Cape Cod Economic Development Council

3225 Main Street, PO Box 226, Barnstable, MA 02630

Barnstable County Telecommunications and Information Technology Survey Project

Final Report on Key Findings and Planning Opportunities

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Prepared by the Interisle Consulting Group

Prepared for the

Cape Cod Economic Development Council and Communities of Barnstable County

by the Interisle Consulting Group

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Summary Overview

The Cape Cod Economic Development Council (CCEDC) initiated in April 2012 a Survey Project to gather comprehensive quantitative and qualitative information on the telecommunications and information technology systems used by all 15 municipalities of Barnstable County. The Interisle Consulting Group was contracted to gather and aggregate this information, and to report on key findings. This Report presents and interprets the findings and data collected during the Project, and serves as a companion to the survey data sets that have been delivered to CCEDC. To use a familiar metaphor, the data sets describe the "trees," while this Report describes the "forest."

Purpose and Objectives

The primary motivation for conducting this Survey was to enable effective planning in support of a *Regional Umbrella Services System (RUSS)* for Barnstable County. The RUSS is intended to support municipalities, school districts, libraries, public safety, and other public sector entities. It will leverage the *OpenCape Municipal Regional Area Network (Municipal RAN)* as a communications backbone for regional applications and improved information sharing amongst all public sector entities, as well as with constituents.

The RUSS will also utilize OpenCape resources to aggregate communications services on a regional basis to improve service qualities and lower costs. This includes improving overall resilience and survivability of vital communications throughout the region and with the rest of the Commonwealth and the World at large. To achieve sufficient resilience, OpenCape will leverage both fiber optic communications and microwave radios located at strategic high sites.

The RUSS is supported by a *Regional Computing Center (RCC)* located at the County Complex in Barnstable. This facility will provide high quality data center resources that will be well connected into both OpenCape fiber and microwave systems. Similarly, the RUSS will leverage the *Strategic Information Office (SIO)* that is based out of the same RCC facility. Today, the SIO provides GIS services and maintains important regional databases for the County. It is anticipated that the SIO will expand services offered to public sector entities throughout the Cape. Collectively, the RUSS, OpenCape, the RCC, and the SIO provide a unique suite of capabilities and resources that have the potential to transform use of communications and information systems by all public sector entities while enabling new applications to serve public interests.

In conducting this Survey of communications and information technology systems, valuable data has been assembled to facilitate transformational planning on a regional basis. This information should be useful to individual towns or school systems as they develop their own plans informed by experience from peer entities. Similarly, small regional collaborative efforts between two or more public sector players should be easier to plan and coordinate with the information and insights gained from this Survey. At the County level, it is now possible to develop plans based on in-depth understanding of the systems, resources, and capabilities of most public sector entities on the Cape.

While this Survey focused on the 15 municipalities located on Cape Cod proper, the OpenCape Municipal RAN extends to the islands comprising Dukes County and Nantucket County. It is intended that this Report should benefit these two Counties in addition to Barnstable County, as collectively, the Cape and Islands reflect a shared heritage and stewardship for an environmental treasure of global importance.

Directions for Using this Report

This Report is intended to serve a broad and diverse audience. At the same time, it necessarily covers a lot of topics, some of which might even be considered esoteric or arcane. The authors have approached this Survey of communications and information systems as directly analogous to a survey of a complex ecosystem, where each element has its own role, and depends on many other system elements in fulfilling its role. In order to appreciate the importance of any of the survey data, it is necessary to understand how the data relates to the larger ecosystem. Therefore, this Report begins with a Field Guide to the communications and information systems utilized by public sector entities on the Cape. Readers who have a good understanding of these communications and information systems may find that the Field Guide need only be skimmed. However, some important observations are included in the Field Guide, so it should not be skipped entirely.

In order to distinguish the forest from the trees, the next section of the Report provides a Summary and Interpretation of Survey Findings. Data is aggregated and interpreted within the overall context. Various tables and charts provide high level overviews of data that, in many cases, is dense. Some of the data captured was inconsistent or incomplete. In these cases, this section of the Report attempts to fill in some of the details and complete the overall picture.

Ultimately, the *raison d'être* for communications and information systems is to support the *applications* that empower people to provide and interpret information, and to communicate with others. The Report section on Applications and Services Used by Communities provides an overview of data gathered about major applications used on the Cape along with some relevant interpretations of this data.

The final section of the Report presents a discussion of Planning Opportunities that the communities of Barnstable County might consider pursuing. These planning opportunities are mapped to some of the information and insights gathered by this Survey, and also propose ways for the County to continuously capture and maintain information that will prove useful to future planning initiatives.

Feedback and suggestions are appreciated, and can be provided to the CCEDC using the contact info on the back cover sheet.

Acknowledgements

The authors have greatly appreciated this opportunity to become better acquainted with the communities of Cape Cod, and to learn first hand how communications and information systems are being used to effectively serve the citizens and businesses residing on the Cape, as well as the many annual visitors. We especially appreciate the time granted to us by Town Managers/Administrators, IT/MIS directors, School Superintendents and Principals, School Technology Directors, Police and Fire Chiefs, Public Safety Technology Coordinators, and the many other Department Heads and knowledgable staff who shared their insights and experiences with us, and answered our many questions about their systems. These conversations proved to be invaluable to this Survey, and we hope everyone's collective input is well reflected in this Report.

We also appreciate the guidance provided by members of the CCEDC, especially Felicia Penn, whose commitment to this initiative has been a source of encouragement. We also benefitted from insights and feedback provided by the Cape Cod Commission, especially Paul Niedzwiecki, Kristy Senatori, and Anne Reynolds. The County IT Department provided technical support to this project, and also helped us get the lay of the land as well as with some introductions to key players. Of particular note, we relied extensively on Taree McIntyre, who wore several hats in helping shepherd us through various aspects of conducting this project. Her responsiveness to our requests and constant good cheer has been much appreciated.

The Interisle Consulting Group would also like to acknowledge the members of our team, including our associates Ron Orazine and The Skyline Group headed by John Higgins. Both associates contributed substantially to the over 200 on-site surveys conducted as part of this Project, as well as their domain expertise to interpret the data collected. Interisle Partners, Fred Goldstein and Colin Strutt, contributed very substantial effort to organizing, aggregating, and refining the survey data, as well as to major sections of this Report. This has been a true team effort.

Chuck Wade
Interisle Consulting Group

Field Guide

This survey of communications and information technologies for the communities of Barnstable County has covered a lot of ground, and addresses a complex mix of systems issues covering a diverse set of local institutions. Since not every reader of this report will be familiar with all of the topics covered, or terminology used, this section has been included as a "Field Guide" to *geography, terrain, flora, and fauna* of the Cape with respect to communications and information systems.

While this is intended to be a reader-optional section of the report, it is still recommended that this material at least be skimmed prior to diving into the presentations of quantitative and qualitative information. This Field Guide is also intended to clarify some matters of interpretation, so that the reader can better understand how the survey team has chosen to represent certain information or judgment calls for how to classify some of the data.

Lay of the Land

Barnstable County defines itself as the "Regional Government of Cape Cod Massachusetts." It encompasses the entirety of Cape Cod, from Bourne to Provincetown, but not the major islands of Nantucket and Martha's Vineyard (Dukes County), which are separate counties. It is one of five Counties in Massachusetts that still acts in the capacity of a regional government (Dukes County and Nantucket County are also active local governments). The County seat is in the Village of Barnstable, where the Superior Court and First District Court are also located.

In all, Barnstable County comprises 15 distinct municipalities, with 14 organized as town governments, plus the Town of Barnstable, which is organized as a city with a council-manager form of government.

Cape Cod was one of the first regions settled by Europeans, and it has a rich history involving Native Americans and European settlers. The entire region is popular with tourists and seasonal residents that enjoy the pleasant seacoast summers of the Cape. Consequently, the population levels fluctuate considerably between winter and summer, at least doubling in the summer, which causes municipal employment to fluctuate as well.

In addition to the 15 towns, there are also distinct school districts, regional schools, water districts, and, within the Town of Barnstable, five autonomous fire districts. For the most part, there is a fair degree of autonomy for schools and water/fire districts. There is also the Barnstable Sheriff's Office that provides a variety of public safety related services to the County, but is now a State-level office.

Towns have overall jurisdictional authority, and focus on providing services to citizens and businesses, protecting public safety, stewardship of the environment, maintaining roads and other municipal infrastructure, and waste management. Towns are also responsible for overall administration, including finances, assessing, tax collections, legal, human resources, and information technology.

Table 1—The 15 towns of Barnstable County with 2010 populations and land area

Barnstable *population: 45,193* *land area: 60.0 sq mi*	**Eastham** *population: 4,956* *land area: 14.0 sq mi*	**Provincetown** *population: 2,942* *land area: 9.7 sq mi*
Bourne *population: 19,754* *land area: 40.9 sq mi*	**Falmouth** *population: 31,531* *land area: 44.2 sq mi*	**Sandwich** *population: 20,675* *land area: 43.0 sq mi*
Brewster *population: 9,820* *land area: 23.0 sq mi*	**Harwich** *population: 12,243* *land area: 21.0 sq mi*	**Truro** *population: 2,003* *land area: 21.1 sq mi*
Chatham *population: 6,125* *land area: 16.2 sq mi*	**Mashpee** *population: 14,006* *land area: 23.5 sq mi*	**Wellfleet** *population: 2,750* *land area: 19.8 sq mi*
Dennis *population: 14,207* *land area: 20.6 sq mi*	**Orleans** *population: 5,890* *land area: 14.2 sq mi*	**Yarmouth** *population: 23,793* *land area: 24.3 sq mi*

Schools are either organized as distinct departments or districts within a town, or as regional districts spanning two or more towns.

There are also two regional technical high schools and two independent charter schools. A complete list is provided in Table 2.

Schools represent the largest slice of the budget pie in every municipality, and they represent the largest base of local government employees. Their buildings also represent some of the largest investments made by the towns and their taxpayers. At the same time, the quality of schools is of great importance to towns, and contributes to the overall health of the community, community identity, and desirability of towns as places to live.

Table 2—List of town and regional school systems

Town School Districts or Departments	
Barnstable	Sandwich
Bourne	Provincetown
Falmouth	Truro (elementary only)
Mashpee	
Regional School Districts	
Dennis-Yarmouth Regional School District Dennis and Yarmouth	
Nauset Public Schools Brewster, Eastham, Orleans, Wellfleet	
Monomoy Regional School District Chatham and Harwich (formed 1-July-2012)	
Regional Technical Schools	
Cape Cod Regional Technical High School—located in Harwich	
Upper Cape Cod Regional Technical School—located in Bourne	
Independent Charter Schools	
Cape Cod Lighthouse Charter School—located in Harwich	
Sturgis Charter Public School—located in Barnstable (Hyannis)	

Regionalization of schools has been driven by shifting demographics in some communities, and budget pressures that have motivated pursuit of economies of scale, particularly for high schools and middles schools. Elementary schools have tended to remain smaller and more local throughout the Cape.

The County is also home to two regional technical high schools, and two well-regarded independent charter schools. The two technical schools and the Sturgis Charter School serve grades 9 – 12, while the Cape Cod Lighthouse Charter School is a middle school serving grades 6–8. Provincetown has the smallest school system in the County, with nearly all students now located within one building, and Barnstable has the largest school system. There is a lot of variability between these extremes.

The region's water systems (departments, divisions, districts) have stewardship over what is arguably the Cape's most precious natural resource—fresh water. In several towns, the management of water systems has been structured according to the "enterprise" model, where the water district collects revenue from users and manages the assets of the water system much like a business would. Table 3 provides a complete listing of water systems operating on the Cape.

The Commonwealth of Massachusetts provides various services on the Cape, including Courts, the State Police, Correctional Facilities (managed by the Barnstable County Sheriff's Office), MassDOT Highways, Health, Environment, and State Parks, to list the most visible agencies and departments. State academic institutions located on the Cape include the Massachusetts Maritime Academy in Bourne and the Cape Cod Community College in Barnstable. Towns, Schools, and Water Systems all interface into Commonwealth Secretariats that provide both funding and oversight of local programs.

At the Federal level, the Cape is home to the Massachusetts Military Reservation, comprising Otis Air Force Base and Camp Edwards. The National Park Service oversees the National Seashore comprising 40 miles of shoreline and 43,500 acres of land along the Lower Cape. The Towns of Eastham, Wellfleet, Truro and Provincetown have large tracts that belong to the National Seashore, with 72% of Provincetown's land contained within the Seashore boundaries. The

Coast Guard is another example of a Federal service that serves an important role in the coastal communities on the Cape.

Table 3—Water Districts, Divisions, and Departments within Barnstable County

Town	Water System
Barnstable	Hyannis Water Division Barnstable Fire District Centerville-Osterville-Marstons Mills Water Dept. Cotuit Water Department
Bourne	Bourne Water District Buzzards Bay Water District North Sagamore Otis Air National Guard Base Water
Brewster	Brewster Water Department
Chatham	Chatham Water Department
Dennis	Dennis Water District
Falmouth	Falmouth Water Department
Harwich	Harwich Water Department
Mashpee	Mashpee Water District
Orleans	Orleans Water Department
Provincetown	Provincetown Water Department (extends into North Truro)
Sandwich	Sandwich Water District
Yarmouth	Yarmouth Water Department

Barnstable County is also home to the Woods Hole Oceanographic Institution (WHOI), a private research facility that is the world's largest non-profit oceanographic research institution, and known for its extensive research in oceans everywhere. It is also one of the largest employers in the region.

While all of the above entities play important roles within Barnstable County, this survey limited its scope primarily to the municipalities and schools plus the County, with some attention given to water districts and the Sheriff's Office.

The approaches taken to managing and utilizing communications and information technologies within the County vary according to the type of local government institution. The towns themselves have essential dependencies on communications and IT, and for several town departments, IT is mission critical. Schools are also reliant on IT, both for administration and educational programs. Water systems require IT for administration and real-time management and operation of their infrastructure. While there is some overlap between these different entities in the area of administration and finance, each has unique needs that require different approaches.

Policy regimes

One way to understand the differing requirements for communications and IT between towns, schools, and water systems is to consider the unique policy regimes that apply to each. For example, water systems operate large distributed systems that include wells, pumping stations, storage facilities, and water quality monitoring. Automation is essential to continuous operation of their infrastructures, both from an efficiency perspective and the ability to coordinate the operational behavior of all aspects of the water system. There is increasing concern about the integrity and security of automated control systems of all types (often referred to as "SCADA"[1] systems) due to the potential for severe consequences if these systems fail. This concern applies to water systems and has come to define the policies governing IT and automation practices.

Schools have very different policies that relate directly to their use of communications and information systems. IT is required to track, not just student performance, but also teacher and school performance. The Commonwealth now requires regular reporting on many metrics relating to overall performance. In addition, schools must maintain *student information systems* that build comprehensive histories of the entire educational experience of every student. Increasingly, schools are seeking to better engage parents in the education of their children, and this has driven new requirements for communications and information sharing. In all of these initiatives, schools are faced with the challenge of protecting student privacy, while meeting the reporting mandates from the Commonwealth and sharing student information with parents.

Schools are also leveraging communications and information technologies in the classroom and in other educational contexts. Access to the Internet is now essential for all curricula, and there are a variety of applications that support educational activities or exercises. Many schools are looking to transition away from paper books to electronic texts that can be regularly updated, and even present dynamic context. In this environment, schools must also deal with restricting student access to appropriate Internet content, while also dealing with complex issues associated with digital rights management.

