regulatory decisions defining basic service as 4 Mbps downstream and 1 Mbps upstream.[33] As shown in the table above, the current standard translates to a minimum Tier 3 downstream and Tier 1 upstream connection to qualify as broadband service.

The rapid advancement of delivered data speeds in the U.S. has caused the FCC to recently change the definition of broadband. In 2000, only 4.4 percent of American households had a broadband connection (as currently defined) in their homes. By 2010, that number had jumped to 68 percent. Moreover, since 2010, average delivered speeds in the U.S. have doubled overall, and today roughly 94 percent of Americans have access to wireline or wireless broadband speeds of at least 10 Mbps downstream. As a result, the FCC raised the minimum threshold for download speeds from Tier 1 to Tier 3 in 2010, and is now considering increasing the downstream threshold to Tier 5.[34] This evolving baseline reflects a growing need for higher bandwidth as Americans increasingly use the internet and communications technologies in all aspects of their lives.

In Maine, the ConnectME Authority, the leading state agency focused on broadband development, has adopted the FCC's tiered definition as the basis for evaluating broadband projects for funding. The Authority considers download and upload speeds at and above Tier 1 as qualifying as broadband service, but has a stated preference for funding projects providing Tier 3 service or better.[35]

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[33] Sixth Broadband Report, 25 FCC Rcd 9556, 9563 ¶10 (2010). The FCC's National Broadband Plan considers 4Mbps and 1Mbps downstream as the minimum threshold for broadband.

[34] Pg. 4. *Four Years of Broadband Growth*, June 2013. The White House Office of Science and Technology Policy & The National Economic Council.

[35] Pg. 5. The ConnectME Authority. 2012. *Developing Broadband in Maine: Strategic Plan.* Available at http://www.maine.gov/connectme/grants/ntia/planning.shtml.

In terms of functionality, the following table shows download speeds required for a range of common internet-based activities:[36]

Figure 14: Minimum Download Speeds per User for Internet-based Activities

Activity	Minimum Download Speed (Mbps)
Email	0.5
Web browsing	
Job searching, navigating government websites	0.5
Interactive pages and short educational videos	1
Streaming radio	Less than 0.5
Phone calls (VoIP)	Less than 0.5
Watching video	
Standard streaming videos	0.7
Streaming feature movies	1.5
HD-quality streaming movie or university lecture	4
Video conferencing	
Basic video conferencing	1
HD video conference and telelearning	4
Gaming	
Game console connecting to the Internet	1
Two-way online gaming in HD	4

Download and upload speeds depend on the type of communications technology service providers utilize. There are a number of different technologies currently available to residential and business users, which offer varying bandwidth capabilities:[37]

[36] FCC Broadband Speed Guide. Available at http://www.fcc.gov/guides/broadband-speed-guide.
[37] Pg. 5. The ConnectME Authority. 2012. *Developing Broadband in Maine: Strategic Plan.* Available at http://www.maine.gov/connectme/grants/ntia/planning.shtml.

Figure 15: Download and Upload Speeds by Communications Technologies

Technology	Download & Upload Speeds
Dial-up	Up to 56 Kbps
2G Mobile	Up to 100 Kbps
3G Mobile	384 Kbps – 2 Mbps
4G Mobile[38]	2 Mbps – 100 Mbps
Satellite[39]	200 Kbps – 2 Mbps
DSL	768 Kbps – 6 Mbps
Traditional Cable	1 Mbps – 10 Mbps
DOCSIS 3.0 Cable	1 Mbps – 30 Mbps
Fixed Wireless	1 Mbps – 10 Mbps
T-1	1.5 Mbps
Fiber Optic	Up to 1 Gbps

The speeds shown above are averages achieved for each technology. Higher speeds are possible for certain technologies depending on network layout and user saturation. If a user is located close to a network node, which houses the networking equipment that sends the network signal, and overall network use at that point in time is low, he will obtain higher connection speeds. As some residents of Islesboro have likely experienced, if a DSL subscriber is located close to FairPoint's remote terminals he can achieve higher download speeds around 15 Mbps.[40] However, as one moves farther away from the remote terminal, download and upload speeds decrease.

Selecting a Community Service Standard and Technology Solution

Tilson believes the FCC's Tier 5 threshold for both download and upload speeds (10 Mbps), with scalability to 1 Gbps service without major recapitalization, is well suited to be a universal service standard on Islesboro for the foreseeable future. Tier 5 will provide the island will sufficient bandwidth for data, video, and voice applications, including those activities survey respondents want to be able to do.

Second, this standard enables the Town to pursue either of Tilson's proposed business models. Either a FTTH network or a DOCSIS 3.0 cable network could deliver symmetrical speeds,

[38] Islesboro currently has 4G mobile access in the Dark Harbor vicinity around Pendleton Yacht Yard from the wireless tower located near the intersection of Derby Road and Pendleton Point Road.

[39] Current satellite service may achieve broadband level speeds, but the excessive latency or delay and data cap precludes the use of many broadband applications.

[40] FairPoint has two remote terminals on the island, one located on the southern half of the island at the intersection of Derby Road and Pendleton Point Road and one located on the northern half of the island at the intersection of Heald Road and Main Road.

meaning equal download and upload speeds, at this standard, which gives the Town some flexibility for selecting a business model that delivers an effective solution to residents and is also economically feasible. If FairPoint were chosen to partner with the Town, Tilson believes a fiber-to-the-node network could provide an advanced DSL service that provides speeds in the range of 16 Mbps downstream and 3 Mbps upstream, which would be a similar range to the "FairPoint Fast" service in the former FiOS territory the company now owns in Eliot, Maine. On the other hand, advanced DSL infrastructure is not scalable to speeds of 1 Gbps, and thus is less future proof. A relevant advanced DSL project to consider is the recent broadband upgrade in Cornwall, England. The project includes a fiber-to-the-node network with copper connections to 50 percent of the 250,000 homes and businesses in the region, with connection speeds ranging between 40 Mbps and 80 Mbps.[41]

Lastly, considering the gap between Islesboro's current service and the national average, symmetrical 10 Mbps service would help the Town better compete with other communities to attract young residents and businesses. As noted in the previous section, 91 percent of the U.S. population has access to wired advertised download speeds greater than 10 Mbps according to the White House Office of Science and Technology Policy. Should the FCC decide to raise the minimum tier for broadband service again, 10 Mbps upstream and downstream would qualify as broadband.

Tilson did not consider 4G Long Term Evolution (LTE) mobile as a viable broadband solution for Islesboro. While LTE could provide a potentially high quality service, current carrier policies on data caps make this uneconomic for residential broadband use, particularly as bandwidth demand changes. Should carriers lift these caps, then such a solution might work. A capital estimate for such a build out was not in scope for this report. That being said, Tilson's proposed FTTH network design could support additional wireless backhaul on the island.

If the Town decides to pursue Business Model #2 and wants to achieve a universal Tier 5 service on the island, Tilson recommends a FTTH solution. FTTH is a commercially-proven technology for fast residential and business broadband service, and would enable the Town to scale service to higher speeds in the future without significant new capital investment. The following section details two types of FTTH network architecture.

Fiber-to-the-Home Network Architecture: Active vs. Passive

The average operational life cycle of a FTTH network is typically 20 years. A FTTH network on Islesboro would consist of several components, including backhaul facilities, FTTC facilities, and service drops. Backhaul service is the backbone bandwidth that connects a town's CO, the aggregation point of the local network, to the internet. FTTC includes all fiber between the CO and each premise's driveway. Since fiber cable is attached to roadside utility poles, the FTTC

[41] Additional information on the Cornwall, England project is available at the following websites: http://www.superfastcornwall.org/about-sfc, http://recombu.com/digital/news/superfast-cornwall-what-is-it_M10880.html

footprint on Islesboro will mirror the road layout on the island. A service drop is the connection between the street curb and a premise.