The towns themselves have the most complex sets of policies, and they must comply with a policy guidelines and mandates from various sources. A summary of relevant policy regimes includes:

- Open meeting laws, Freedom of Information (FOI) requirements
- Audit practices relating to finance and accounting
- Payment processing, potentially PCI DSS[2]
- Tax reporting requirements
- Assessing and appraising standards
- Councils on Aging certifications
- Libraries, patron privacy and digital rights management
- Law enforcement, especially FBI Criminal Justice Information Systems (CJIS) requirements
- Emergency medical services (EMS) and Health Departments, which come under HIPAA[3] guidance

Some of these policies apply to specific departments, such as Assessor's Offices, Police Departments (FBI CJIS), or Fire and Rescue Departments (HIPAA for emergency patient care). This may, in turn, result in some intentional isolation of systems. For example, every police department has its own servers for records management applications, in part to assure compliance with FBI CJIS guidelines, but also to meet stringent requirements for system availability.

It is worth emphasizing that this diversity of policy regimes creates unique challenges for IT professionals working for town governments. It would be rare for their peers in industry to have to deal with such policy diversity. This is less of a challenge for IT professionals working for schools or water systems where policies tend to be less diverse. What is particularly challenging for town IT professionals is balancing the needs for openness and transparency in government with stringent requirements to protect individual privacy, and some sensitive information.

Sites of Interest

One of the important objectives for this survey was to identify those sites of interest from a communications or information technology perspective. The types of sites that were considered for inclusion included:

- Facilities where people use information technologies and communications services in order to perform their work or carry out their duties—*e.g.,* office buildings, schools, police and fire stations, DPW facilities
- Community centers where citizens congregate or come to access information resources or community services—*e.g.,* libraries, senior centers, youth centers, visitor information centers
- Recreation facilities, including golf courses, beaches (and beach parking), marinas, sports venues, and parks
- Transportation hubs, such as airports or ferry terminals
- Structures that can play some role in the deployment of communications systems—*e.g.,* radio antenna towers, water towers as microwave radio platforms, other "high sites," network interconnect sites

Our team developed an initial site list by scanning information available from town and school web sites, and other public sources.

Obvious sites included town halls and offices, public safety facilities, schools, community centers of all types, libraries, recreational facilities, transportation centers, and various miscellaneous sites that appeared relevant. As we met with people from each community, we confirmed our list of sites for that community and solicited input on other sites, and the state of sites. We learned that some sites were being decommissioned, and we found out about new sites, or sites where the role or purpose had changed in a significant way.

If a town deems a site significant enough to extend their town data or voice network to that site, then it should be treated as a site of interest, and all such sites were added to our list. This is equally true for County facilities and the Sheriff's Office. We also checked our list against the list of sites being connected to OpenCape, and included all of the OpenCape sites in our list, with the exception of telco central offices and sites outside the County's borders.

In order to constrain the scope of this survey, we did not include Commonwealth facilities, nor did we include any Federal facilities. This is not to say that such facilities are unimportant from a regional planning perspective—they do have considerable relevance—but merely that this project was focused on the sites and facilities owned by the municipal or County entities that exist on the Cape.

There are some challenges in defining a site, and placing it on a map. Geographical search tools are notoriously error prone when it comes to mapping addresses to actual sites. Consequently, we asked town or school representatives to confirm site latitude and longitude (lat/long) coordinates based on satellite map images. We also sought assistance in identifying the most relevant building at a site with multiple buildings. For example, many DPW facilities consist of multiple buildings or sheds, but typically there is one building that serves as the office or location where communications gear and IT systems are located, and we have attempted to provide coordinates to those buildings.

Another complicating factor is that some sites or buildings have multiple roles that sometimes result in treating a single physical location as multiple sites. One example is when there is a radio tower at a site that may, or may not, be used by the organization(s) that occupy the site. Another example is when two or more distinctly different organizations/departments reside within the same building, but where there is some physical isolation between the tenants, and each has its own communications and IT facilities. An example of this situation is the Eddy Elementary School in Brewster. This School is part of both the Town and the Nauset Public School District. In addition, the Brewster Recreation Department is located in this same building, but in an isolated section and with their own network connections and IT systems. In this case, we've elected to treat this one building as two sites. Similarly, we treat the microwave sites that OpenCape will be using as distinct sites, so that planners can easily select just these "tower" sites.

It is also worth noting that there are instances where municipal buildings are not currently in use, but might still have network connections into a Town network, or even provide network interconnection to other sites.

In some instances, commercial properties are rented for municipal or County offices or other purposes (*e.g.,* roof rights for placing microwave or public safety radios). These are treated in this survey as municipal or County sites, even though owned by a commercial enterprise or private individual. An example is the Human Services office for Falmouth that is located in a commercial building adjacent to Town Hall. There are also instances of municipal/County sites that are located on Federally-owned land or at Federal facilities, such as might be the case with the Massachusetts Military Reservation (MMR, a.k.a., Otis AFB) or the National Seashore.

Conversely, there are also examples of commercial operations utilizing municipal-owned facilities. This is common with airports, town wharfs/piers, ferry terminals, and certain recreational facilities, such as golf courses. As another example, both of the Regional Technical High Schools have commercial operations that share their buildings and facilities. In some towns, not-for-profit organizations, such as the local Chamber of Commerce, may reside within a municipal-owned facility. Because these non-governmental uses of sites tend to have their own communications and IT systems, we have not included these as separate sites, and we have not tracked such uses. However, there are examples where the site contact might be someone who works for a commercial operation, and is not a municipal employee.

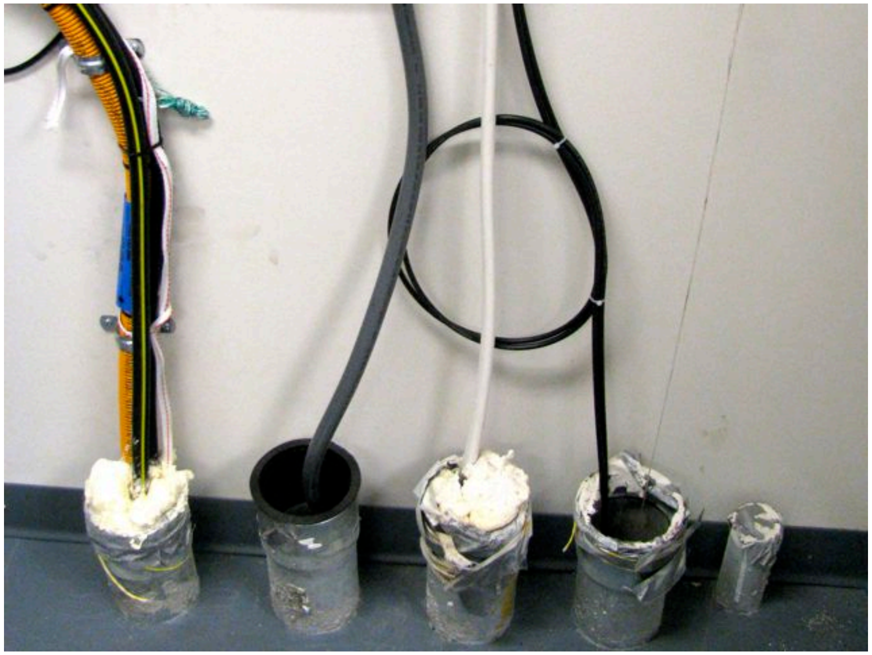

Figure 1—Example of conduits bringing communications and electrical connections into a building. The conduit on the left is bringing in both Comcast cable and fiber. The gray cable in the next conduit is used for electrical connections while the white cable from the third conduit brings in copper phone circuits. The black cables coming from the conduit on the right are town-provided and used to connect to an adjacent building.

Connections to Sites

Each site of interest fits within a larger ecosystem that includes connections of various types, including traditional telephone services, cable TV and Internet, fiber-optic connections, and wireless radio links, but also including electrical power, water, sewer, and natural gas connections.

For each type of connection, there are "rights of way" issues that relate to the specific site and the land it resides on, but also on the abutting streets and other rights of way. Rights of way are often shared by multiple providers, such as pole rights on streets that are utilized by electrical power and multiple communications providers, including the incumbent telco (Verizon), cable (Comcast), and fiber optics lines, that might be provided by Verizon, Comcast, OpenCape, or even the Town itself. In most cases, Towns have some pole rights related to fire alarm signaling that might be usable for other communications purposes, such as municipal fiber.

Figure 2—The same conduits shown in Figure 1 run to the base of this pole on the street that feeds power and communications into the building. The conduit on the right is passing town-owned cable to another conduit that goes across the street to an annex building.

While rights of way would seem to be governed by the local municipality, there are many jurisdictional and ownership complications, as well as overlapping governing agencies. The Commonwealth is often a player; especially where State highways and bridges are concerned, and the Federal government owns large tracts of land on the Cape that overlap multiple municipal boundaries. All of these issues are of interest to anyone involved in planning for regional communications infrastructure, but most are outside of the scope of this survey.

What this survey has attempted to do is capture information about some of the established communications service providers that connect to each site, as well as information about how these connections are established. For instance, does Verizon connect to a building via underground conduit from the street, or via an aerial connection directly from a pole on the street? Similar information was also captured for Comcast cable and electrical power feeds. Also, what types of connections are provided, such as copper wire, coaxial cable, fiber, or even wireless? To the extent feasible, our survey teams also attempted to capture information about the utility poles used to feed connections to sites, which might be different for each provider, though it is typical for a single pole to feed electrical and all communications services to a building.

There are also examples where sites have their own private copper or fiber communications to other sites, and this might include private conduit between buildings as well. This is typically to connect sites that are adjacent to each other. However, Harwich and Barnstable have deployed fiber optic communications between non-adjacent sites. Barnstable's new fiber-optic network (BFON) is quite extensive and reaches most sites within the Town using the same poles as the electrical and communications providers. Harwich's private fiber network is unique in that it leverages town-provided conduit that runs underground through streets to interconnect multiple sites. Some towns are also planning to acquire laterals off OpenCape's fiber-optic network to create their own municipal networks.

Figure 3—Electrical and communications utility feeds from the same pole as shown in Figure 2.

Another way that municipal-controlled networks have emerged in recent years is through negotiations with cable companies (now all Comcast properties) to deploy fiber-based *I-NETs* that allow communications between many municipal sites on the Comcast fiber-optic backbone. The towns of Chatham, Dennis, Yarmouth, and Sandwich have such I-NET arrangements. For each I–NET, the town has a central facility that has point-to-point fiber connections to the other sites on the I-NET. While I-NETs provide considerable control to Towns, the fiber remains the property of Comcast, and may be subject to future negotiations for continued use. Comcast has also taken the position that they will not offer such arrangements to communities in the future. The section on Town Networks will provide further details on I-NETs used on the Cape.

The towns of Barnstable, Bourne, Falmouth, and Mashpee have deployed microwave links to interconnect sites utilizing their own equipment and "high" sites. In these cases, the communications arrives at the site wirelessly via a small microwave radio that is typically located on the roof or an antenna mast. Data speeds can range from under 10 Mbps to over 100 Mbps. While not as fast as the 1 to 10 Gbps speeds that can be easily achieved with fiber, such radio networks have worked well, and are capable of supporting voice and data services, as well as some video. In the section on Town Networks, these wireless networks will be described in greater detail.

Figure 4—A simple example of a microwave radio link placed outside a window aiming at a nearby water tower where there is a companion radio that extends communications throughout the Town.

In addition to capturing information about how sites connect to traditional communications services providers and electrical utilities, our survey has also detailed which sites are connected to municipal-owned networks, or municipal-controlled networks in the case of I-NETs. In some cases, a site will be connected to more than one such network. For example, Barnstable will maintain its existing wireless network as a backup to the new BFON fiber being deployed.

We also attempted to note which sites have natural gas connections, simply because this makes it more feasible to deploy a local generator that can run for prolonged periods with less environmental exposure and for less fuel cost. Electricity is, of course, essential to all communications and IT systems, and the resilience of communications/IT is directly related to the ability to maintain electrical power in the event of a regional or local outage. We also noted which sites currently have generators installed.

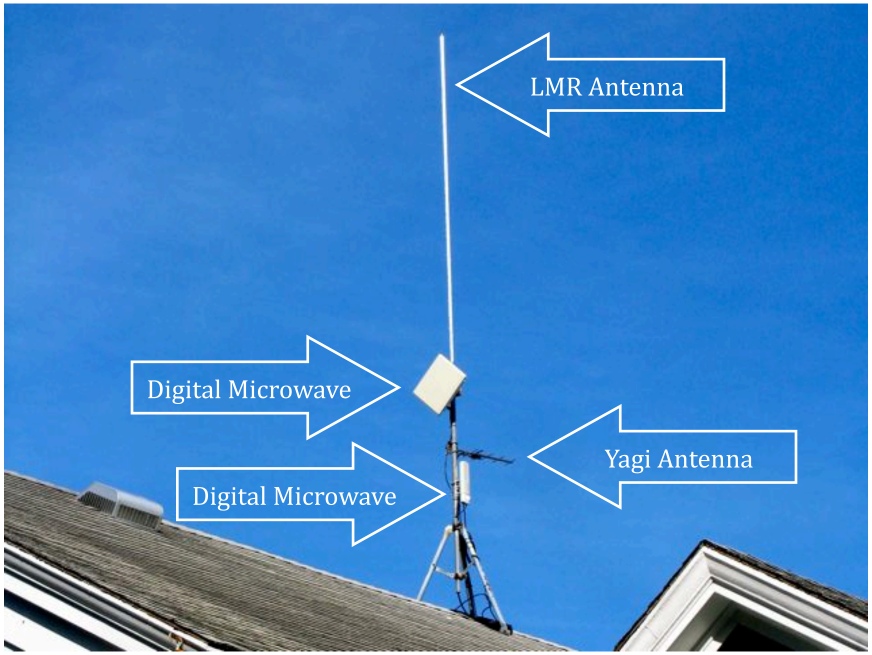

Figure 5—Another example of wireless connections to a site. The tall white pole at the top of the mast is for a Land Mobile Radio (LMR) system. The diamond-shaped panel is a digital microwave antenna to another site. Next down the mast is a "Yagi" antenna that is the horizontal bar with multiple short crossbars along it. The Yagi antenna is used to feed signals to the LMR antenna from a central radio site. Below the Yagi is a white rectangular digital microwave antenna that connects to a central town microwave hub located on a water tower. This example also illustrates how different departments can share a common antenna mount and rooftop, since public safety, schools, and town administration are all represented on this single antenna mount.

It is worth noting that it is increasingly common for sites to also be generators of electrical power as well as users of electricity. Solar panels and windmills are increasingly common across the Cape, and the wires that once brought electricity to the site, may also be used to provide power back into the electrical grid. There are also some sites that have co-generation facilities using natural gas, with the Cape Cod Technical High School serving as a prime example where such a co-generation facility is in operation. Such facilities have the potential to extend power resilience beyond a single site. In a similar vein, some sites also provide pumping operations for water or sewer systems, and so play a role in providing services that are essential to public health and community resilience.

How a site is connected to the larger world can significantly affect the utility of a site for its intended purposes, as well as future purposes, and also how well that site can continue to operate during major disruptive events, such as storms that take down communications circuits and electrical power lines. For example, if a site has a wireless microwave link into a Town network, and an on-site generator that can maintain power to communications systems, then it is much more likely that such a site will be able to continue operations in the face of a broad array of potential disruptions. If the microwave link is capable of supporting both voice and data, then even more operational capabilities can be maintained.

Data collected during this survey regarding how sites are connected should prove to be valuable to planners considering suitability of sites, and assessing where improvements may be warranted or where new capabilities could be introduced.

Figure 6—Example of a Verizon copper circuit demarc panel that terminates 100 circuits (pairs). Note that these are just the circuits between the street pole and the building. Out at the street, Verizon often does not have enough available live circuits to activate all 100 circuits to a site.

Site Demarcation Points

During on-site surveys, we not only noted how power and communications are delivered to a building, we also confirmed what communications facilities were provided inside the building at what is generally referred to as the *demarcation,* or simply *"demarc,"* point in the building where the external communications provider (*e.g.,* Verizon, Comcast) hands off communications to the building wiring and communications equipment. In some cases, the communications providers place their own equipment at the site to produce whatever signals are delivered to the customer. For example, when Verizon provides a T1[4] circuit for either voice or data or both, they install equipment at the site to deliver the T1 interface to the customer. Comcast cable modems can be thought of as doing the same thing, but with the added wrinkle that the customer could provide their own modem.

While Verizon delivers most services via its legacy copper-wiring infrastructure, it does also provide fiber optic communications to some sites as an alternative or to provide greater bandwidth. In the case of Verizon, all fiber optic services are delivered as "lit" services, meaning that Verizon provides the equipment to interface to the fiber optics on their side, and the customer then connects locally to the *premises side* of the Verizon equipment.

Comcast typically delivers its TV, Internet, and phone services via coaxial cable. Cable TV services generally require the customer to extend the coaxial connections to the actual TV or set top box. However, Internet services can be deployed within the customer site using either coaxial cable or standard Ethernet wiring, or even wirelessly, depending on the type of cable modem employed. Phone services require a specialized cable modem that often provides interfaces to traditional telephone wiring. Where Comcast provides T1 voice services, they will also provide additional equipment to deliver both voice and data services, and interface into the customer's phone system.

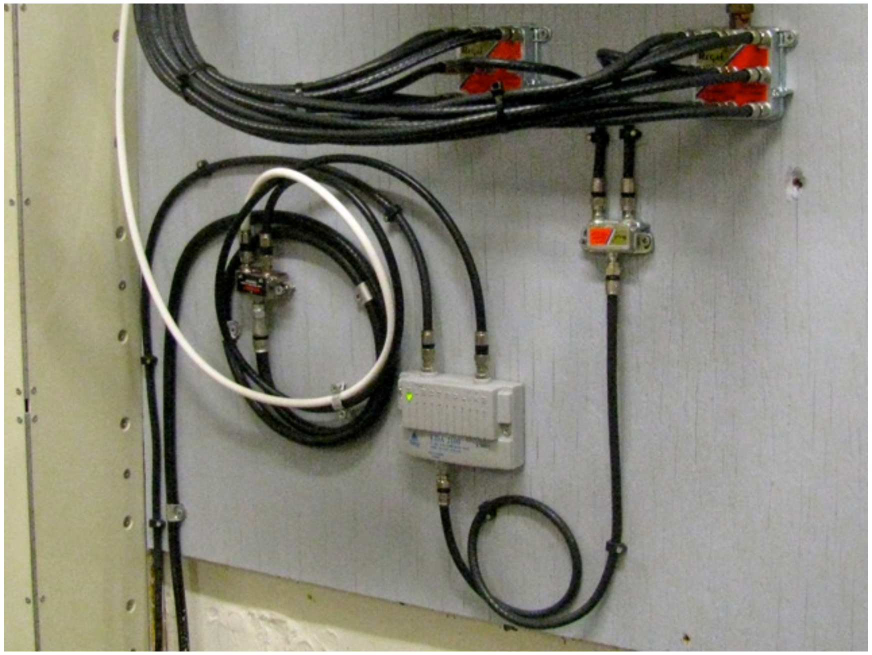

Figure 7—A Comcast demarc. The Comcast outside coax cable comes up from below on the left and into the bottom of the splitter on the left. The white cable coming out of the top of the splitter goes to a cable modem for Internet service, while the black cable goes over to the gray video amplifier on the right, which then feeds into the multi-tap splitters to distribute Cable TV to multiple points in the building. This happens to be a Fire Station, where both paid and volunteer firefighters appreciate having TV service for down time.

Comcast also provides communications services based on fiber optic cables. Normally, Comcast will only deliver these services "lit" with their own equipment. However, several communities have arrangements with Comcast to provide "dark" fiber I-NET services, where the municipality provides the equipment to light the fiber and deliver services between sites without any involvement from Comcast.

Figure 8—This is a Comcast demarc for a town's fiber I-NET service. The Comcast fiber comes in from the street into the left hand side of this box (lower left black cable), and the customer connections for data and public access TV are made behind the door on the right. The yellow cables coming out of the top right hand section of the box are fiber optic connections to Town network equipment and a local access TV studio. (Of course, MediaOne was acquired by Comcast.)

Comcast fiber is also used to provide broadcast services and channel feeds into their head ends for local access TV services. Note that some communities have fiber services that are only used for local access TV, and not for data or other services. However, the communities with I-NET arrangements often have fiber optic cables where some strands are available for the local community to light and do what they want with, while other strands in the same cable are dedicated for video production and distribution.

A complicating factor with both Verizon and Comcast is that they might be providing access services for another communications service provider. For example, Earthlink and Windstream both provide T1 voice trunks to customers on the Cape. However, they don't have their own wires, and so they actually lease wires from Verizon for the *access circuit* to get from the customer's site to the communications service provider. They will in turn provide the equipment to interface into the customer's site, which means the customer still sees a single point of demarcation.

Internet service providers (ISPs) will also arrange access circuits through either the incumbent phone company (Verizon) or the incumbent cable company (Comcast). For example, several Towns and School systems utilize MEC as their ISP, but in some cases, MEC will provide Internet services over Verizon circuits and in other cases over Comcast cable. Again, our survey has sought to capture this sort of information. We have also noted some individual analog telephone lines nominally provided by these carriers, but which appear to actually be resold Verizon lines.

Finally, it is worth noting that some demarcation points have additional complexities. In several cases, we observed that Comcast has run fiber into and out of a municipal-owned site, with no local connection. The assumption is that Comcast has provisioned the building to be able to connect into their fiber services, but no such service is currently in use. In other cases, there are other players who use the demarcation facility. This is most commonly seen where a municipality has leased out use of a radio antenna mast or tower to cellular service providers. An example of this is the Truro public safety facility where the Town owns a well-placed cell tower used by multiple operators. The demarcation room in the basement of the Police station has multiple cellular operators, including Verizon, connecting through this room to get to the Town's cell tower.

Site Infrastructure and Wiring

Each site provides its own infrastructure essential to communications and IT systems. Obviously electrical power is vital, but so is local building wiring for communications to phones and computers. Heating and Air Conditioning are also essential to both equipment and people who work at the site. The topic of site infrastructure can be surprisingly complex, but in this survey, we focused on the matters most directly relevant to providing adequate communications and IT services at the site.

Within a building, there is typically some sort of wiring or cable system for allowing phones, computers, and servers to communicate with each other, and with the outside world. Traditional phone wiring uses a single pair of wires for an analog phone, though typical practice is to run at least two pair to each phone, and these days 4-pair has become the norm. In order to patch connections from phones to phone systems (*e.g.,* key systems or PBXs), or directly to an outside telephone connection, "punch-down blocks" are used to enable semi-permanent connections that can be easily changed if necessary.

Phone wiring is not adequate for high-speed data communications though, which instead uses 4-pair unshielded twisted pair (UTP) wiring that looks similar to phone wiring, and can be used for phones, but is quite different from legacy phone wiring.

Copper UTP data cables have been standardized for the bandwidth they can carry by "Category" designations. *Category 3,* or *Cat 3,* wiring is the original data cabling approach, and is good for 10 Mbps. There was a *Cat 4* standard used for a brief period of time in the 1992–1993 timeframe, but was quickly supplanted by *Cat 5,* which is good for 100 Mbps and even faster. As gigabit Ethernet communications was introduced, Cat 5 was "enhanced" to become *Cat 5e,* and more recently, *Cat 6* was introduced. These Category definitions apply to not only the cable, but also the connectors and patch panels used to interconnect equipment, including Ethernet switches, with in-building wiring. Unlike with phone wiring that uses punch-down blocks, data patch panels use jacks and plugs for interconnecting or patching equipment through in-building wiring.

In all cases, the maximum length of any Ethernet copper cabling, including all patch cables, is 100 meters. Typically, this distance restriction applies to the connection between an Ethernet switch and any device connected into the network via the switch—*e.g.,* PCs, servers, wireless access points, VoIP phones.

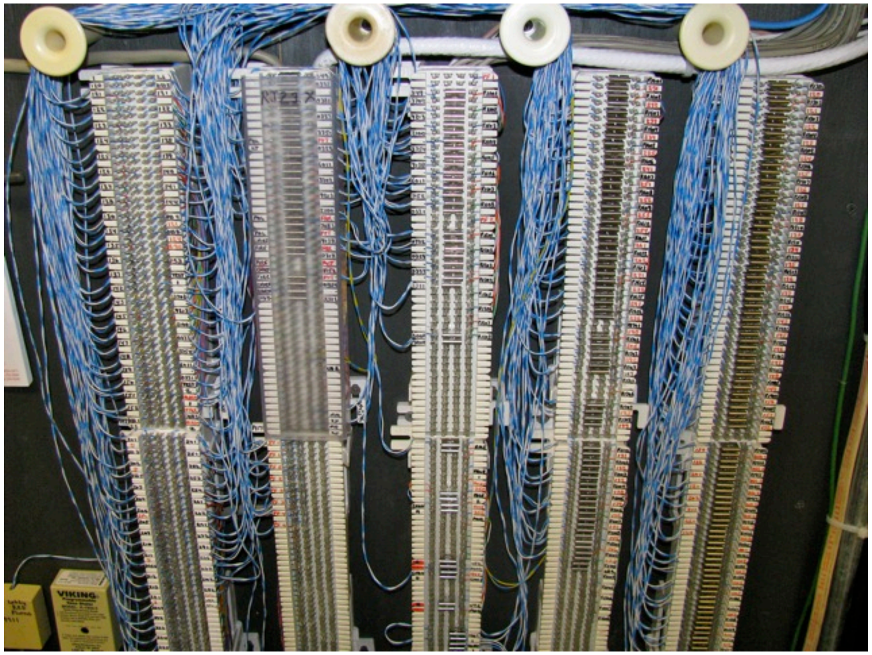

Figure 9—An example of telephone punch down blocks and traditional copper telephone wiring. Connections between different punch down positions are made by pushing copper wires onto metal blades that have narrow slots. The wire is pushed into the slot, which strips the insulation and tightly presses the copper wire into the metal blade slot, making contact. Adjacent metal blades are connected, allowing subsequent wires to be punched down, thereby splicing the wires to create connections.

Historically, buildings were first wired for phones, but starting in the late ’80s and early ’90s, it became common to install Cat 3 and later Cat 5, Cat 5e or Cat 6 wiring and patch panels. While high-speed data does *not* work over traditional phone wiring, phones work just fine over any category of data wiring. Hence, it has also become common to deploy new wiring that can be used for both phones and data communications.

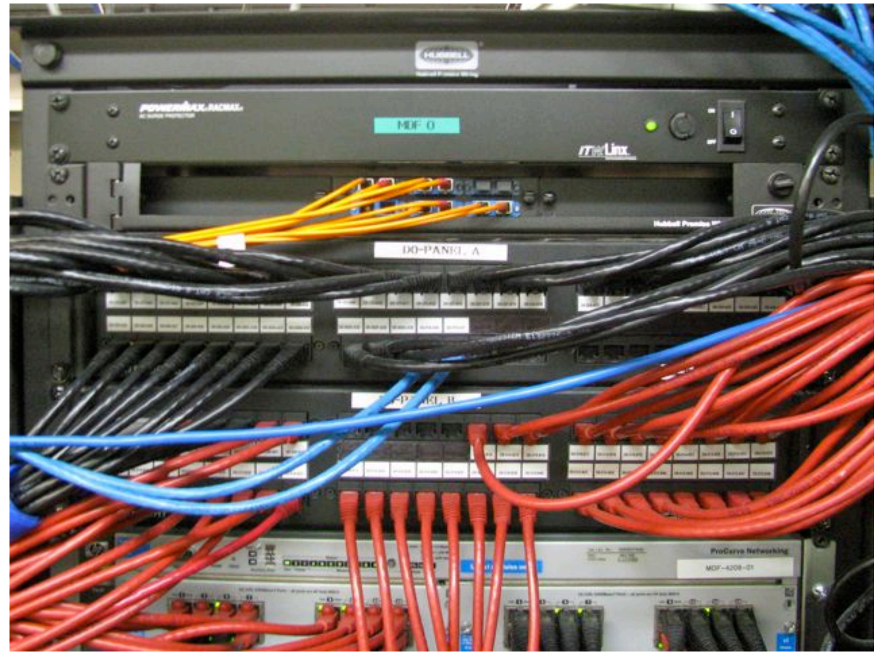

Figure 10—An example of Cat 6 copper patch cables (red, black, and blue cables) connecting to corresponding Cat 6 patch panels. At the top is a fiber optic patch panel feeding the yellow fiber optic cables. In this example, the fiber optic connections are used to extend communications to remote wiring closets within a large building, while the Cat 6 copper cables are used to connect to local Ethernet switches and other computer systems. The top portion of an Ethernet switch is showing at the bottom.

However, when older buildings have been retrofitted with new wiring for data purposes, it was common to leave phone wiring in place, and only run data wiring to where computers are used. Therefore, it is important to know whether phone and data wiring are separate, or use the same system of cabling and patch panels for both. Even when all wiring uses the data standards, it is not uncommon for phone wiring to be kept separate from data wiring.

Another complicating factor has been the introduction of *Voice over IP* or *VoIP* as an alternative to the traditional phone. A VoIP phone is a special-purpose computer that provides voice communications over data packets, typically using a so-called VoIP PBX, which is just an application running on a computer, to handle calling and interfacing with the traditional phone network. Hence VoIP requires data-capable wiring.

Figure 11—Example of a "power injector" used to convert a regular Ethernet connection (blue cable) into a "Power over Ethernet" (PoE) connection (yellow cable). The black wire is a DC power cable from a separate power supply. In this case, the power injector is being used to send power and data over the yellow cable to a Cisco wireless access point, but this would also work for a VoIP phone.

VoIP phones, however, also introduce a new requirement for DC electrical power to be provided over the data cabling, often referred to as Power over Ethernet or PoE. Wireless access points also frequently use PoE connections so they can be located where wireless signals will be optimal, without having to have a power outlet available. There are several ways to inject power over data cables, but the preferred approach involves building this capability into the Ethernet switches used to interconnect computers.

Figure 12—A modest and inexpensive 16-port Ethernet switch that provides Power over Ethernet for the left-most 8 ports. Switches similar to this are used by several towns for smaller sites. Street price for this particular FS116P model is under $200.

Over the past couple of decades, local phone systems, whether simple key systems or more capable PBXs have evolved to become IP phone systems that internally switch calls using data packet switching techniques. However, many of these systems are designed to work with digital phone handsets that can be used over traditional phone wiring, simply because there is so much of it installed in the real world. Consequently, several towns and schools have deployed more modern IP PBXs, but do not use VoIP phones. This avoids the cost of rewiring phone stations, and also deploying PoE switches. Where high speed data communications exists to other sites, VoIP phones have been used to deploy a few phones at smaller sites, but where the phones are part of a Town phone system and do not rely on the phone company for communications within the Town. In some cases, this means that it is more common to find VoIP phones, associated with new data wiring and PoE at smaller sites, than at larger sites.

For larger sites and campus settings, it may be necessary to extend data communications beyond the 100 meters allowed for copper UTP cabling, no matter what the Category. This is typically accomplished by running fiber from a central point out to remote "wiring closets" where additional switches are deployed to connect via copper cabling to more data devices. Since fiber is capable of operating over much longer distances than copper, this approach works well within a large building, such as a school, and even throughout a campus or municipal complex, or even an entire town or region—*e.g.,* town I-NETs, OpenCape.