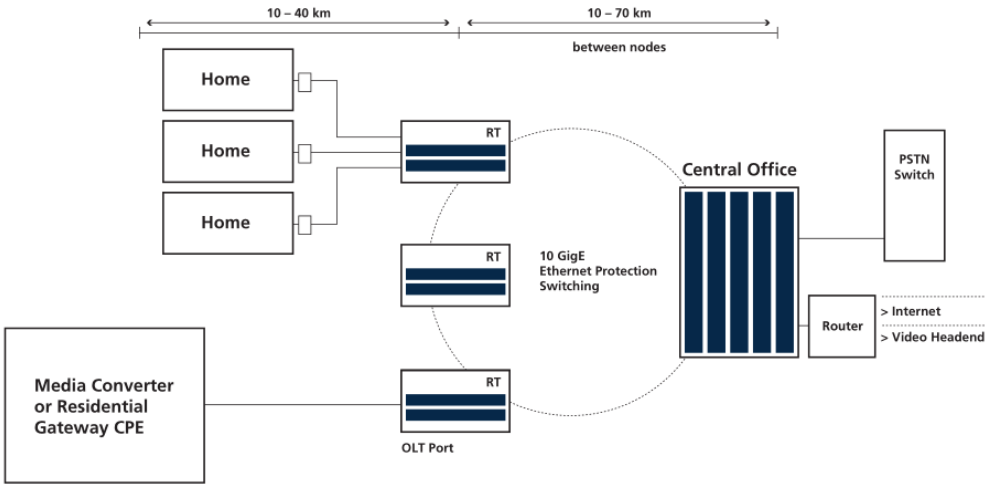
A FTTH network can be similarly be broken down into its inside plant (ISP) and outside plant (OSP) components. ISP includes the networking gear located in the CO, which converts the backhaul signal to a signal that can be distributed to end users. OSP includes all facilities from the exterior of the CO to the premise, which includes steel strand that is attached to utility poles, fiber cable that is lashed to the strand, and service drops from the street curb to each premise.

These terms are important because they dictate the timing of capital deployment during a network build out, as further detailed below.

There are two primary types of FTTH technology: Active Ethernet (AE) and Passive Optical Networking (PON). Each type of network architecture can serve both residential and business applications with Gigabit upload and download capabilities. The primary difference is that in an AE network each premise is served with a dedicated fiber feed and bandwidth, whereas in a PON network bandwidth is split among users. In other words, AE is a point-to-point network whereas PON is a point-to-multipoint network.

An AE network involves point-to-point fiber connections that are deployed from the CO to each premise being provided with service:

Figure 16: Active (AE) Fiber-to-the-Home Architecture

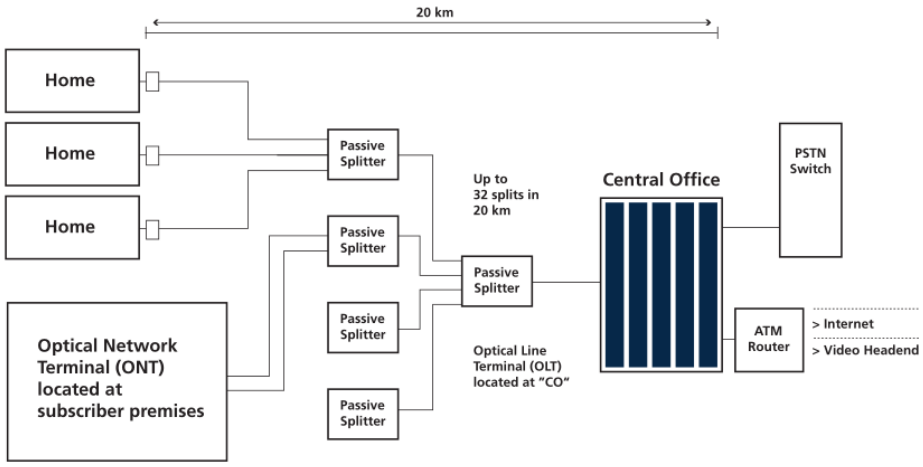


As illustrated above, each pair of fibers connecting to a consumer premise is fed from the local CO. The fiber from the CO terminates in an Optical Networking Terminal (ONT) at each premise, which converts the fiber's light signal to be transmitted over Ethernet (CAT5) wiring inside the

home or business. Since each pair is a dedicated feed, there is no sharing of network bandwidth among end users.

PON networks deliberately involve the sharing of bandwidth across a number of end users:

Figure 17: Passive (PON) Fiber-to-the-Home Architecture



PON networks have equipment located in their OSP facilities called optical splitters, which enables up to 32 end users to share bandwidth being transmitted from the local CO.[42] The short distribution component from each splitter to a premise is the only part of the network dedicated to each end user.

Comparing AE and PON FTTH capabilities, each networking technology has relative pros and cons:

- **Bandwidth**. AE offers dedicated, symmetrical bandwidth that is nearly limitless. It is considered to be more future proof than PON because network upgrades only require changing signal equipment in the CO, whereas upgrading a PON network requires installing new equipment in the network nodes (where bandwidth is split).

- **Capital costs**. The costs for deploying an AE network are higher than for a PON network because AE requires higher fiber strand counts. That being said, PON optronics, which transmit the network signal, are generally more expensive than AE optronics, especially for high speeds. In terms of range, AE optronics can reach consumers that are located up to 70 km away from a CO, whereas PON customers must be within 20 km of a CO because splitters degrade signal strength.

[42] There is PON equipment commercially available designed to accommodate up to 64:1 splitting.

- **Operating costs**. Troubleshooting and maintenance costs for AE and PON networks depend on the network location of restoration incidents. While the aggregation device at a node in an AE network is complex due to the number of fiber strands terminating there, troubleshooting with an AE network's router is typically considered to be easier than doing so in PON splitters.

- **Customer premise equipment**. CPE devices, which include the ONT, are interoperable for AE and PON networks.

- **Video**. Broadcast video can be offered relatively easily over a PON network as an RF overlay, whereas IPTV technology needs to be used in an AE network. IPTV requires a service provider to invest in head end networking equipment, which requires substantial investment.

Overall, a passive network has lower deployment costs and is considered by some to be better suited to residential consumers' smaller bandwidth requirements. Conversely, AE architecture is considered by some to be better tailored for business applications due to higher bandwidth capabilities and to be a more stable technical standard by avoiding costly equipment and network upgrades in a future scaling event.

Network Backhaul Requirements

For Tier 5 upstream and downstream service, Tilson believes that 500 Mbps of backhaul bandwidth should be a sufficient starting point for a FTTH network on Islesboro.[43] At present, the only existing communications facility capable of providing a backhaul service to the island is a subsea fiber cable owned by FairPoint. While FairPoint may have the technical capacity to lease dark fiber capacity on its cable, the fiber is not available on an open-access basis and would be subject to negotiation. The Town indicated that FairPoint previously conveyed during a ConnectME Authority grant application effort there is not availability of backhaul capacity on their subsea fiber line. This scenario of backhaul utilization raises a competitive dynamic if FairPoint is not the network operator.

An alternative option for backhaul is to lease fiber from Central Maine Power (CMP). CMP does not currently have any subsea fiber deployed anywhere in Penobscot Bay, but the company is planning to upgrade the current 12kV subsea power line between Islesboro and Northport, ME. Fiber is commonly installed in power lines for the operator to regulate electricity transmission. Tilson reached out to CMP's lead point-of-contact for the project, Sarah Mazurek (Sarah.Mazurek@cmpco.com), who agreed to include up to 24 strands as part of the cable installation. Tilson requested that 10 strands be reserved for a potential future FTTH build out on the island. It is unlikely that all 10 strands would be needed to operate a network on the island, but due to the relative low cost of including back up strands in the initial build, Tilson recommends having extra fiber available in case it would be needed in the future. CMP estimates that the installation of the new cable will be complete in early 2015.

[43] Based on consultation with GWI's network engineering team, who provided the backhaul quote for the OPEX budget with a recommendation for 1 Gbps for 10 Mbps per household universal service standard.

Leasing CMP's fiber would enable the network owner to connect a CO on the island to Northport, where a lateral would need to be built between the subsea cable's termination point and the Three Ring Binder. The Three Ring Binder runs from Northport to the internet point-of-presence in Boston, MA, thus providing the necessary backhaul to serve a FTTH network on Islesboro via the Town's chosen service provider.

Islesboro Fiber-to-the-Curb Network Design

Using road layout, parcel lot, and premise location data provided by the Town, Tilson conducted a desktop survey to develop a FTTC design that reaches all occupied properties on Islesboro. Tilson's design assumes an AE architecture for OSP, with dedicated fiber feeds between the CO and each premise. A passive architecture would have smaller strand counts, as service between the CO and neighborhood nodes (where splitters are located) could be aggregated. However, for the purposes of initial estimation, AE and PON capital amounts in a network of this scale are comparable.