Figure 13—An example of a wireless (Wi-Fi) access point installed in a school. Note that only one wire is going to this device, since PoE is used to provide power over the same cable that connects it into the network. This is an HP access point that is centrally controlled by an HP wireless controller, along with about 40 other access points distributed throughout a large school complex.

The up-and-coming means for communicating within a building is to use wireless LANs, specifically Wi-Fi in compliance with the IEEE 802.11 family of standards. Wi-Fi is very common, and quite popular in residential contexts, because it avoids rewiring homes, and allows people to roam within their home with their various digital gadgets. It is also becoming increasingly common in office and other work environments for similar reasons. However, Wi-Fi introduces additional challenges in the workplace, including security and management of access to the shared radio channels. With growing demand, wireless technologies have continued to evolve rapidly, and this is becoming a more viable option for some buildings. Availability of wireless is now quite common, even in buildings with modern wiring, and so this should now be considered one of the important local infrastructure capabilities.

An important objective for our survey was to capture information about the types of wiring used within sites, as well as whether this wiring is associated with patch panels that improve reliability and flexibility. Of specific concern is the Category of data wiring, recognizing that some buildings have been wired at various times, and may have more than one Category of wiring deployed. We have also sought to indicate whether buildings use separate wiring for voice and data, or a shared wiring plant. For larger sites, we have ascertained whether in-building fiber is available, and the type of fiber. We have also attempted to capture information about wireless capabilities at sites.

Network Equipment

In reality, communications at a site requires more than just wires and patch panels. Both phones and computers need switches to allow traffic to flow between devices within the building, as well as to communicate with the outside world. These switches come in a variety of flavors, and can operate in fundamentally different ways. However, it is quite common for combinations of switching technology to be deployed at a site, and these different technologies may, or may not, be capable of interoperating with each other.

The interfaces provided by outside communications providers, such as Verizon or Comcast, can also differ radically from systems used at a site, necessitating deployment of gateways or converters to map between different technologies. Even when the underlying technologies are similar, there can be remarkable differences between products that reflect different price points, different usage scenarios, different vintages or different sets of capabilities.

Further complicating matters is the tendency to combine different technologies into a single product, or to use different technical capabilities to handle the same function in different ways. Consequently, there are a lot of products filling various niches in overlapping ways such that it can often be difficult to say what function a specific product is playing within an actual real-world context. However, it is still important to know what network equipment is deployed at a site and what roles this equipment is playing at the site in order to be able to adequately characterize what capabilities a site has.

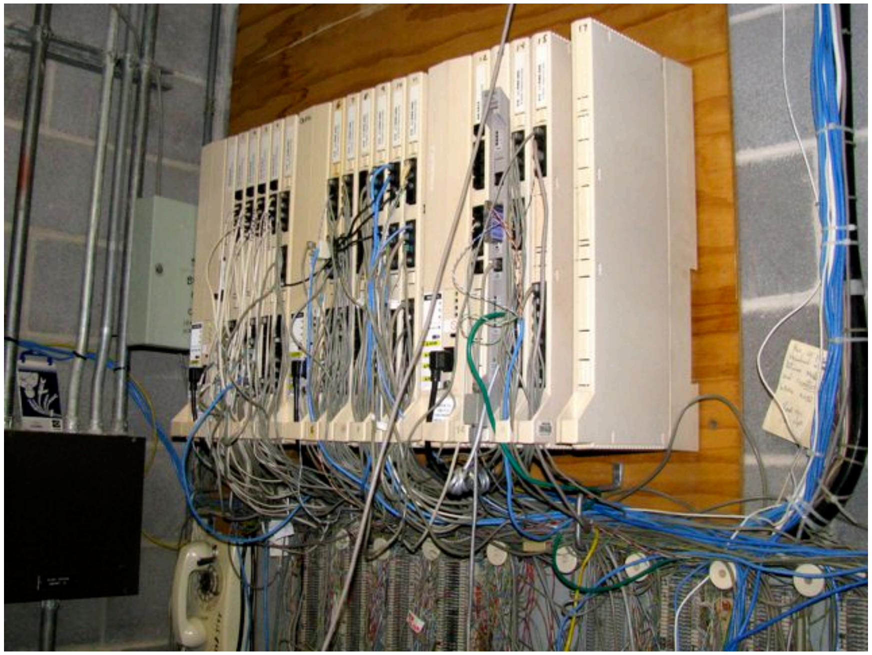

Figure 14—A large, but old, key system. In this case, a Merlin Legend with three bays and enough line cards to support about 150 phones. The punch-down blocks below the Merlin are used to patch in wiring to local phones and to outside lines. ***Yes, that old rotary phone in the lower left still works!***

Phone systems

One of the most challenging product areas is telephone switching. Across the Cape there are literally phone switches ranging in age from three decades old to products introduced within the past five years. Obviously, there are significant differences in capabilities between these antiquated products and recent introductions. However, they all provide a telephone handset interface to the user, which has changed relatively little in decades.

Historically, there are two broad categories of local phone switches, *key systems,* and *Private Branch Exchanges (PBXs).* Simplistically, a key system requires the handset user to press a button (key) to select a line for an outside call. However, more modern key systems may hide these functions to simplify user choices. Key systems are appropriate for small office settings, although there are some large schools on the Cape that are using oversized key systems for well over 100 internal phones.

A PBX on the other hand provides many of the same services as the public telephone network, but on a local, or private, basis. PBXs can also be connected to each other to extend a phone system beyond a single site, and potentially, via a private voice network, to an entire multi-national organization. Historically, PBXs were large and expensive systems, with all phones directly connected to them; however, with the transition to IP-based PBXs that utilize packet switching and computer applications to handle placing phone calls, a PBX can be a small appliance costing as little as a few hundred dollars, though well-supported full-featured ones cost more. The actual switching is then done across external Ethernet-based switches and routers. Again, we found examples of all types of PBXs, though these are less common than the key systems.

In practice, most modern telephone systems are hybrids of key, PBX and IP-based systems. These hybrid PBXs provide support for electronic key telephone sets in order to allow users easy access to multiple calls at once, or to provide secretarial coverage. They may support a mix of standard analog phones (also useful for devices such as fax machines) and IP-based phones. They may support analog trunks (outside lines), digital trunks (usually ISDN Primary Rate Interface or PRI), and even VoIP (a.k.a. SIP) trunks. We did not, however, observe much VoIP/SIP trunking on the Cape.

The site survey data presents information about the types of phone systems deployed at sites, as well as the make and model. We have also tried to capture for each site how the phone system interconnects with the public telephone network, though in some cases we were unable to capture the relevant details from a site, since physical inspections are often unable to ascertain how outside lines, or internal extensions, are actually used.

Figure 15—A Cisco VoIP PBX that currently supports about 500 VoIP phones spread across 7 buildings. This configuration includes four Cisco MCS 7825 "Media Convergence Servers." If they look like regular application servers, it's because that's what they really are. (The blue Barracuda spam firewall above the Cisco voice servers is for email services, not voice.)

We actually encountered several situations where telephone equipment and wiring had been left in place, even though it had not been used in years. Curiously, some of these unused systems were still powered on. Also, some of the older equipment suffers from interface failures that never get fixed, sometimes because replacement modules are not available. Simply looking at the equipment will not reveal what interfaces are actually working. To get the best assessment of local phone extension usage, it is generally necessary to capture a list of active extensions, and perhaps even the current configuration listing for the phone system itself.

Further complicating matters is that Verizon rarely ever de-installs equipment they place at a customer site. Again, we found many instances of Verizon equipment still powered on, but unused. Similarly, outside wiring to internal customer systems never gets removed, so the general impression from an inspection is that there are more lines in use than is actually the case. Ultimately, the best way to determine what is still being used is to examine phone bills in detail, or access the Verizon electronic account records for the site in question.

Ethernet Switches

The original concept behind Ethernet Local Area Networks (LANs) was that devices should be able to communicate with each other over a shared passive cable that all devices on the LAN plugged into. However, this form of Ethernet has not been used in over two decades. Instead, modern Ethernet communications requires active switches that communicate with devices over copper or fiber cables. A switch can be as small as 4 ports or large enough to handle several hundred physical connections, each operating at gigabits per second.

The features and capabilities built into modern switches can be bewildering and potentially subsume all other types of networking equipment, even voice PBXs. Ethernet switches can also be found embedded in other products, such as firewalls, routers, or wireless access points, and even PBXs. Switches also provide more utilitarian functions, such as injecting DC power into cables to power other devices, especially phones and wireless devices. This *Power over Ethernet,* or P*oE,* capability has become much more popular in recent years, and is a feature found in many recently deployed switches of all sizes. For example, small 4- or 8-port switches with PoE are often deployed to power VoIP phones or wireless access points at both small and large sites (see Figure 12 above for an example). It is also increasingly common to see large 100+ port switches that provide PoE for all or most ports (see Figure 16 below).

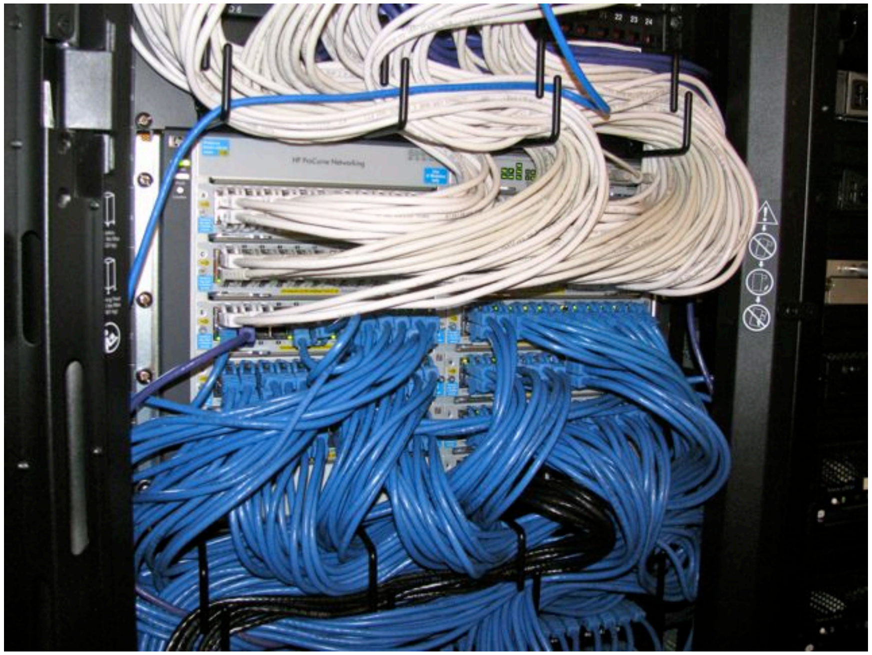

Figure 16—A large switch frame with 12 module slots and 10 installed modules, each with 24 ports for a total of 240 ports. Two slots remain for future expansion. Patch cables connect to patch panels, which in turn connect to in-building wiring.

witches are also deployed as modular systems, where there is a base enclosure to which power supplies, controller cards, and switch modules are added. While there is inconsistent terminology for this type of modular switch system, this document will refer to these as *switch frames,* where the base enclosure is the *frame* and the switching elements are modules. Typically, for a switch to be larger than 48 – 50 ports, it must be a switch frame with multiple modules installed.

Of course, the other way to add more switch ports at a site is to simply *stack* up more switches. There are even switches that are designed to be interconnected into a logical *stack* that can be managed and configured as a single switch, even though the stack comprises multiple individual switches. The bottom line is that there are many ways to deploy Ethernet switches, including haphazardly.

Nearly every site included in this survey has at least one switch, and some have large networks of switches providing up to 1,000 ports within a single site. The price per port varies widely, with more expensive per port costs generally associated with higher-end feature sets, though not always. There are also full-featured switches deployed where expensive features go unused, and limited capability switches deployed where more features would enable more cost effective networking.

This survey has managed to capture quite a bit of information about switch models deployed within the towns and schools, but with the caution that some of this is analogous to counting pebbles and boulders as if they were the same things. While in principle, they're both rocks, the differences are still profound, and a "pile of boulders" is nothing like a "pile of pebbles." Within Barnstable County, we found individual pebbles, stones, and boulders, as well as "piles" of all types. We also note that "Carrier Ethernet" or "MetroE" switches —the type used by OpenCape—are functionally quite different from the switches used in local area networks. They share a name but provide a service that is more like a private line than the original Ethernet LAN concept.

Wireless LANs

Over the past decade, wireless LANs, or Wi-Fi technology, has become quite popular, and even pervasive. Nearly every home with an Internet connection now also has some sort of wireless LAN. This has driven rapid evolution of wireless LAN technologies, which now represents a consumer-driven technology space. There are two major drivers for adoption of wireless LANs, (1) avoiding re-wiring existing buildings and (2) mobility. With the increasing popularity of smartphones, tablets, and lightweight laptops, mobility is becoming the primary driver for new wireless technologies, both the wireless LAN or Wi-Fi flavor, and also cellular data services (*e.g.,* 3G or 4G services).

There is a significant sea change underway. We may have already passed the point where there are more computing devices in use that have *only* wireless network interfaces than there are computers that still support a wired connection. This is very apparent in the schools, where we found most schools are concerned with upgrading their wireless networks, and are now less concerned with the state of their wired networks.

Figure 17—A wireless access point (a.k.a. base station) hiding behind a picture. It can actually be difficult to find wireless devices because they are often placed discretely where they will not be seen, for example above ceiling tiles.

Historically, workplaces have been cautious about deploying wireless LANs due to concerns about security, as well as the capacity constraints of older wireless technologies. However, many of the arguments against using wireless LANs in the workplace are evaporating in the face of today's realities where many employees are carrying around smartphones that communicate constantly with high-speed cellular networks, and that may have the same computational power and storage capacity as the employee's older desktop computer. This is frequently referred to in the press as the "BYOD" or "Bring Your Own Device" movement.

For public entities, wireless Internet access has also become a new service that is increasingly being offered to citizens and visitors. Most libraries on the Cape now provide some form of public Wi-Fi access, often leveraging the "free" Comcast Internet services made available to libraries. Public access to the Internet via Wi-Fi is also becoming much more common at town halls, schools, or other town sites frequented by the public.

From a planning perspective, supporting wireless LANs is clearly going to become a significant new technology challenge for towns and schools across the Cape. It would be nice to also have complete information about the wireless technologies currently deployed. However, it is often difficult to get much information about specific wireless technologies from on-site inspections. This is because wireless access points are often mounted high on walls, or even above ceiling panels where they are not visible. Furthermore, wireless is often deployed in an *ad hoc* manner, sometimes without IT involvement. What our survey has been able to determine is which sites currently use Wi-Fi for employee access, and which sites offer public Wi-Fi access to the Internet.

With new generations of wireless LAN products now coming to market that offer greater speed and capacity, it may be possible for some sites that are currently suffering from out-of-date wiring to make the leap to wireless as a way to improve services without incurring the cost of re-wiring facilities. Another trend worth noting is the introduction of wireless VoIP phones that are battery operated to improve mobility, but also to eliminate the need for central Power over Ethernet (PoE).

Some of the schools, as well as the County complex, have deployed more elaborate wireless network systems that utilize many wireless access points (APs) operating in a coordinated manner throughout the school to improve coverage, and allow a user to connect once, and roam between access points without having to re-connect. These systems may use a central controller that communicates with all APs to manage use of wireless channels and user connections to the network. These wireless controllers are often modules installed in a switch frame (see Figure 18), but can also be standalone boxes. It is also possible to use "controller-less" wireless APs that are able to coordinate amongst their neighbor APs.

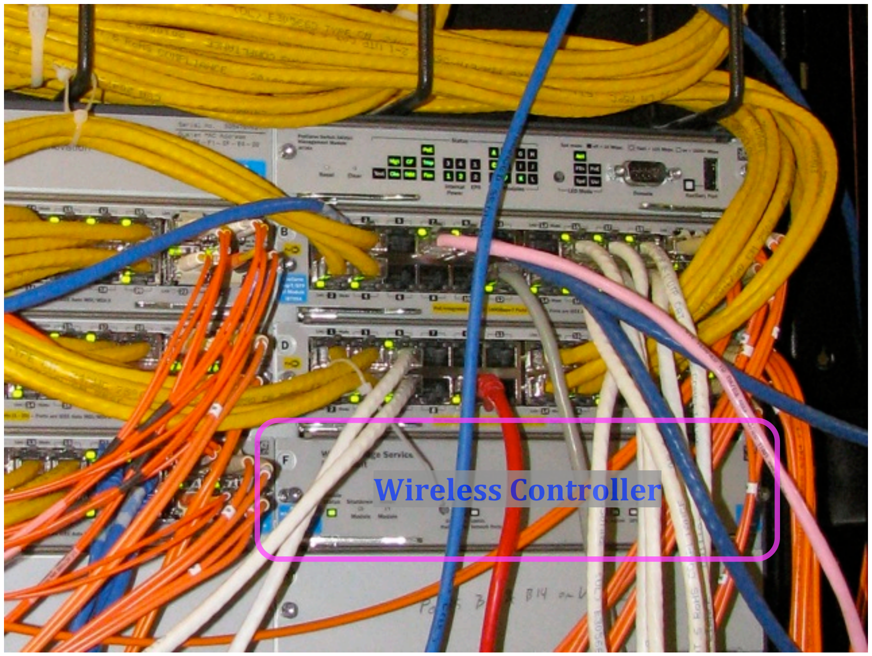

Figure 18—Shown above is portion of a large swich frame similar to the one shown in Figure 16 above. In this case, the module installed in the 'F' slot is a wireless controller that coordinates many wireless access points deployed throughout a large high school. The other modules are switches, with both copper Cat 6 connections (yellow cables) and fiber optic connections (orange cables) to other switches.

The Cape Cod Regional Technical High School and the Wellfleet Public Library are examples of sites where these newer controller-less wireless networks have been deployed. Again, our survey has tried to identify all of the sites currently using wireless networks, as opposed to *ad hoc* deployments of uncoordinated wireless APs.

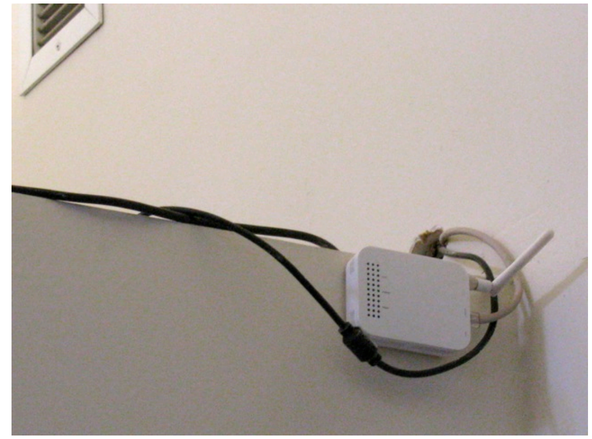

Figure 19—This is an Open-Mesh wireless access point at the Wellfleet Public Library. While this unit is directly cabled into the network, other similar units located within the library connect only wirelessly, to both users and the network. All Open-Mesh access points coordinate directly with each other in a distributed manner without requiring a central controller.

Routers

At one time, routers were easily identifiable devices in networks. However, the technology of routing packet traffic between different subnets and the Internet has largely been integrated into other products. The function of routing packets is still essential to the operation of networks, but this function is more likely to be performed by firewalls, switches, and cable modems, than by distinct boxes labeled "routers."

Where routers still exist as standalone products is when the router is deployed to map between different technologies. Historically, such a device was called a "gateway," and that term is still common. For example, to connect an Ethernet LAN to a telco-provided frame-relay or T1 circuit, a distinct router product often handles this function. Another example where separate routers are deployed is when a local network is connected to a microwave link to reach other sites.

Figure 20—Here is a Cisco 2800 router used to terminate three T1 circuits (the black, gray, and white cables on the right). This router combines voice and data over the T1 circuits, with the white cable on the left connecting into the data network. There are also seven analog phone circuits that are digitized and then multiplexed onto the T1 trunks.

In reality, the Comcast cable modems used for "Business Class" Internet services are routers performing the same function as the LAN to telco circuit example above, but where the wide-area connection is over the cable network. Some of the Comcast *modems* are also performing other conversion functions, such as providing telephone services over the cable network. The most basic Comcast Internet access does use a simple cable modem that does not provide routing functions, but these are typically used only for the *free* service provided to schools and libraries, as well as for the most basic consumer connections.

Another common interface conversion is from a wired LAN to a wireless LAN. Consumer-oriented wireless LANs are usually based on router technology, whereas in workplace settings it is more common to use wireless APs that do not perform routing functions. However, many smaller sites on the Cape are using consumer-oriented wireless products.

Most firewalls are also routers in addition to playing their gatekeeping roles, except that a firewall typically only supports Ethernet interfaces. More discussion of firewalls is provided below.

Some Ethernet switches are also capable of providing routing functions. Industry terminology defines regular LAN switching as "Layer 2" packet switching, whereas routing is defined as "Layer 3" packet switching. Therefore, a switch that has both Layer 2 and 3 capabilities is able to perform routing between different subnets. Where there are a lot of subnets, it is common practice to use Layer 2/3 switches, and so the routing functions are buried in the switches. For example, the switches used throughout the Barnstable County complex are Layer 2/3 switches. Many of the larger schools and some of the town networks are using Layer 2/3 switches to manage traffic across many LANs.

In terms of our survey, we found standalone routers were used infrequently, and those that were encountered were typically associated with connections to telco circuits or for town microwave networks. Of course, many of the Comcast cable modems could be considered as routers, but it was simpler to just associate cable modems with cable Internet connections. Cable modems are typically owned by Comcast, anyway, and provided as part of the service, though they can be separately purchased by customers.

Firewalls

In most cases, separate firewalls have been deployed at sites to interconnect local networks with the Internet in a secure manner. In such cases, the firewall is also performing the job of routing traffic between the local network and the Internet. However, just as firewalls perform routing functions, some routers also perform firewall functions. For example, many Comcast cable modems are also capable of performing basic firewall functions, such as *Network Address Translation (NAT)* and *stateful packet inspection.* Therefore, some sites are connected to the Internet with only a cable modem acting as gateway, router, and firewall.

However, it is much more common for distinct firewalls to be deployed between sites and the public Internet. It is also common for wireless LANs to be built into firewalls, in part because wireless LANs tend to be untrusted networks. Again, the typical consumer wireless device is also a firewall. But, there are firewalls intended for workplace environments that include wireless LAN support and that are promoted for their alleged improvement in security. This can further complicate identifying firewalls and wireless devices at sites, because they sometimes are the same box.

Figure 21—An example of a firewall with an integrated wireless access point. This model is used at a couple of sites where it provides firewall access to the Internet as well as local Wi-Fi services. It also includes an integral 5-port Ethernet switch. Other similar products from various vendors are in use at other sites.

Firewalls are frequently used to establish secure connections over the Internet, often referred to as "VPNs." For example, it is common for firewalls to be used to connect multiple sites to each other or to a central site using encrypted VPN connections to prevent eavesdropping and other security attacks on traffic between sites. These are sometimes called "VPN networks," and this technique is widely used today. On the Cape, some towns, such as Falmouth, Provincetown, Truro, and Wellfleet use VPNs for all or part of their town networks. The County also uses some VPN connections to get to remote sites.

There are many other security functions that are commonly deployed in modern firewalls, and some of these functions depend on regularly updated databases used to detect malware, spam, or inappropriate content. Often, firewall vendors sell subscription services for keeping these databases updated, and so they are really just another form of software maintenance with associated recurring charges.

For high-traffic connections to the Internet, it may be difficult to have a single box perform all of the firewall functions, especially for content tracking, spam filtering, malware detection, or intrusion prevention. In such situations, separate appliances can handle some of the application-oriented functions, such as monitoring email and web traffic. When these application-oriented functions are split out from a single firewall, they actually take on the characteristics of an application server, more than a traditional firewall. And, like other applications, they are associated with recurring charges or subscription fees to keep the databases updated.

Land Mobile Radio (LMR) Systems

Radios used by police fire, emergency medical, DPWs, schools, and other municipal departments for voice communications are typically referred to as land mobile radio (LMR) systems. These systems comprise mobile radios that communicate with fixed transmitter, receiver, and transceiver radios. Other elements include antennas and antenna towers for fixed radios, communications circuits used to connect to the fixed radios, and radio consoles used in dispatch operations.

In the simplest LMR systems, a single fixed antenna is used with both a transmit and receive radio combination (a.k.a., a transceiver) to communicate with a set of mobile radios mounted in vehicles, or carried by people as portables or walkie-talkies. Mobile radios are also capable of both transmitting and receiving so that a user can participate in a radio conversation. A single, fixed site LMR system can be effective for a school or campus, or where distances are relatively short with little in the way of obstructions (line of sight).

While mobile units may be able to communicate directly with one another when in close proximity, when mobile-to-mobile communications is required, a fixed site is generally configured as a repeater, which retransmits on one frequency what it receives on another. Mobile units thus communicate through the repeater, not directly. Some mobile units are configured to operate either directly or via a repeater.

Figure 22—Walkie-talkies used by a school sitting in their charging cradles. These are associated with a simple radio system deployed at a single site.

Where a single fixed radio site cannot provide sufficient coverage, multiple fixed sites are used. Several schemes are used to allow multiple fixed radio sites to interoperate with mobile radios where some mobiles will be "within range" of one fixed site, where other mobiles may be in range of other fixed sites. For example, multiple receiver sites can be deployed to overcome the weaker transmit power of mobile radios, but still use a single, high-power transmit site. There are also simulcast systems that utilize multiple transceiver sites that are synchronized so that they all transmit at precisely the same times to avoid mobile radios hearing transmitter interference or echoes.

The Barnstable Sheriff's Office operates a regional 800 MHz simulcast radio system used by local police, fire, and emergency medical services, as well as the State Police. Several fire departments also have radio systems operating in the 400 MHz band that use simpler schemes suitable for more localized environments. DPWs, schools (including some school bus operators), and other departments or water systems use a variety of other radio technologies, ranging from the simplest, single transceiver site, to schemes involving single transmitter sites with multiple receiver sites located strategically within the coverage area.

Figure 23—Three Motorola transmitters located in a *radio shack* next to a radio antenna tower.

With the exception of some recently deployed 400 MHz systems used by fire departments, nearly all radio systems used on the Cape are old—some very old. However, FCC requirements to narrowband[5] most LMR systems have resulted in some recent upgrades to older radio systems.

The first thing needed for an LMR system is an FCC license to operate on specific channels in a designated band using a predetermined radio technology. The survey team queried the FCC database of licenses, and found over 100 licenses assigned to the towns on the Cape, as well as to Barnstable County and the Sheriff's Office. It appears that many of these are no longer actively used, though towns tend to hang onto licenses for older, outdated radio systems.

Figure 24—Two marine radios located in a Harbormaster Office.

The next thing needed for an LMR system is a site where the transmit antenna can be located, or multiple sites if multiple transmitters are required. Transmit sites must be centrally located, and ideally at the highest feasible elevation. Antenna towers and water towers are preferred, but the tops of buildings are also frequently used. Transmitter sites must be identified on the FCC licenses that allow use of the allocated frequencies. Separate receiver sites may also be needed, depending on the type of LMR system.

Figure 25—A town-owned antenna tower used for public safety radios, and also leased to cellular service providers. *The Osprey family are not being charged any rent for their nest on top, but if town finances get any worse…*

It is important to note that antenna sites can be multi-use, where various types of radio systems can share the same tower. For example, many town-owned radio antenna towers (including some water towers) are leased out to cellular service providers for their cell sites. Similarly, microwave radios used for point-to-point or point-to-multipoint communications links can also share antenna sites with LMR radios, cell sites, and other radio systems.

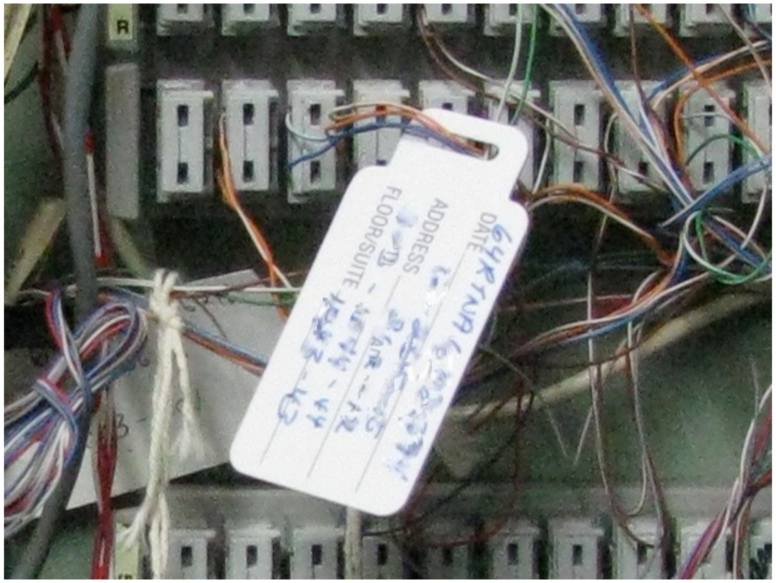

Figure 26—Tag for an RTNA circuit comprising two copper pairs used for a remote radio receiver. Note that the circuit number is written in along the top (right) of the tag, and includes the "RTNA" designation, which is just a telco labeling convention. (The other numbers on this tag have been intentionally blurred.)

Where an LMR system utilizes multiple fixed radio sites, it is necessary to backhaul voice signals to or from these sites. For example, if a mobile radio signal is picked up by a receiver, then that signal needs to get back to a central site, where it can be heard, and possibly retransmitted back out over a high-power transmitter so that other radios can hear the original sender (repeating). These communications lines have historically been special copper circuits provided by the incumbent phone company, and are typically referred to as RTNA or FDDA circuits. Currently, it is difficult to account for, and track, the use of RTNA or FDDA circuits for radio systems throughout the County. It is also increasingly difficult to be able to order new circuits of this type, simply because staff downsizing by the phone company has eliminated most of the crafts people who knew how to deploy (and maintain) such circuits.

It is also possible to use point-to-point radio links in lieu of copper circuits, though only where there is line of sight between the locations (see the Yagi antenna in Figure 5 for an example).

Figure 27—A classic Zetron radio dispatch console is shown. Fire or police dispatchers use such consoles to communicate via multiple radios with emergency responders and coordinate actions involving multiple organizations, such as State Police, local Police, Fire, emergency medical, or DPW crews. While this equipment is solid, it is getting *long in the tooth,* and many such consoles will need to be replaced in coming years. Some manufacturers have discontinued support for consoles of this vintage.

Another necessary element in an LMR system is the mobile radio. This is either a vehicle-mounted radio with an externally mounted antenna, or a handheld radio of some sort, but with a smaller antenna. Vehicle-mounted radios can be larger, or have larger antennas, and they can also draw their electrical power from the vehicle. Handheld radios must be battery operated, and are consequently constrained in transmit power. Their smaller antenna sizes may also limit their use in some of the “low bands” where lower frequencies imply larger antennas.