For ISP equipment, a FTTH network on Islesboro would need two chassis (assuming full network uptake). A chassis is the primary networking gear location in the CO that contains optronics to transmit the network signal. The chassis model Tilson used in the design has a maximum capacity of 504 end users, necessitating the need for two.[44] Based on the island's premise layout, Tilson located one chassis at Meadow Pond Road and Main Road (Chassis 1) the intersection of Mill Creek Road and Main Road (Chassis 2):

[44] For Islesboro, Tilson believes an AdTran 5000 chassis would be well suited for the number of users. This model has a maximum capacity of 504 end users, but other AdTran models and equipment from other manufacturers can accommodate a range of customer counts.

Figure 18: Islesboro Fiber-to-the-Curb Layout

Based on these chassis locations, which would be installed in cabinets mounted on roadside utility poles, Tilson developed fiber strand counts to provide dedicated pairs of fibers into each premise on the island. The resulting FTTC network would contain fiber cable with strand counts between 12F to 432F:[45]

Figure 19: Islesboro Fiber-to-the-Curb Strand Allocation

Strand Count	Road Footage	Portion of FTTC Footprint
12F	50,266	22%
24F	34,495	15%
48F	55,010	25%
96F	30,412	14%
144F	30,619	14%
288F	17,615	8%
432F	5,253	2%

[45] The map shows all fiber counts 48F and above. Green indicates 48F, purple indicates 96F, orange indicates 144F, yellow indicates 288F, and red indicates 432F.

In total, the FTTC network on Islesboro would cover 42.36 road miles and be attached to an estimated 1,392 utility poles.[46] The actual amount of fiber cable used in FTTC footprint would be 10 percent more than the road mileage covered, or 46.56 miles, due to cable sag between utility poles, slack built into the network to accommodate future modifications and repairs, and road crossings.

Seven Hundred Acre Island and Minot Island Network Design

The Town also asked Tilson to complete a high level design for broadband facilities on Seven Hundred Acre Island and Minot Island with a technology solution consistent to Islesboro's. As there is no fiber currently serving the islands and no plan to do so in the future, Tilson considered a 1 Gpbs microwave backhaul configuration from Islesboro Central School to each island. The school was selected as collocation site because it has line-of-sight to each island, which Tilson determined in a desktop survey. Each island would need its own chassis; since the number of premises on each island is much lower than the main island, Tilson chose a smaller, less expensive model. Lastly, due to the small number of households on each island, passive architecture is not appropriate and Tilson would recommend an AE solution.

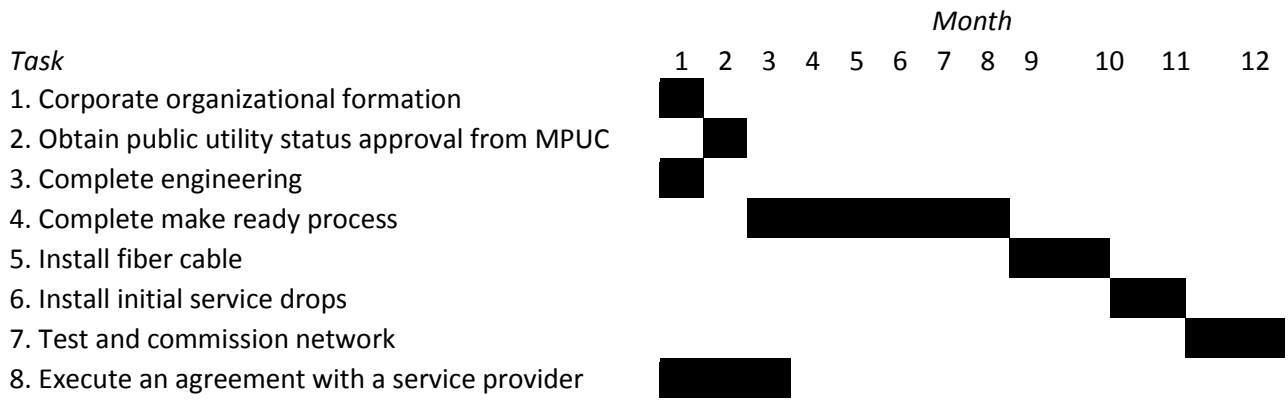
Construction Timeline

For Business Model #1, the commercial service provider's construction timeline would depend on their needs and negotiation with the Town. For Business Model #2, Tilson estimates that it would take a total of 12 months to construct a FTTH network on Islesboro and the two outlying islands. This timeline includes the following activities, some of which overlap:

1. Corporate organizational formation: 1 month
2. Obtain public utility status approval from the Maine Public Utilities Commission: 1 month
3. Complete engineering: 1 month
4. Complete make ready process: 6 months
5. Install fiber cable: 2 months
6. Install initial service drops: 1 month
7. Test and commission network: 1 month
8. Execute an agreement with a service provider: 3 months

[46] This assumes a 160 average pole span on the island, which was determined by the Tilson team during the route ride out with Page Clason.

Figure 20: Projected Network Construction Timeline



Conclusion

Through this study, Tilson aims to provide the Town with a platform to explore potential options for improving broadband on Islesboro. For next steps, the Town needs additional information from the commercial service provider community to effectively evaluate the value of all possibilities. Tilson recommends that the Town proceed into a formal RFI process requesting specific information from service providers about the required amount of investment needed to pursue a commercial initiative. With this information in hand, the Town will be able to better understand the needs and evaluate the options for network construction, maintenance, network operation, and service provision moving forward.

Regardless of the business model and technology solution the Town chooses, Islesboro residents and businesses will benefit from improved broadband access. Broadband development can play a key role in helping Islesboro develop its economy and sustain its year round community, benefitting all members of the community.

Appendix

National Broadband Availability Map

Residential Survey and Results

Business Survey and Results

School Survey and Results

Economic Benefit Analysis

FTTH Cost Estimates Detailed

Town of Leverett, MA Request for Information

Town of Leverett, MA Request for Proposals: Fiber to the Curb Network Design

Town of Leverett, MA Invitation for Bid: Fiber Optic to the Home Installation, Splicing, Termination, Testing, and Maintenance Services

Broadband Planning and Digital Equity

City of Cambridge Broadband Task Force Meeting
June 17, 2015
Presented by Anne Schwieger

SESSION OVERVIEW

1. What do we know? What do we want to learn? (10 minutes)

SESSION OVERVIEW

1. What do we know? What do we want to learn? (10 minutes)

2. Cities and Digital Equity (15 minutes)
   - Scope of the Problem and Assumptions
   - Models

SESSION OVERVIEW

1. What do we know? What do we want to learn? (10 minutes)

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3. Digital Equity Efforts in Cambridge and Boston (25 minutes)

SESSION OVERVIEW

1. What do we know? What do we want to learn? (10 minutes)

2. Cities and Digital Equity (15 minutes)
   - Scope of the Problem and Assumptions
   - Models

3. Digital Equity Efforts in Cambridge and Boston (25 minutes)

4. Group Convo/Wrap-up (10 minutes)

THE DIGITAL DIVIDE

Access:

98% of US households are in areas with *access* to broadband

Adoption:

70% of households have *adopted* broadband in the home

Source:
National Telecommunications and Information Administration, http://1.usa.gov/1SRoc24

Pew Internet
http://pewrsr.ch/1HlPkUl

THE DIGITAL DIVIDE

Barriers to Adoption:

THE DIGITAL DIVIDE

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Cost

- *Can I afford broadband in my home?*

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- *Can I afford broadband in my home?*

Relevancy

- *What can I do with broadband in my home?*

THE DIGITAL DIVIDE

Barriers to Adoption:

Cost

- *Can I afford broadband in my home?*

Relevancy

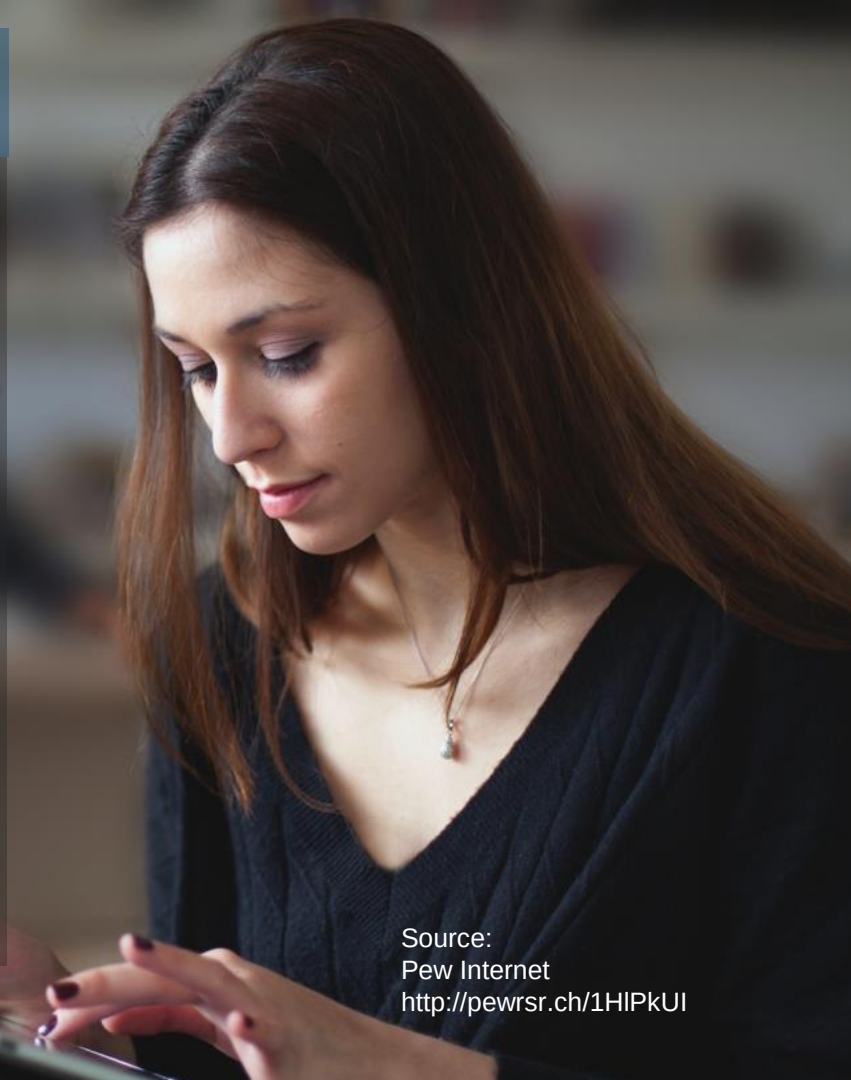
- *What can I do with broadband in my home?*

Digital Literacy

- *How do I use devices and the Internet itself?*

BROADBAND USE IN THE HOME

Demographic Group	% Home Broadband Adopters
White, Non-Hispanic	74%
Black, Non-Hispanic	62%
Hispanic	56%
No high school diploma	28%
Less than $30,000/year	52%
Over 65 years of age	47%



Source:
Pew Internet
http://pewrsr.ch/1HlPkUI

ASSUMPTIONS: SMARTPHONES

Opportunities

- Can serve as gateway to digital citizenship
- Increasingly critical part of online life
- Mode of access for demographic groups least likely to have broadband at home

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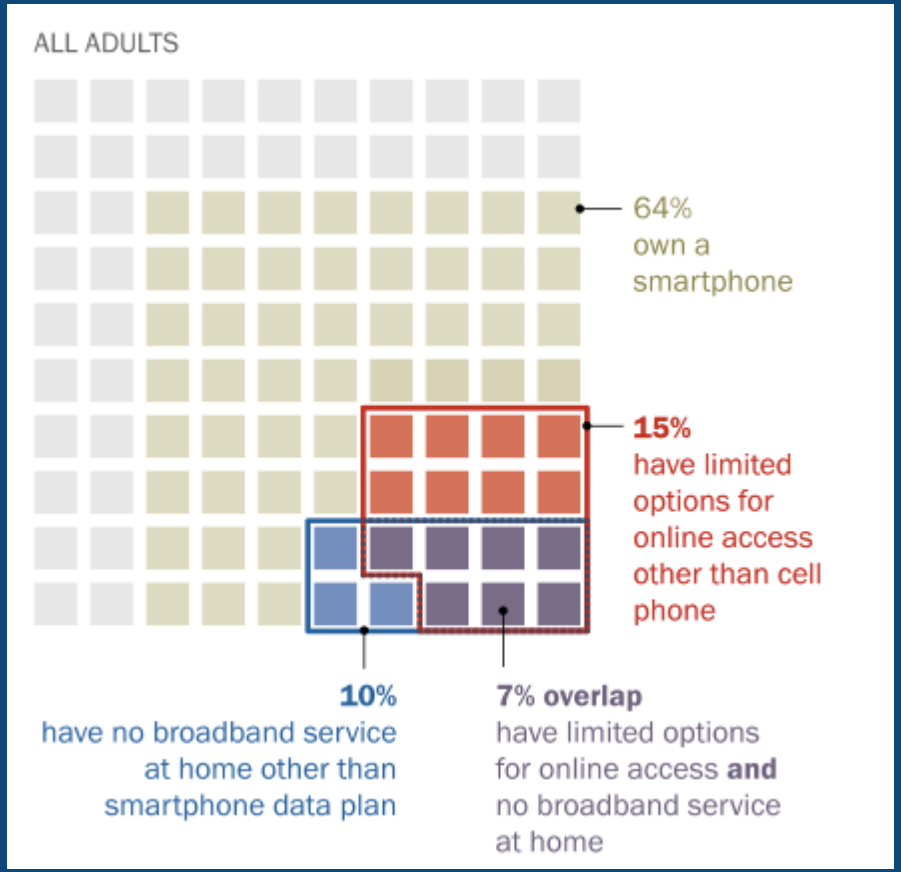
Limitations

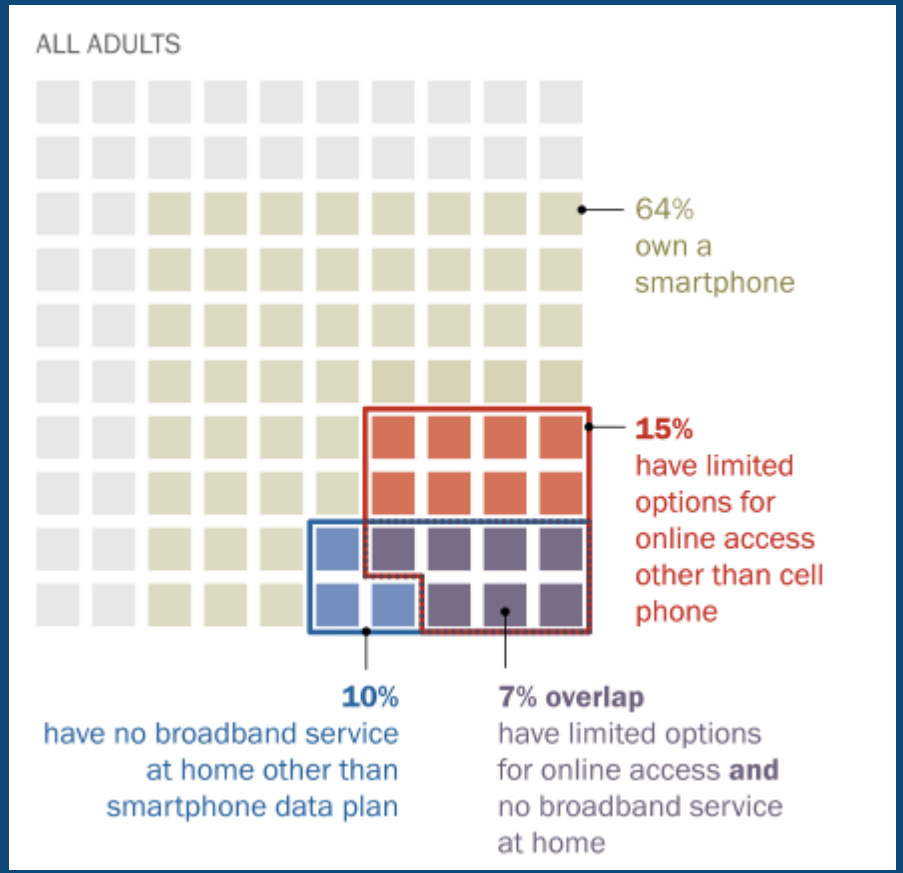
- User interface ill suited for some key activities
- Download/upload can be hindered by speed
- Data usage caps discourage online exploration

ASSUMPTIONS: SMARTPHONES



Source: Pew Research Center American Trends Panel survey, October 3-27 2014.
http://pewrsr.ch/1KjjQ25

ASSUMPTIONS: SMARTPHONES



Who is most impacted?