Finally, an LMR system usually requires one or more dispatcher consoles (see Figure 27). These are special systems used to coordinate radio communications across multiple channels, each of which may have multiple users communicating with each other in a “talk group” that is analogous to a conference call. The dispatcher is able to simultaneously monitor multiple radio channels, and even multiple distinct LMR systems, and may have the ability to control channel allocations or patch users from one channel through to users on another channel. Every emergency dispatch center will have at least one console, which includes police and fire headquarter sites, though in a few instances police and fire share a single dispatch center. As with the radio systems, nearly all dispatcher radio consoles on the Cape are old and outdated.

Newer LMR technologies are available, including “P25”[6] systems that are capable of communicating over Ethernet or IP packet-switched networks, assuming adequate quality of service levels can be maintained for the network. This can eliminate the need for traditional telco RTNA or FDDA circuits to communicate with radio sites. Deploying such systems on the Cape for public safety use would be a very expensive proposition, hence the tendency to stick with current systems. There are also proposals to deploy public safety radio systems based on the same 4G technologies used by cellular service providers, but these systems can only be deployed by a designated national operator, FirstNet,[7] and the timeframes for such deployments are uncertain, and not likely to be anytime soon.

Figure 28—This is the controller associated with the dispatcher console shown in Figure 27. Such controllers connect with multiple radios, and possibly paging systems or telephones. The ability to connect to multiple radios means that a dispatcher has access to more radio channels than any mobile user. For example, dispatchers can talk to radios used by police, fire, DPW, and possibly others such as park rangers, school bus operators or private ambulance services.

Electrical Power

A computer does not absolutely need a network connection to be able to operate, but it does need a connection to an electrical power source, or a self-contained battery, which will eventually need to be charged. Similarly, all other communications and information systems need to be supplied with electrical power, either continuously or for periodic recharging.

Figure 29—The backup generator for the Falmouth Police Headquarters. In this case, the generator is fueled by natural gas.

Unfortunately, power supplied by electrical utilities is not 100% reliable, and probably never will be. Therefore, backup power sources need to be on tap wherever communications or information systems need to be continuously available. This is of greatest concern to those responsible for public safety, but it is a significant concern for nearly all municipal departments. Prolonged power outages could seriously disrupt ordinary business operations, adversely impacting productivity and potentially resulting in other costs or losses. While schools might not be considered critical operations, school buildings often serve as emergency shelters, and so must have backup power to operate during potentially long periods in the case of wide-scale disruptions. As has been discovered the hard way with disasters in other places, shelters need to have reliable communications during both the actual emergency and the recovery.

There are two widely used backup power systems: on-site generators and battery-driven power supplies. Communications and information systems usually require both, with battery-based systems necessary to provide short-term power immediately upon loss of utility power while generators are brought online to provide longer-term backup power.

Backup generators have two essential external requirements, a source of fuel and a means to switch a site from utility power over to generator power—*i.e.,* a *transfer* switch. Fuel is typically natural gas or diesel, though propane and gasoline are also possible fuel sources. Natural gas is often preferred, since it is normally piped in so there is no need for on-site storage or fuel resupply by truck, it is more environmentally friendly, and it is relatively less expensive than other fuels. However, natural gas is not available at every site.

Generator transfer switches are conceptually simple devices. They need to simultaneously disconnect the electrical utility while connecting the generator to any circuits that will be powered by the generator. Transfer switches can be either manually operated, or automatic, though automatic is probably more common these days. Automatic switchover is non-trivial, since there needs to be a means for detecting loss of power versus intermittent outages, starting the generator, waiting for the generator to come up to speed, and then cutting over to generator power. The cutover may need to be staged, as a generator might not be able to handle the surge if every circuit cuts over at once. Further complicating matters is the reality that many generators cannot handle the full load for a site, and only power a subset of electrical circuits. There are also serious safety issues that need to be addressed in the way that power is switched, with a particular concern that local generator power should *not leak* back out into the electrical grid.

Unfortunately, while generators are typically tested on a periodic basis—usually as an automated weekly test—transfer switches are seldom tested as frequently. Often, transfer switches get tested when the power goes out, which isn't too helpful if such a test fails. Another complicating factor is that electrical loads at a site can change, or be redistributed across circuits, which might result in problems with transfer switch cutovers or situations where generator capacity is exceeded. When a transfer switch is tested, all the circuits and devices consuming power from the generator will also be tested along with the generator.

Figure 30—A small APC brand UPS (in corner) used to provide battery backed up power for a Dell Optiplex desktop computer that is being used as a specialized server (IMC mobile switch for police information sharing and data communications with cruisers).

For electronic systems, the first line of defense is the Uninterruptible Power Supply or UPS. This is almost always based on a bank of batteries that are kept continuously charged while the utility power is available, but that can then provide power when utility power is lost. The problem with UPSs is the batteries, since current battery technology can only store relatively small amounts of energy. Therefore, UPSs are used to ride out short power interruptions, which are the most common, and UPSs can also be used to provide interim power while a generator is brought online, which can take anywhere from about 10 seconds to several minutes.

Batteries present other problems besides limited power storage—notably they have operational lifetimes of only 3–5 years, and even if left unused, their shelf lives tend to be no more than 5–6 years for the types of batteries employed in UPSs. They are also quite heavy, so changing batteries can be a chore. Since the materials used in batteries are environmentally hazardous, they must be recycled, and the total cost for replacing batteries can be significant.

Figure 31—A pair of APC Smart-UPS X 1500 UPSs used to provide redundant power backup for a large server "blade" system as shown in Figure 34. Each UPS is a 2U (3.5") rack mount unit.

There are many types of UPSs, ranging from small units intended for home use or for small offices, up to mid-sized units intended for servers or multiple computers, on up to large systems intended to handle large loads, potentially even an entire site. UPSs can also provide power conditioning to deal with under and over voltage problems with utility power as well as power surges. Some UPSs can be attached to networks, which allows remote monitoring of the status of both utility power and UPS health. Network-attached UPSs can also provide environment monitoring of temperature, humidity, and whether water is leaking onto a floor, and may also be used in providing some physical security functions, such as detecting when cabinet doors are opened.

While UPSs may provide protection for under/over voltage conditions and surges, they should be the last line of defense for electrostatic discharges (*e.g.,* lightening strikes or solar flares). Other protections should be incorporated into each site's electrical system to prevent damaging or dangerous situations due to electrostatic discharges or ESD. This applies not only to electrical circuits, but also telephone, cable, and radio systems (since radio antennas are natural lightening rods). Only fiber tends to be immune from ESD issues.

In an ideal world, backup power systems would be designed as complete systems tailored to the needs of each site. Generators, transfer switches, UPSs, and ESD protections should all be considered as elements of an overall backup power system. Unfortunately, it is rare to encounter integrated backup power system designs for municipal sites. The current reality is that most of these systems are deployed in an *ad hoc* manner with little regard for potential synergies or potential system incompatibilities.

Environmental Systems

Electronic systems not only consume power, they throw off excess heat. If operated in enclosed spaces without adequate ventilation or cooling, then heat can build up and result in operational problems. This is not usually a problem for small electronic boxes, but it is generally a concern for power hungry servers, disk storage systems, and large high-performance network devices. It can also be an issue where people need to work in the same room as computers that put out a lot of heat. Electronic systems also need operating temperatures above freezing, though this is seldom a practical concern except for systems that must operate outdoors (*e.g.,* microwave radios or cameras).

Figure 32—An example of the indoor portion of a ductless heat pump for a Town's server room. Note the black and gray unit mounted on the wall to the lower left of this picture. This is a holding tank for water condensed out of the air, with a pump to purge the water before the tank overflows. When these pumps fail—and most will eventually—the result is localized flooding within the room.

Extremes of humidity or high moisture content can also result in operational problems for electronic systems. Very low humidity results in increased potential for static electricity to build up and potentially damage electronics, while high humidity can lead to condensation problems that can cause temporary or permanent hardware failures. Another possible consequence of moisture is corrosion of metal parts, especially steel and aluminum. While residents and tourists may appreciate the *good salt air* along the coast, the corrosive effect of moisture combined with airborne salt can result in rapid corrosion of metal and electrical connections.

As a rule of thumb, human office workers and electronic systems favor the same environmental conditions. Consequently, if a building heating, ventilation and air conditioning (HVAC) system is able to maintain a comfortable working environment for the people, then the electronics should be fine. However, if electronics systems are enclosed in cabinets, or concentrated in a room, then temperature and humidity can get outside of recommended operating ranges.

The standard approaches to dealing with enclosed or concentrated electronic systems involve either increasing air circulation, or adding auxiliary cooling (air conditioning) systems. Another option is to utilize a heat pump, which tends to be more efficient, and can also provide heat as well as cooling. While the familiar, single-unit window air conditioner can be made to work, this is not an ideal choice for many situations, in part because servers and other electronic systems tend to be located in interior rooms where there are no outside walls for such single-unit systems to be installed. More typically, an auxiliary air conditioning unit will have an indoor unit that cools the air that is connected via plumbing to an outdoor unit that exhausts the heat. Heat pumps also have indoor and outdoor units.

During the survey, we attempted to assess whether or not HVAC capacity was adequate for critical communications or information systems. We also tried to determine if any options existed for remote monitoring of environmental conditions. For example, whether monitoring sytems were installed that might sound alarms or send out pages or emails if temperature or humidity levels exceed safe operating ranges.

Another point worth emphasizing is that HVAC systems also require electrical power. In the event of power failures, a backup power system might need to also power HVAC systems in order to prevent overheating of electronic systems. Since HVAC systems involve motors with associated startup surges, these systems can place considerable burdens on generators.

Application Platforms

Computer-based applications are the *raison d'être* for information technology deployments, including data networks. Applications are the means by which data is captured and organized into meaningful information that can be presented to users. However, an application must run on some type of *computing system,* or *platform.*

Figure 33—Shown above are two tower servers that provide central application services for a small town. The tower on the left is an old and outdated HP ProLiant ML150, while the tower to the right is a more modern HP ProLiant ML350 G6 with its front cover removed. Both are running Windows Server 2003. Also note the APC UPS on the lower right of this photo used to provide backup power for the servers.

Modern applications can run on various *application platforms,* including mobile devices, such as smart phones and tablets, on general-purpose personal computers (PCs), such as laptops and desktops, and on shared-use server systems. All of these platforms are continually evolving to increase computational power and storage capacity for equivalent cost.

Figure 34—An example of a blade system, in this case an HP c3000 enclosure capable of supporting up to eight blade servers. This enclosure is fully populated with a set of four diskless servers on the right, plus three dual disk servers on the left. In the upper left is a storage array blade that actually contains 12 small form factor disk drives. There are four switch blades plugged into the back side of this enclosure to provide redundant, high-throughput network access. Note that when these blades communicate with each other or with the storage array, they do not consume network capacity outside the blade enclosure. Network capacity within the blade enclosure is enormous. This enclosure takes up 6U (10.5") of vertical rack space.

Each platform is also associated with an Operating System (OS) that manages the underlying hardware, and provides the necessary services for installing and running applications. A single *hardware platform* (*e.g.,* a PC or server system) can typically run more than one OS or *software platform.* For example, a server system might be able to run any of Microsoft's Windows OSs, or any of several Unix OS variants (*e.g.,* Linux, Ubuntu, BSD Unix).

A typical desktop or laptop PC will run one of the Microsoft Windows OSs, with Windows XP and Windows 7 being the most popular versions today. However, the same PC can also run a variety of Unix OSs, with Linux (*e.g.,* Ubuntu) and BSD Unix as popular examples. Apple's Mac computers are essentially equivalent to PCs, but delivered running Apple's Mac OS, which is itself a variant of BSD Unix. Apple computers are also capable of running Windows OSs and other Linux or Unix variants. Most mobile devices these days have either Apple's iOS or a variant of Google's Android OS embedded within the hardware.

Computers designed to provide central services of host applications used by many users are generically referred to as *servers,* and they tend to feature more powerful processors, more main memory, faster disk drives, and greater storage capacity. Servers may also include features designed to make them more robust, such as dual power supplies or multiple network connections. While a traditional desktop system can be used as a server, it is preferable in most cases to use a purpose-built server. Servers are installed either as free standing tower systems (see Figure 33) or as rack-mounted computer systems.

In recent years, a new form factor for servers has been introduced that is commonly referred to as a "blade" system (see Figure 34). A blade system comprises a largish rack mount enclosure that is capable of having multiple servers *plugged* into the enclosure from the front. On the back side, Ethernet switch "blades" are plugged in, providing an integrated server and switch environment. All the blades share a redundant power system and specialized controllers that allow the blades to be remotely operated and managed in a *lights out* manner—*i.e.,* no human operators on site. While blade systems have high initial costs, when the enclosures are fully populated, the overall system can be cost effective, and typically has lower operational costs. Blade servers also tend to be very dense, and a single enclosure could pack in dozens of high-power CPUs with potentially hundreds of processor cores. It may also be possible to configure individual blades to back up other blades so that failure of one blade will result in automatic switchover to a backup server. The Town of Barnstable and the County itself currently have blade systems installed, allowing both IT operations to displace many individual server systems resulting in lower electrical power consumption, improved resilience, and considerable increases in overall server capacity. However, only large IT operations will have the scale to justify the up front costs of blade systems.

For high capacity data storage applications, specialized servers have been developed that combine many disk drives into storage arrays that can be efficiently shared across multiple servers. These storage arrays also provide redundancy for disk drives such that failure of any one disk drive will not result in any loss of data. At the low end, storage systems might comprise a handful of disk drives in what is often referred to as a *Network Attached Storage (NAS)* system where the files on these disks can be shared over an Ethernet network. Higher end storage systems are often categorized as *Storage Array Networks (SANs),* and may involve multiple systems that can collectively support hundreds, or even thousands of disk drives. NAS and SAN systems are fairly popular for IT operations on the Cape, and are used by both small and large operations.

Another type of application platform is the so-called *"appliance."* This is typically a purpose-built server system that has been configured to run a special combination of OS and applications that are *built into* the appliance. Appliances are frequently used for applications such as shared storage systems, with NAS systems one common example. Appliances are also popular for network security applications (*e.g.,* firewalls, spam filters), but also for use in utility contexts, such as a town water system where multiple appliances are installed at wellheads, pumping stations, and storage facilities to automate operations.

Server systems tend to run specialized versions of Windows, Unix, or Mac OS. These specialized versions include some capabilities not typically provided with OSs intended for single users, but may also leave out user interface capabilities, since most servers are not used directly by end users.

Over the past decade, a new type of platform has emerged—the *virtual machine.* Virtual machines are essentially instances of a particular OS operating on top of another OS. This increases flexibility, allowing, for example, a Unix OS to *host* multiple other virtual machine OSs, including Windows or other Unix variants, or even Apple's Mac OS server. Similarly, a Windows OS could be the host for other Window OS instances as well as virtual machines running Unix variant OSs. An interesting twist on *appliances* is that they are now sometimes delivered as virtual machines that can be run on a host server system—*i.e.,* a kind of *soft* appliance without the hardware.

Examples of nearly every type of application platform described above can be found in towns and schools on the Cape. Town departments typically deploy PCs running Windows XP or 7 for town employees, with desktops much more common than laptops. Mobile devices are gaining in popularity for some town departments, but currently represent only a small percentage of deployments. Town IT departments also operate servers for shared applications, with the majority of servers running one of the Microsoft server OSs (2003, 2008, or 2008R2). However, there are also instances where a Unix OS variant is used instead of a Windows server OS.

Schools tend to be even more diverse in their use of application platforms. Teachers and administrators may use either Windows or Apple PCs, but teachers are more likely to use laptops instead of desktops. Student computer labs are typically desktop systems, but are just as likely to be Apple computers as Windows PCs. Use of tablets is a growing trend, with both Android-based and Apple iOS tablets. Apple iPods are also used in some elementary schools as specialized teaching tools. Server systems currently deployed by schools include Windows OSs, several variants of Unix or Linux, including Novell Netware Open Enterprise Server, and even some instances of Apple's Mac OS server.