- Young adults
- Low household income
- Low levels of educational attainment
- Non-whites

Source: Pew Research Center American Trends Panel survey, October 3-27 2014.
http://pewrsr.ch/1KjjQ25

ASSUMPTIONS: SMARTPHONES

Civic, Economic, and Educational Activities	Less Connected	Home Broadband	Difference
Use Internet to visit local, state, or federal government website	57%	79%	-22%
Use Internet to get information from a government agency on health/safety	35%	54%	-19%
Use Internet to get information or apply for job	45%	60%	-15%
Use Internet to take a class for credit toward a degree	12%	24%	-12%
Use Internet for online banking	35%	70%	-35%
Use Internet to get local or community news	55%	80%	-25%
Use Internet to get national or international news	52%	77%	-25%

Note: Reported frequencies are weighted. Sample based on the 3,477 respondents who use the Internet. 2009 Federal Communications Commission (FCC) Survey of 5,000 respondents nationwide. Less connected = dial up Internet or no Internet at home, including individuals with mobile access only.
Source: Mossberger, K., Tolbert, C., & Franko, W. (2013). Mobile Access and the Less-Connected. In *Digital Cities: The Internet and the Geography of Opportunity* (p. 74). New York, NY: Oxford University Press.

ASSUMPTIONS: PUBLIC LIBRARIES

Opportunities

- Free
- Training and assistance
- Locations across city
- 44% of households below poverty line report using computers or the Internet at a public library
- Youth and minorities are among most frequent public access users

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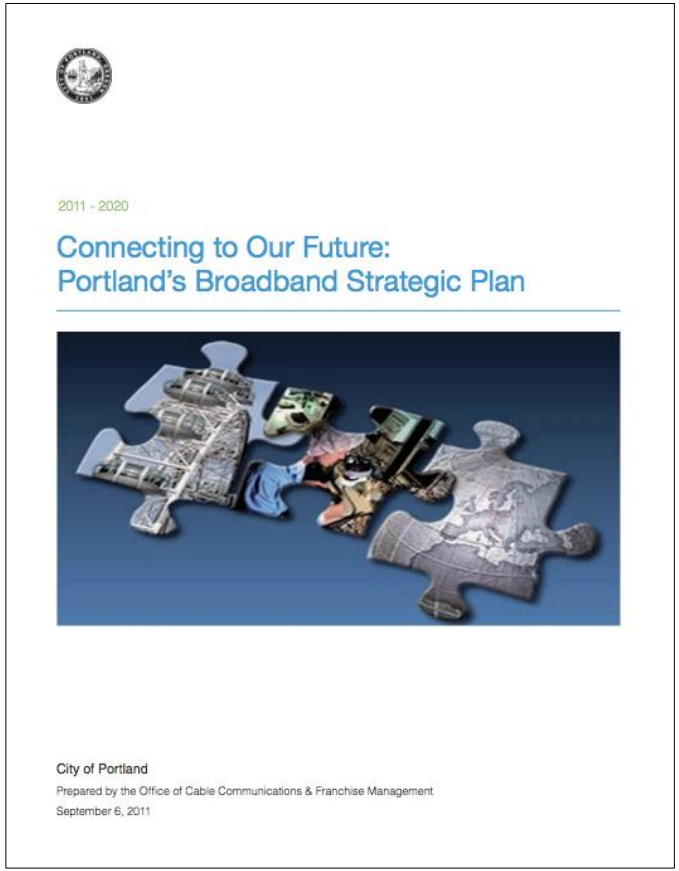
Limitations

- Hours of business
- Staff capacity
- Wait time
- Duration of time slot

MODEL: PORTLAND, OR



2011 - 2020

Connecting to Our Future:
Portland's Broadband Strategic Plan

City of Portland

Prepared by the Office of Cable Communications & Franchise Management

September 6, 2011

Connecting to Our Future

- Connected the broadband planning process to other major citywide goals
- Currently using as basis for creation of a digital inclusion plan

MODEL: CHICAGO, IL

Chicago Tech Plan

- Access and adoption understood as critical to Chicago's future in global, tech-driven economy
- Place-based orientation informed by evidence from Smart Communities BTOP-funded pilot
- Goal of increasing options for low-cost broadband

CONCLUSION

Two Major Conclusions:

1. Must not lose site of home broadband adoption goals

2. Need integrated approach to broadband planning

The Digital Divide In Cambridge

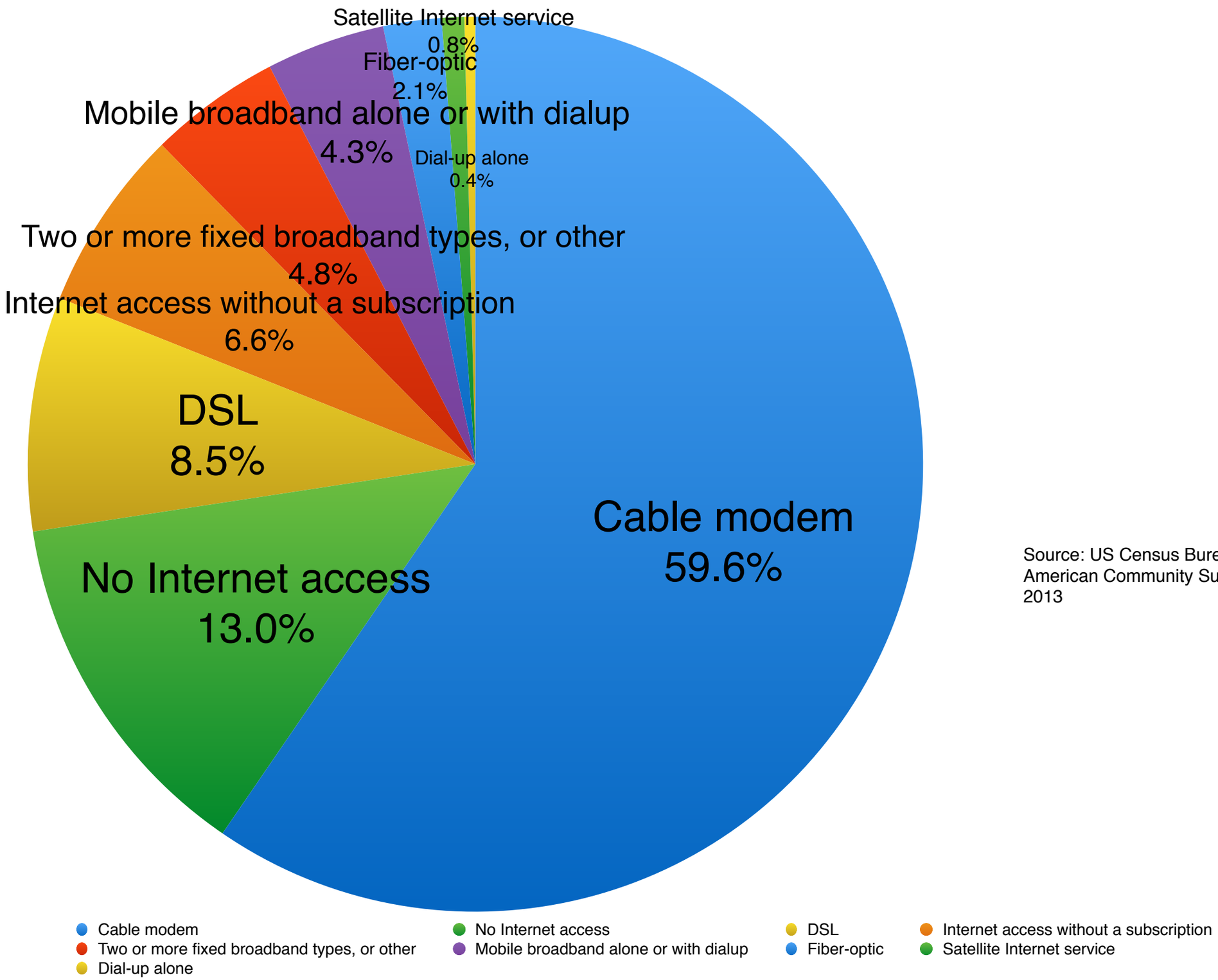
Results of the US Census 2013 American Community Survey