Water systems are similar to town departments in their use of application platforms; however, they also utilize special-purpose appliances for operational controls and system-wide automation. These appliances are often described generically as *Industrial Control Systems,* and are typically integrated into *Supervisory Control and Data Acquisition (SCADA)*[1] systems for controlling an entire water delivery system, or a wastewater treatment facility. Such systems are kept isolated from other systems for security reasons.

Some towns and schools are now using virtual machine hosts for their server platforms. This increases flexibility allowing the same server platform to host various OS types, as well as customized combinations of applications and OSs, including virtual appliances. Virtualized environments also improve options for system recovery and backup, including better support for disaster recovery scenarios. This is because an image of a virtual machine (a file that contains a snapshot of the entire VM along with its data files) can be taken to another site where the image can be installed on another VM host system.

Applications and Services

There is considerable variety in the assortment of applications used by towns and schools today. Many of these applications are tailored to local needs, or designed for specific functions, although popular generic applications are also used, such as email, word processing, or spreadsheets. Some applications have been developed by towns themselves, or were custom built for town departments by third party developers. There are also a variety of *application services* used, including email services, document-sharing services, web hosting, mapping services, offsite backup, and security services.

Some applications are used on a single platform by one user at a time. These include popular "office" applications, such as word processing, spreadsheets, presentations, database, and email, as well as examples such as accounting packages (*e.g.,* QuickBooks), engineering tools (*e.g.,* AutoCAD), or GIS tools (*e.g.,* ArcGIS). Other applications are shared by multiple users, and tend to run on servers.

It is also quite common for applications to operate in a distributed manner, with portions of the application operating on more than one computing platform at the same time. For example, web-based applications rely on a client browser application running on a mobile device or PC interacting with web services running on one or more server systems. Many of the applications used by towns and schools are also based on a similar client-server model.

Applications can also be deployed as distributed services, where a service provider operates a network of servers used to host an application for many subscribers. This includes broadly used generic application services, such as basic email or collaborative document tools (*e.g.,* Google Docs), and also includes more specialized services, such as financial accounting (*e.g.,* MUNIS hosted service), library automation (*e.g.,* CLAMS), or displaying GIS map data to the public (*e.g.,* PeopleGIS MapsOnline).

With the increasing popularity of mobile devices, such as smartphones and tablets, there is a significant shift underway toward greater use of application services. This is often described as moving applications into the *"Cloud,"* or just *cloud-based services.* Schools are rapidly adopting cloud services to reduce their operating expenses and also to facilitate introduction of mobile devices for students and teachers. Cloud services also make it easier for students to work on school assignments at home and school, and may even make it possible for students and teachers to interact in new ways.

One surprising result from the survey is just how much diversity was found in applications and services used by local government institutions on the Cape. Over 240 distinct applications have been identified so far, representing over 150 vendors (developers and service providers). The survey team has grouped these applications and services into 24 categories.

While about a dozen specific applications or services are used broadly across the Cape by multiple towns or schools, there are many examples of applications used by only a single department.

The recurring costs associated with application software maintenance or service subscription fees are often the largest non-labor component of IT budgets, and much larger than total recurring costs for communications services.

At the same time, applications have contributed significantly to improving productivity of employees as well as delivery of better services to constituents, often with improved quality or new services that were not previously viable. Therefore, the net cost of applications needs to factor in expenses weighed against benefits. It is also worth noting that some applications are required as a result of regulations or mandates from the Commonwealth or Federal Government.

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Summary and Interpretation of Survey Findings

The full survey data is being delivered as a series of spreadsheets and map files. While there is a lot of information about the communications and information systems deployed by local government institutions in Barnstable County, it can be difficult to see the forest for all the trees and undergrowth. Therefore, this section of the project's final report is intended to summarize the survey information in ways that should bring to the surface the most important findings, and also serve to point to where detailed data can be examined to facilitate future planning activities.

One important point needs to be emphasized: there is constant change underway with communications and information systems. In some cases, the changes are driven by IT organizations as initiatives intended to upgrade systems and improve services. In other cases, changes are due to external factors, such as new buildings coming online while other buildings are being retired, or other regionalization efforts, such as new regional school districts or the efforts underway by public safety departments to implement a regional emergency communications center. Our impression is that the Cape is poised for a lot more change as towns and schools expand their networks leveraging OpenCape and their own local fiber or microwave facilities. The net effect will be to cause the data collected by this survey to become outdated quickly, and we acknowledge that some data is already out of date.

There are also inconsistencies in the data collected. There was a tendency to provide the survey team with the information people had at hand, which tended to be different sets of information as we went from town to town or school to school. In particular, cost data was difficult to capture consistently, and there is a lot more cost data that future planners may want to try capturing in a more systematic way. It will also be necessary to decide what information is really needed, as there is some drag associated with having too much data.

Communities

The focus of this survey has been on the utilization of communications and information systems by the towns and schools of Barnstable County, along with the County itself, the Sheriff's Office, and some directly related entities, such as water and fire districts. The term *"community"* is used to refer generically to any of these local governmental institutions. The "Field Guide" provides more background information under the "Lay of the Land" topic.

In total, there are fifteen towns on the Cape, and three regional school districts, Dennis-Yarmouth, Monomoy, and Nauset. However, two of the regional school districts require some further explanation.

The *Nauset Public Schools* comprise a region that includes the four towns of Brewster, Eastham, Orleans, and Wellfleet. However, only the Middle School and High School are fully within the Nauset system. The elementary schools remain under the control of local school committees in each town, but are administered by Nauset Public Schools. In addition, Truro has only a single elementary school that includes up to grade 6, but sends most of its grade 7–12 students to the Nauset Middle and High Schools. Collectively, the total population of all *five* towns is only about 25,400.

The *Monomoy Regional School District* combines the former Chatham and Harwich school departments, but was just established on July 1, 2012. Consequently, the survey captured data from these schools just as this new district came into being, and so some information is out of date. The data was also organized with the towns, though in some of the tables presented in this summary, we have broken Monomoy out to facilitate comparisons with the other regionals.

A separate grouping of Independent Schools is used to summarize data from the two technical high schools and the two independent charter schools. However, there are no affiliations between these schools, and this grouping is merely a convention used in this report to summarize data from these schools.

The *Cape Cod Regional Technical High School* located in Harwich and the *Upper Cape Cod Regional Technical School* located in Bourne provide regional technical educational programs for high school students, as well as adults. However, these regional schools operate independently from the towns, and from each other.

Table 4—List of communities included in survey, along with counts of sites identified and surveyed.

Community	Identified	Surveyed
Barnstable	56	29
Barnstable County	11	9
Barnstable Sheriff's Office	4	2
Bourne	23	14
Brewster	10	7
Chatham	12	9
Dennis	18	12
Dennis-Yarmouth Regional Schools	8	7
Eastham	6	6
Falmouth	30	15
Harwich	14	9
Independent Schools	5	3
Mashpee	18	11
Monomoy Regional Schools	6	6
Nauset Public Schools	8	8
Orleans	10	7
Provincetown	20	10
Sandwich	18	15
Truro	13	7
Wellfleet	11	9
Yarmouth	20	15
Total	**321**	**210**

There are also two independent charter schools. The *Sturgis Charter Public School* is a high school located in downtown Hyannis. This past summer, Sturgis added a second building to accommodate growing enrollment. The new building is known as "Sturgis-West" while the original building (a former furniture store) is now known as "Sturgis-East." Similarly, the *Cape Cod Lighthouse Charter School* (a middle school) moved this summer from its original location in Orleans to a new school in a remodeled former movie theater located in East Harwich. Given construction and startup issues, neither Sturgis-West nor the new Lighthouse Charter School buildings were included in the physical surveys.

The Barnstable Sheriff's Office has also been included in this survey, though technically, this is now organized as a State entity. However, this office has historically played an important role on the Cape, and currently provides essential services to public safety departments. During the survey, we grouped data from the Sheriff's Office with the County, as both entities have countywide roles. For some of the summary tables, we have split out the Sheriff's Office data so it can be seen in comparison to other "communities."

Sites by Community and Category

Throughout this survey project, an iterative approach has been used to first identify sites of interest and then refine information about sites, such as geographical locations, site contacts, descriptions, uses of the site, and other relevant information. See the discussion on Sites of Interest in the Field Guide for more information on how sites were selected.

As part of the deliverables set, a spreadsheet is provided that lists the sites along with some basic information and notes on these sites. Links to Google and Bing mapping services are also included to jump directly to a satellite image of each site. This spreadsheet was also used to assign unique four-letter *Site IDs* to each site to make it easier to refer unambiguously to the sites. The site ID starts with two letters that indicate the town where the site is located. These are typically the first two letters of the town's name. The third letter in the site ID is a group indicator intended to make it easier to sort the sites into broad groupings. For example, every school uses 'S' in the third position of the site ID. The fourth letter is merely used to insure uniqueness of the site ID, and is sometimes mnemonic. It is important to note that this site ID was introduced as an expediency for this survey project, and it is not being proposed for long-term use, nor is it intended to replace other identifiers that might be used by the towns or Commonwealth.

Table 4 provides a summary of the number of relevant sites identified in each community, along with a count of the sites actually surveyed as part of this project. Note that a small set of sites was only partially surveyed due to various site-specific issues. This includes some sites that were not intended to be surveyed, but where the survey team was able to conduct an external survey when they were "in the neighborhood."

Many sites are used by a single department or serve some well-defined role within their communities. Consequently, most sites could be easily grouped into common categories, which are shown in Table 5 for each community. However, there are many sites that serve multiple roles, and may be home to multiple departments. These are

Table 5—Categorization of sites by community

	Community Services	DPW	Education	Government / Admin.	Highway	Library	Public Safety	Recreation
Barnstable	2	3	8	1	3	7	6	2
Barnstable County	3			8			1	
Barnstable Sheriff's Office	1						3	
Bourne	1	2	5	1	2	1	5	1
Brewster	1	2		1	1	1	2	1
Chatham	1	1		2	1	1	3	1
Dennis	1	1		2	1	4	3	1
Dennis-Yarmouth Schools			7					
Eastham	1	1		1		1	2	1
Falmouth	1	1	8	1	1	1	1	1
Harwich	3	1			1	3	3	3
Independent Schools			4					
Mashpee	1		3	2		1	3	1
Monomoy Regional Schools			6					
Nauset Public Schools			8					
Orleans	1	2		1	2	1	2	1
Provincetown		2	1	4	1	1	4	
Sandwich	3	2	3	2	2	1	4	3
Truro	1	1	1	1		1	1	1
Wellfleet	1	1		1	1	1	2	2
Yarmouth	1	2		1	3	3	4	1
Total	**23**	**22**	**54**	**29**	**19**	**28**	**49**	**20**

typically grouped into the "Government/Administration" category, but there are still other sites where ambiguity remains. For the most part, the site list spreadsheet includes sufficient notes on usage to clarify the actual purpose for a site, as well as which departments use a site. There are also instances where a single building is used by distinctly different entities, sometimes using different addresses. There are even instances where a town has leased space in a commercial building, or where a town-owned building is also used by non-governmental users (*e.g.,* a Chamber of Commerce).

Therefore, sometimes a judgment call was made as to how to treat a site, or whether one physical site should be treated as more than one site. To cite one example, the Brewster Recreation Department is located at the Eddy Elementary School, and both share the same address. However, the Eddy School is part of the Nauset Public Schools district while the Brewster Recreation Department is in a physically isolated office within the building, and has its own phone system and Internet connections, as well as its own computers. In other words, there is no sharing of communications or IT between these two entities, even though they share a street address. In this case, we decided to treat these as two sites. Fortunately, the number of situations where such judgment calls were necessary was small relative to the overall list of sites. We recognize that other people might come to different conclusions than we did as to how to assign or count sites.

Another point worth noting about site categorization is that some sites do not fit into any of the categories shown in Table 5. Examples include antenna towers or water towers which were included if they are used by town networks or will be connected onto the OpenCape backbone. Some water system facilities or water treatment plants are not included in one of the listed categories, and the same is true for solid waste management sites. There are also a few transportation sites, such as airports or ferry terminals. Nearly every town has a small set of sites that do not fit into the categories shown, but that might be considered belonging to a miscellaneous category.

Figure 35—The new Wellfleet water tower. This site, and a similar new water tower in Barnstable (Cotuit) are included in the site list because these sites will be connected into OpenCape and will serve as high sites for microwave communications.

Site HVAC Adequacy and Backup Power

The adequacy of HVAC (heating, ventilation, and air conditioning/cooling) was assessed for sites surveyed. However, in many cases where critical rooms were on a whole building HVAC system, it was not feasible to determine absolutely if adequate cooling was available to handle extreme conditions. Therefore, the survey teams focused on instances where the site had obvious inadequacies. This information is summarized in the “Inadequate HVAC” column in Table 6.

Figure 36—An example of a generator that has served for a long time. In this case, the generator does not power IT systems at this site, as it may predate the use of modern IT systems.

The survey also attempted to confirm availability of backup generators for sites. This resulted in yes or no answers for about 180 sites, and this information is also summarized in Table 6. Note that there were a few sites where generator availability was uncertain, typically because an adjacent building had a generator, and we were unable to determine if that same generator also provided backup power for the site in question. We attempted to determine if a generator was capable of backing up an entire site, or only part of a site. However, there were many instances where the local people we interfaced with were uncertain about generator capabilities.

As a related matter, the survey attempted to identify whether generators used natural gas or diesel fuel (propane gas is another option, but seldom observed on the Cape). We also noted when there was an obvious natural gas feed to a site, whether there was a generator or not. Unfortunately, availability of natural gas feeds or whether a generator used natural gas was not always visible. We were able to confirm natural gas feeds to at least 43 sites, but the real number is likely much higher. Other sources of information could be used to more accurately confirm which sites have access to natural gas. The reason this matters is that generators that operate off natural gas can be fueled with less environmental risk, and can be used for prolonged periods without the need for fuel deliveries.

Another issue related to backup power is the use of battery backup uninterruptible power supplies (UPSs). About 90% of sites surveyed included some sort of UPS, though many were the inexpensive consumer-oriented models. Only about 14% of sites included a central UPS system, with about 75% using multiple UPSs. Sites where servers were located tended to use industrial grade UPSs, typically rack mounted with at least the capability of being upgraded to allow remote monitoring of their health. However, many other sites used collections of UPSs in often haphazard configurations.

A general issue with UPSs is that batteries have limited lifetimes of 2–5 years, depending on use. Just sitting on a shelf, all batteries will lose capacity. Therefore, it is difficult from visual inspections to assess the readiness of UPSs to handle power outages. This is less of a concern where a generator will kick in, since the UPS need only provide power long enough for the generator to come online. This can range from seconds to a few minutes.

Backup power is an issue important enough to warrant more comprehensive and coordinated planning. If nothing else, establishing recommended practices that are promoted to all relevant parties could be helpful in hardening the region’s systems against power disruptions for both brief interruptions and prolonged outages.