Saul Tannenbaum
June 17, 2015
Prepared for the Cambridge Broadband Taskforce

Limits of the Data

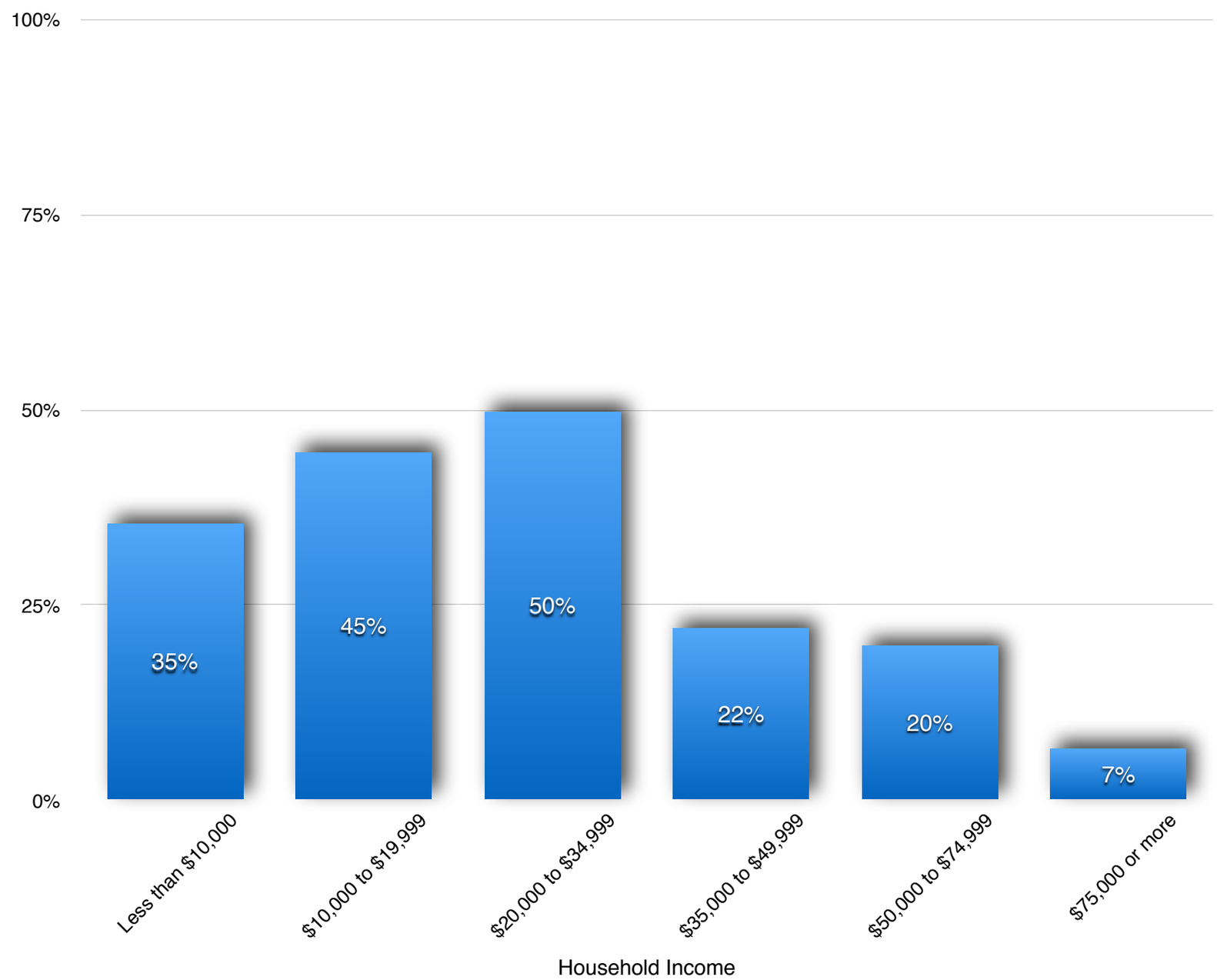
- American **Survey** Data, not door-to-door census
- First time Census Bureau has asked these questions about computer ownership and broadband
- No historical baseline
- **Lots** of margin of error

Internet Access Types

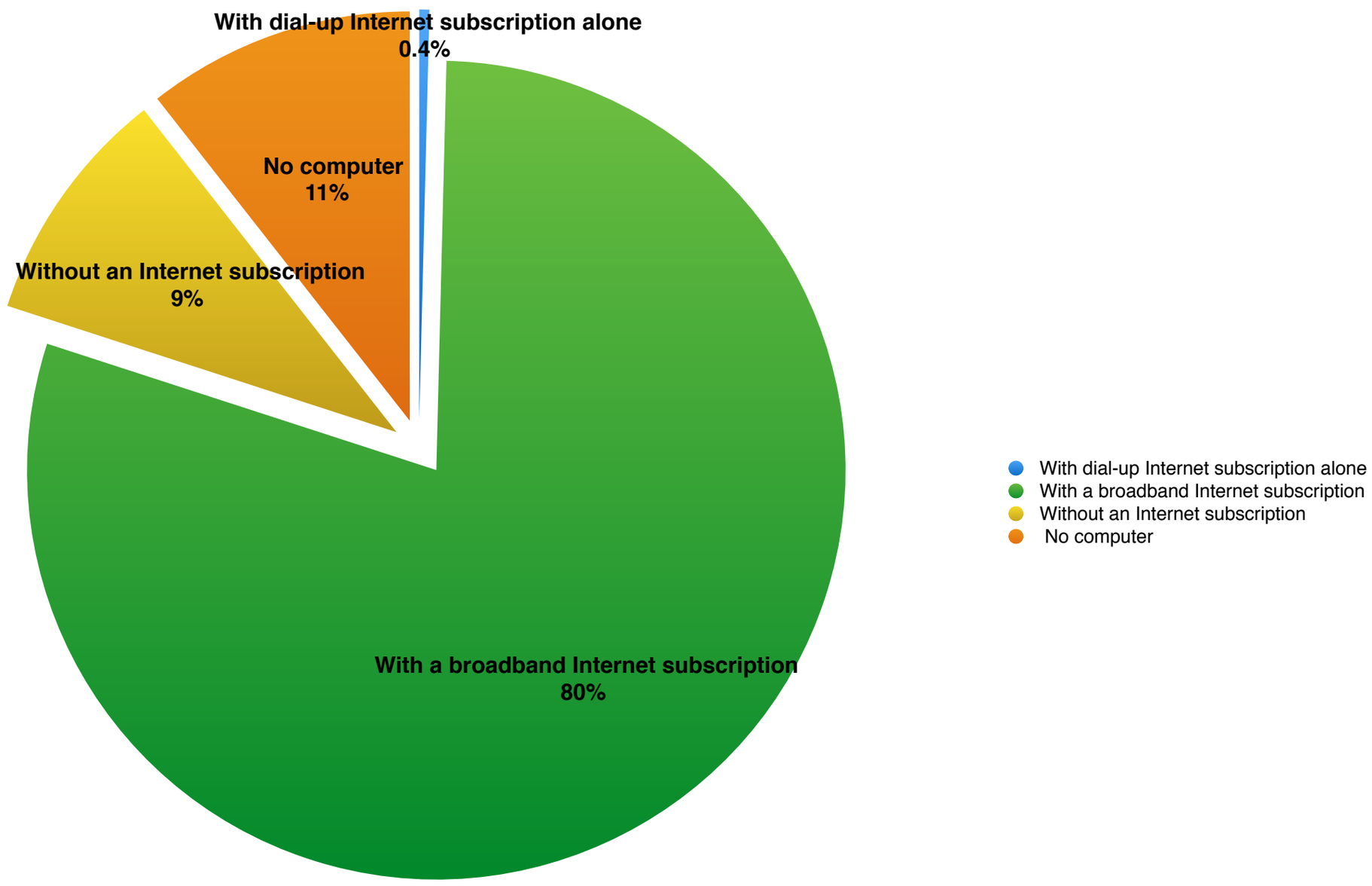


Source: US Census Bureau. American Community Survey, 2013

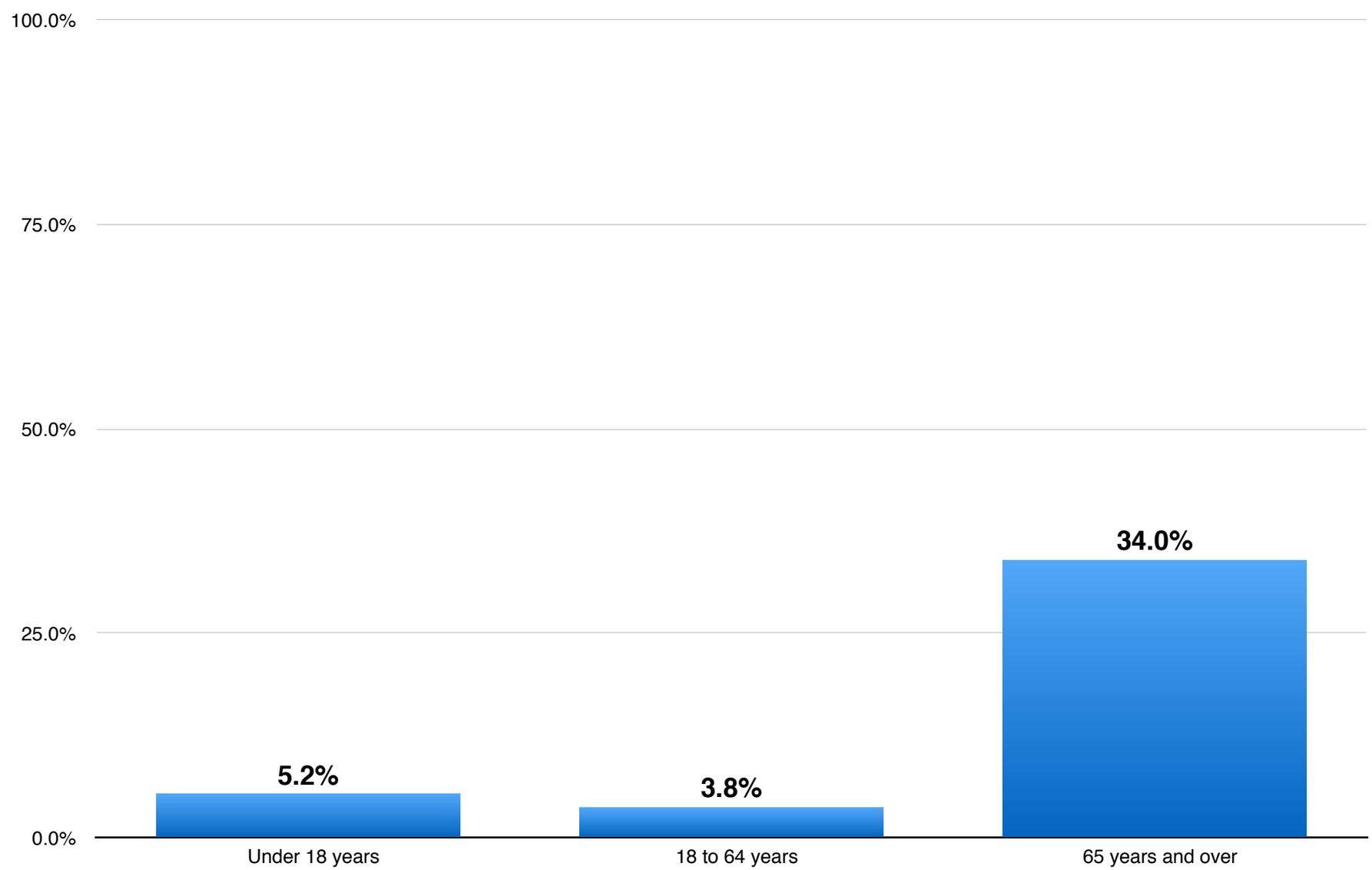
Households Without Internet Subscription, by Household Income



Household Computer Ownership



No access to computer by age



Recommended Reading

http://www.kendraalbert.com/post/81240570057/filing-for-divorce-in-ma-doing-law-school-right

I'm in a seminar called Access to Civil Justice, which is all about how difficult it is for people of low or moderate means to access the civil litigation system…

As part of this class, we have to figure out how to file for divorce. And not as Harvard Law School students. Unlike us, most folks who are filing for divorce pro se (without a lawyer) don't have access to a personal computer and an incredible research library, or an endless amount of time to putz around online.

Broadband Summit Take-aways

What I was looking for

- Examples of cities like Cambridge that have implemented or in process of implementing muni broadband
  - Urban
  - High density

What I heard

- Most examples are smaller, spread out cities
- In all or most cases those that attempted it also owned a muni electric utility
  - Mitigated financial risk
  - Revenue might be covering operation, but not cap ex
- The prices offered for Internet access were comparable to Comcast and more than Verizon
  - Albeit greater speeds offered

Rationales for Muni systems

- Create access to swaths of territory that private carriers have not serviced
- Create infrastructure to attract or keep business
- Offer access speeds greater than what carriers provided (especially those with slow flavor of DSL only or satellite)

Objectives stated by muni towns & cities	Cambridge needs
Connect unwired structures	
Attract/keep business	
Faster speed	
Lower price than private	

The Digital Divide

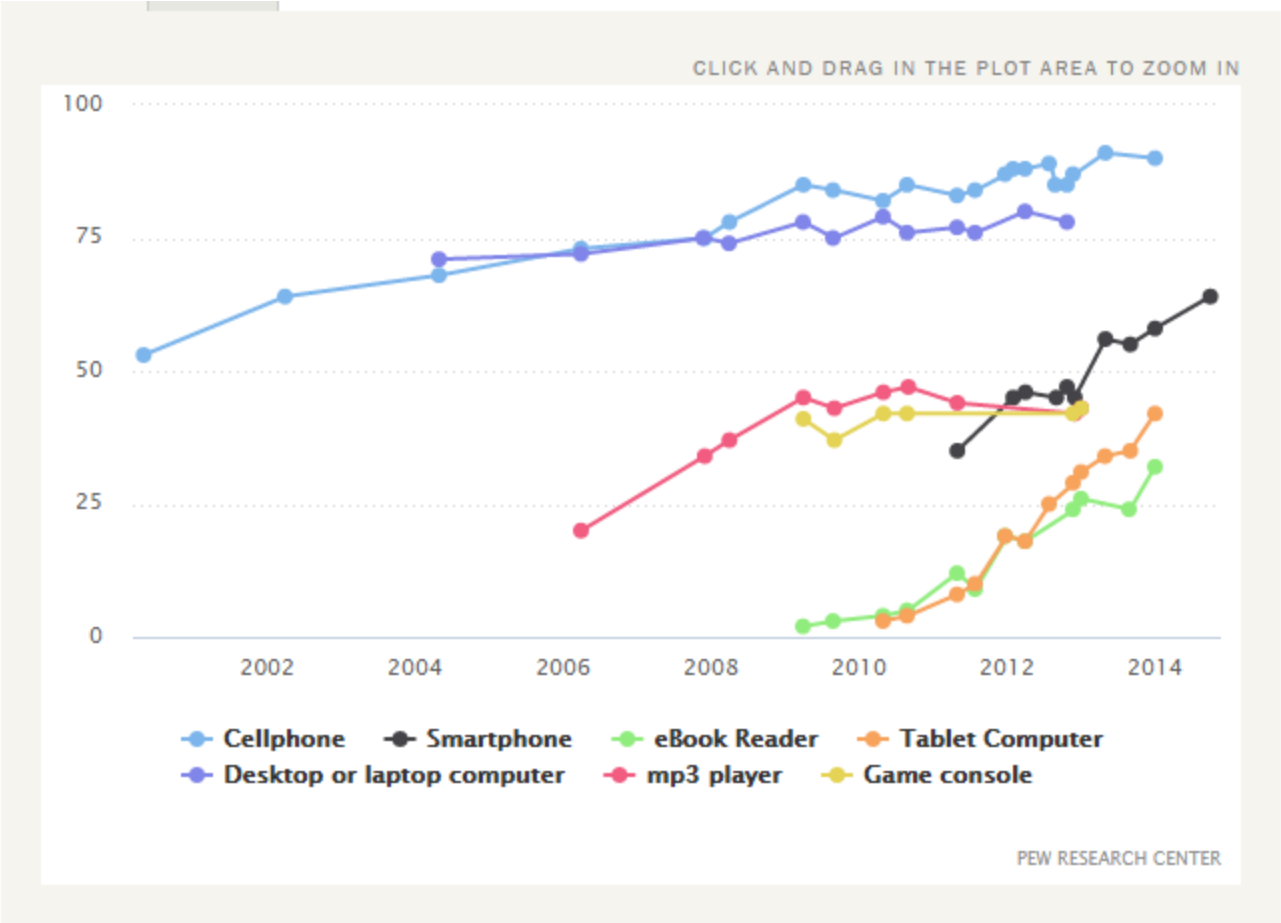
Facing a Crisis or Creating a Myth?

MIT Press 2001

Digital Divide Observations

- Historically, tech-created divides have been self correcting
  - Telephone (decades, cross subsidies helped)
  - Television (TV set in 1950--$6000)
    - Adopted universally as high value to users
    - Free content but expensive (for the time) hardware.
  - Cable/DBS—reached 87% of all households
    - Cost not a primary factor for nonsubcribers
  - PC adoption (Apple II was $4000 in 1981)
  - 1990s: Women 30% of Internet users; 2015: 50%

- Today: Smart Phones (10% in 2008, 64% today)


CLICK AND DRAG IN THE PLOT AREA TO ZOOM IN
100
75
50
25
0
2002
2004
2006
2008
2010
2012
2014
Cellphone
Smartphone
eBook Reader
Tablet Computer
Desktop or laptop computer
mp3 player
Game console
PEW RESEARCH CENTER

Issue of Measurement

- What are we measuring? What should we measure?
- What time frame?
- What is the goal and what metric to judge achievement?

Internet users in 2014

Among adults, the % who use the internet, email, or access the internet via a mobile device

		Use internet
	All adults	**87%**
	Sex	
a	Men	87
b	Women	86
	Race/ethnicity*	
a	White	85
b	African-American	81
c	Hispanic	83
	Age group	
a	18-29	97[cd]
b	30-49	93[d]
c	50-64	88[d]
d	65+	57
	Education level	
a	High school grad or less	76
b	Some college	91[a]
c	College+	97[ab]
	Household income	
a	Less than $30,000/yr	77
b	$30,000-$49,999	85
c	$50,000-$74,999	93[ab]
d	$75,000+	99[ab]
	Community type	
a	Urban	88
b	Suburban	87
c	Rural	83

Source, Pew Research Center Internet Project Survey, January 9-12, 2014. N=1,006 adults.
Note: Percentages marked with a superscript letter (e.g., [a]) indicate a statistically significant difference between that row and the row designated by that superscript letter, among categories of each demographic characteristic (e.g., age).
* The results for race/ethnicity are based off a combined sample from two weekly omnibus surveys, January 9-12 and January 23-26, 2014. The combined total n for these surveys was

Non-internet user demographics

% of all adults within each group who do not use the internet

		Do not use internet
	All adults (n=6,010)	*14%*
a	Men (n=2,733)	14
b	Women (n=3,277)	15
a	White, Non-Hispanic (n=4,223)	13
b	Black, Non-Hispanic (n=664)	20[a]
c	Hispanic (n=682)	17[a]
a	18-29 (n=945)	2
b	30-49 (n=1,590)	6a
c	50-64 (n=1,842)	17[ab]
d	65+ (n=1,526)	41[abc]
a	No high school diploma (n=454)	44[bcd]
b	High school grad (n=1,667)	22[cd]
c	Some college (n=1,627)	7[d]
d	College+ (n=2,225)	3
a	Less than $30,000/yr (n=1,682)	25[bcd]
b	$30,000-$49,999 (n=1,030)	12[cd]
c	$50,000-$74,999 (n=787)	5[d]
d	$75,000+ (n=1,644)	3
a	Urban (n=1,850)	13
b	Suburban (n=2,980)	13
c	Rural (n=1,180)	21[ab]

Pew Research Center's Internet Project survey, July 18 – September 30, 2013.
Note: Percentages marked with a superscript letter (e.g., [a]) indicate a statistically significant difference between that row and the row designated by that superscript letter, among categories of each demographic characteristic (e.g., age).

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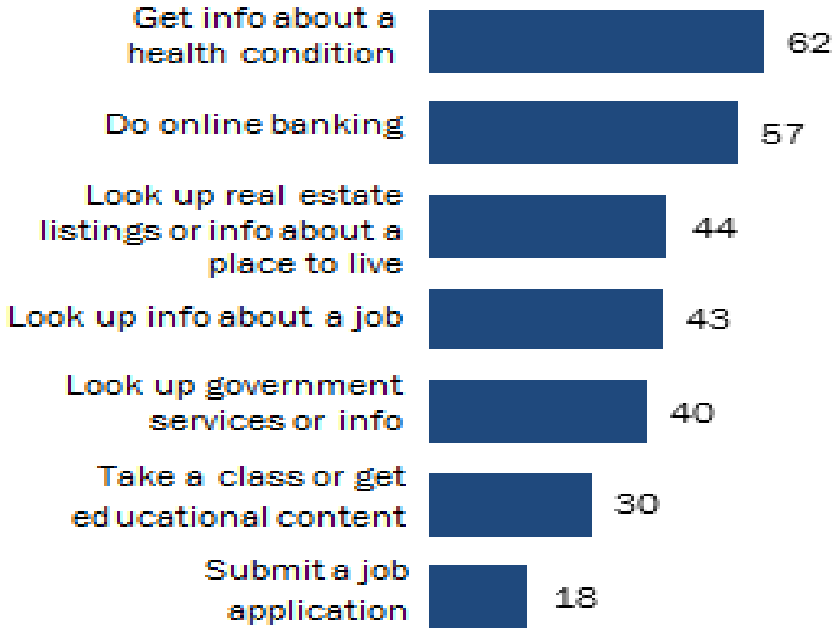
More than Half of Smartphone Owners Have Used Their Phone to get Health Information, do Online Banking

% of smartphone owners who have used their phone to do the following in the last year



Pew Research Center American Trends Panel survey, October 3-27 2014.

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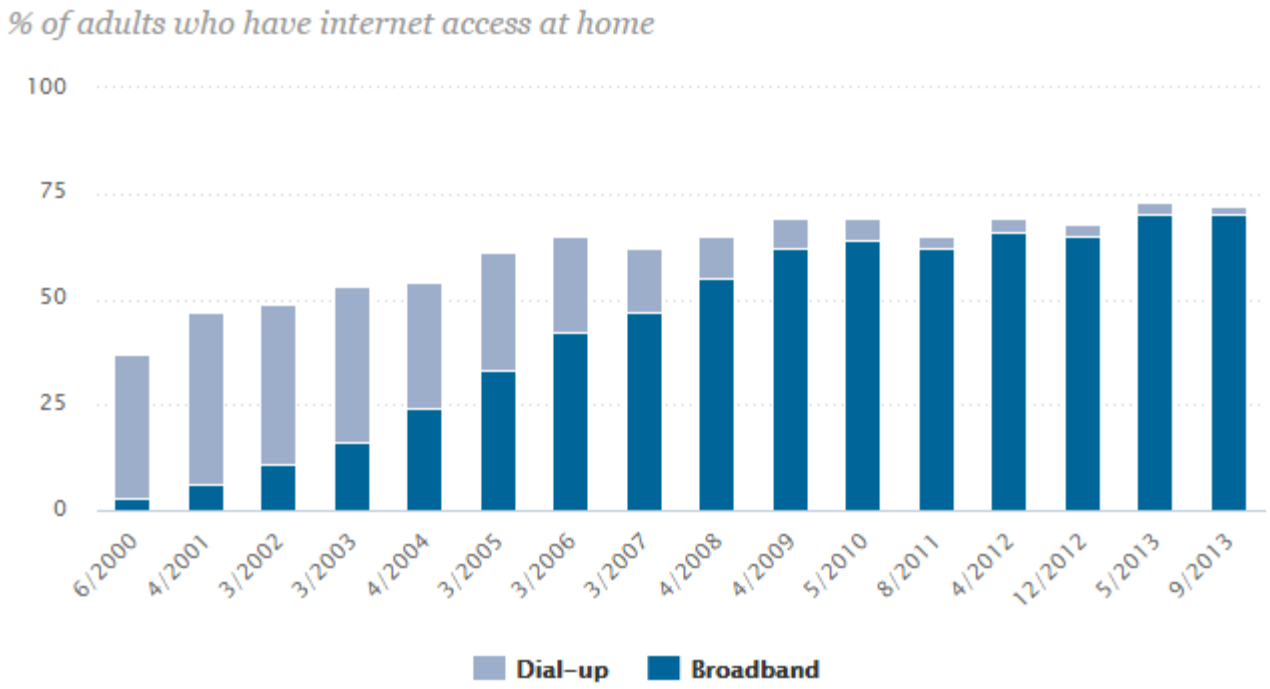
Broadband Adoption, 2000-2013



Broadband Penetration

Industry Statistics			Source
Broadband and Internet Household Penetration			
According to Census, more than 200 million Americans access the Internet via broadband at home or elsewhere.			
Broadband at Home	72.4%	October 2012	Census (Survey)
Internet Anywhere	86%	September 2013	Pew (Survey)