Table 6—Site HVAC adequacy and generator availability

	Inadequate HVAC	No Generator Available	Generator Available	Generator Backs up whole site
Barnstable	10	9	15	6
Barnstable County		3	3	1
Barnstable Sheriff's Office			4	2
Bourne	4	6	9	4
Brewster	4	3	4	3
Chatham	3	6	5	3
Dennis	5	4	6	2
Dennis-Yarmouth Schools		1	6	
Eastham		1	4	
Falmouth	5	2	11	
Harwich	4	5	4	
Independent Schools	1	2	2	
Mashpee	6	2	8	
Monomoy Regional Schools				
Nauset Public Schools	2	1	5	1
Orleans	2	2	4	1
Provincetown	1	4	3	2
Sandwich	4	5	10	
Truro		1	5	2
Wellfleet		1	3	
Yarmouth	1	3	9	2
Total	**52**	**61**	**120**	**29**

External Electrical Connections to Sites

Every site of interest connects to the electrical power grid from some utility pole on a nearby street. In rare cases, sites have more than one connection to the power grid from two different streets for added diversity. It is also increasingly common for sites to generate power via solar panels, wind, or natural gas fed generators. In these cases, the electrical connections are used to both receive power and also deliver power back to the grid.

There are really only two ways that sites are connected to electric power lines on the street—aerially via wires strung from pole to building or via underground conduit from pole to building. Occasionally, a building will have both aerial and conduit connections, generally due to additions being made to existing buildings.

Over a sample size of 94 sites, 86% received electrical connections via conduit and 14% aerially. Provincetown is the only town where aerial connections approached 40% of the sites surveyed. As a rule of thumb, any non-residential building that has been built in the last 20 years, or been significantly upgraded in this timeframe will use conduit for electrical connections.

Conduit generally belongs to the building owner, though the portion of conduit that enters the street right of way may be the responsibility of the utility company. Any conduit used for electrical power cannot be used for communications cabling, usually stipulated by building and electrical codes. This is due to the potential for shorts between electrical cables and communications cables if they are in the same conduit. However, fiber optic cable does not share this liability with copper cable, as fiber is non-conductive. In some cases, it might be possible to make exceptions for running fiber through electrical conduit, but only if no other options are available.

External Network Utility Connections to Sites

Essentially every site in this survey has telephone connections into the legacy, copper-based phone system provided by Verizon, and nearly all sites also have cable connections from Comcast. However, a handful of sites no longer use legacy phone connections, and some sites might not use Comcast cable connections.

Figure 37—Shown above is a conduit deployed by the Town of Harwich Water Department entering the basement of Town Hall. This fiber supports data and voice communications, and Harwich has their ShoreTel PBX distributed between Town Hall and the Police HQ over this fiber. The conduit runs under Town streets from the public safety complex to Town Hall and the Brooks Library, and on out to the Community Center. It also reaches the middle and high school land parcels, but is not currently connected to the schools. The silver and blue lines seen coming out of the conduit are pull lines that can be used to easily pull additional fiber through this conduit. There is no difference between this conduit and conduit used by Verizon or Comcast, except that the Town owns this conduit, and it runs between sites, not just out to the street.

Both Verizon and Comcast also provide fiber optic connections, since both maintain fiber backbones on the Cape. However, Verizon fiber connections were seen only rarely for service delivery. Specifically, Verizon provides fiber-based services to Barnstable Town Hall, the two Sheriff's facilities on Otis AFB, and the County complex. In each of these instances, they also provide traditional copper services as well. Verizon fiber is also used to service cell sites collocated at some town or school facilities, but these services are independent of any services provided to the host sites.

Comcast services are much more likely to be delivered via fiber connections. However, these fiber connections are primarily used for local access TV channel video broadcasting, or for provision of town I-NETs. Comcast fiber is also used in a few instances for carrier-provided Ethernet connections (*e.g.,* the Sheriff's Office makes use of this service). We also observed Comcast fiber brought into a couple of buildings, but with no local connections. However, traditional cable TV and Internet services are always delivered via coaxial copper cable instead of fiber. When Comcast provides phone services, they will also use coax cable connections.

Figure 38—This is an example of Comcast directly buried cable where the cable is enclosed in an outer orange jacket, but does not run through conduits as the electrical services to this site do. The photo on the right shows the building entrance, with the black Comcast cable coming out of the orange jacket, and then entering the foundation wall.

As with electrical connections, telephone and cable services are distributed via utility poles on streets, and brought into buildings using aerial lines or buried conduit. Comcast will also occasionally use directly buried cable instead of conduit for both fiber and coax cable (Figure 38 shows an example). There are also a few instances where both aerial and conduit (or buried cable) connections are made to a single building.

It is also necessary to point out that both Verizon and Comcast tend to only rarely remove wiring or equipment once it is installed at a customer site. This means that carrier wiring and equipment tends to accumulate over the years in the demarcation (or just *demarc*) rooms where carrier connections are terminated on the customer's premises. This is especially true for Verizon, and they even tend to leave equipment powered on with connections into patch panels. This makes it difficult to determine what is actually in use. This is also true for Comcast cable TV connections. For example, many schools were originally wired with coax cable to distribute TV programming to every classroom. However, few schools still use TV programming as part of their educational curriculum, but the Comcast connections to video distribution systems will remain. This "residue" from past services makes it difficult to survey a site and know what is actually in use.

Bill statements from the carriers can help to clarify what services are currently in use, but even bills can be in error, and it is not uncommon for customers to pay for unused services over long periods. Comcast is also well known for sending out bills with zero-dollar charges for mystery services further complicating matters, especially since Comcast does provide free Internet services to schools and libraries. It would be nice to think that zero-dollar bills go with "free" services, but that is not always the case. Information from customer equipment, such as phone systems, can also help to clarify what communications services are actually used, but this requires access to the configuration details for these systems. The bottom line is that many older buildings include wiring and equipment that is no longer in use, and it is often difficult to determine what is, and is not, in use.

Over a sample size of 188 sites, Verizon connections are delivered via conduit for 76% of the sites, via aerial for 21% of the sites, and via both aerial and conduit for 3% of the sites. Only a small handful of sites receive Verizon services via fiber.

Similar statistics for Comcast are that aerial connections are used for 14% of the sites with the remainder being conduit or direct buried cable. About 5% of the sites also have fiber connections in addition to coax cable. The survey team also noted that 80 sites in total seem to have active cable TV connections.

Figure 39—An example of a conduit that suffered a truck backing into it. The telco circuits that used to run through this conduit are obviously no longer functional.

Another useful rule of thumb is that if a site has any conduit in place to connect to utilities on the street, then it is likely that conduit is used for all utility connections. Where conduit is in use, and Comcast adds service to a building, then they will usually run direct buried cable if they cannot make arrangements to use existing conduit. Just note that, for every rule, there will be exceptions.

As a general observation, the condition of conduits at poles is poor in many cases (see Figure 39 for an example). They are often bent in the case of steel conduit, or cracked in the case of PVC conduit, probably due to vehicular encounters. In perhaps the majority of cases, caps are not installed or no filler is in place to prevent water entering the conduits, or animals using conduits for nesting. These concerns apply to both electrical and communications utility connections, however the problems are more prevalent for communications services. For a communications hub site (*e.g.,* VPN hub, fiber hub for a town I-NET), anything that lowers the reliability of communications services could affect the entire town network. This issue also affects OpenCape connections to buildings.

OpenCape Connections to Sites

Since OpenCape was in the midst of running its fiber throughout the Cape during the same time that this survey was being conducted, the survey teams only occasionally encountered OpenCape connections to sites, though these were not yet fully terminated. In some cases the fiber optic cable from OpenCape had been run into the building.

Where there is existing conduit, it appears that OpenCape has made arrangements to use this conduit for building entry. In a couple of observed situations, new conduit appears to have been laid for OpenCape use.

Full details on how OpenCape has connected to each building should be available from OpenCape or its partner CapeNet, or the contractors.

The site list spreadsheet provided with this project's deliverables indicates which sites are slated to be connected to OpenCape. However, it is likely that additional sites will be connected when this initial deployment phase is completed. Furthermore, some towns and schools are planning to add more lateral connections to their sites from the OpenCape backbone. The close working relationship between the County and OpenCape should make it easy to keep track of these connections, and associated details.

Figure 40—An example of a pole that is used to carry OpenCape fiber. The Warning label has been placed on the pole by the contractor running the fiber, and merely advises utility workers that the fiber cable is not strong enough to support a ladder. Also note the "N.B.G.& E.L. CO" metal tag indicating this pole is owned by the Gas and Electric Light Company (*i.e.,* NSTAR), as opposed to Verizon. The numbers indicate this is pole 40/13 within this part of town. Pole numbers were captured by the survey team for poles used to deliver services to sites, though in many cases, poles have lost their numbers.

Site Internal Wiring

Once a site connects to the outside world, there still need to be internal (intra-site) connections to distribute power and provide communications services to phones and computers. There may also be specialized internal connections to security alarms, environmental monitoring devices, and elevator call boxes.

As sites were surveyed, we attempted to determine what sorts of intra-site connection facilities were available and in use, but with the primary focus on the state of wiring for data networks. Of course, some sites also utilize wireless LANs for internal connections.

Table 7—Count of surveyed sites by wiring type (with some overlap)

	Cat 5	Cat 5e	Cat 6	Fiber
Barnstable	23	5		5
Barnstable County	4	5	1	7
Barnstable Sheriff's Office		2		
Bourne	10	3		5
Brewster	5	1	1	
Chatham	3	5	2	2
Dennis	6	2	2	3
Dennis-Yarmouth Schools	2	4	1	7
Eastham	4	1	1	
Falmouth	6	4	2	5
Harwich	6	1		4
Independent Schools	2	2	2	3
Mashpee	5	6		
Monomoy Regional Schools	4	2		
Nauset Public Schools	2	4	1	2
Orleans		6		
Provincetown	2	6	1	
Sandwich	9	5	4	2
Truro	5	1		
Wellfleet	2	3	2	
Yarmouth	10	4		
Total	**110**	**72**	**20**	**45**

One important site qualification is whether phones and data connections use the same, or different wiring facilities. Older buildings are more likely to have legacy 2-pair, 4-wire telephone wiring that is unsuited for high-speed data connections. Even older 10 Mbps Ethernet LAN connections will not work over legacy phone wiring, never mind newer 100 Mbps or 1 Gbps connections. However, many modern, all-digital phones are designed to work well over legacy telephone wiring, simply because even digital phones do not require a lot of bandwidth.

Copper data wiring suitable for high-speed data connections always uses four twisted pairs in a single cable that is standardized according categories that are assigned numbers. For example, *Category 3* data cables are suitable for Ethernet speeds up to 10 Mbps, while *Category 6* is suitable for speeds up to 1 Gbps, or even faster. *Category 4* wiring was designed for maximum speeds of 20 Mbps, and is rarely encountered, but was found at one school. *Category 5* is suitable for 100 Mbps, and may support 1 Gbps over shorter lengths. *Category 5e* ('e' for enhanced) cables are also rated for 1 Gbps. The category designations also apply to the *RJ45* connectors (jacks and plugs) used to connect cables to devices and *patch panels.* In other words, a given category of cable should be used with connectors that correspond to the same category designation—*i.e.,* Cat 5e cable with Cat 5e connectors, or Cat 6 cable with Cat 6 connectors.

While it is possible to wire data devices directly into switches, the preferred practice is to have internal building wiring run to wall jacks on the user end, and to patch panels at the switch end. Short *patch cables* are then used to connect user data devices to wall jacks, and similarly to connect to switch ports at the switch end. Small sites often do not use patch panels, while larger sites generally do.

While data does not work at high speed over phone wiring, phones have no problem using any of the data categories of wiring. Therefore, modern building wiring uses the same data wiring for both phones and data. This means that any jack can be used for either a phone or data device connection. An RJ45 jack will even accept a traditional *RJ11* 2-pair phone plug. In addition, voice-over-IP

(VoIP) phones require data cabling, since these are true data devices using Ethernet protocols. In order to have all phones powered in a consistent manner—ideally from a battery backed-up source—it is also preferred that VoIP phones receive their power over the data cable, a technique referred to as *Power over Ethernet,* or *PoE.* Data switches are the preferred devices to inject power over data cables. Note that wireless access points are also often powered over the data cable using PoE.

Whereas older buildings generally have separate phone and data wiring, newer, or recently refurbished, sites tend to have common data and phone wiring using the same cables and patch panels. However, due to legacy phone systems, it is also quite common to encounter data cabling that is patched into traditional *punch-down* blocks, that were historically the preferred patching mechanism for phones. Some punch-down blocks are even rated according to data categories.

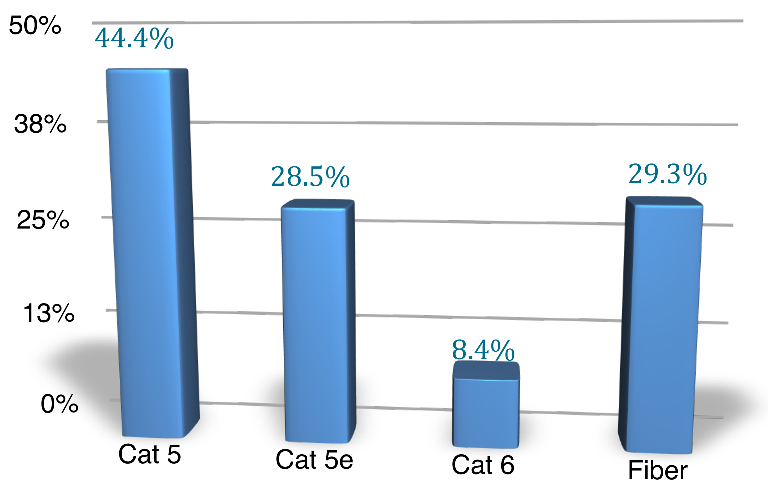

Figure 41—Distribution of surveyed sites according to category of wiring, and whether fiber is used at the site. Some sites have more than one Category of wiring installed.

The other issue with intra-site wiring is how to deal with the constraint that copper Ethernet data cables must not exceed 100 meters in total length (counting the patch cables at both ends). The preferred approach to dealing with these distance constraints in larger buildings or campus settings is to use fiber optic cables instead of copper cables. However, fiber optic connections tend to be more expensive than copper connections, and they are not commonly supported on devices. Therefore, preferred practice is to run fiber from a central switch to remote switches placed in *wiring closets* that are located strategically around a building or campus so that copper data cables never exceed the 100 m restriction.

There are two types of fiber optic cable in wide use today, *multi-mode fiber* (MM fiber or MMF) and *single-mode fiber* (SM fiber or SMF). Without getting into the technical details, the essential difference is that MM fiber is somewhat easier to work with and terminate, but full-speed operation is constrained to distances ranging from 220 m to 1 km. On the other hand, SM fiber can traverse 10–100 km before needing repeaters. Either MMF or SMF can be used within a building, and recent practice is to run both types of fiber within a building, since the cost of the fiber itself is low, though terminating it can be more expensive than copper cables.

In summary, the information about intra-site wiring we attempted to gather includes the following:

- Is phone and data wiring separate? (typically yes for older buildings)
- What, if any, data wiring is available in the building, and what category of cable and patch panels are used?
- Are mixed categories of wiring used, and what types?
- Is fiber used to interconnect switches in wiring closets?
  - What type(s) of fiber (MM or SM) are used?

Table 7 shows how the surveyed sites are distributed in terms of what type of data category wiring is in use, and whether fiber is run within the site. Also, since some sites use more than one category of data wiring, there is some overlap where sites are counted twice. The same is true for fiber, since any site with fiber also has data wiring. Note that this does not count I-NET or other external fiber connections, but does count fiber used between adjacent buildings. Figure 41 shows how the surveyed sites were distributed in terms of categories of data wiring, and whether the site has intra-site fiber. The key message from this data is that Cat 5 wiring is the most common, with Cat 5e the next most likely. Cat 6, however, is relatively rare, and only the larger sites or campuses have fiber.

There are some *caveats* worth noting with this data. First, smaller sites tend to use *ad hoc* wiring approaches, often running data cables as needed; frequently with little regard to matching cable and connector categories. This generally works as long as cable distances are relatively short. However, it does make it hard to determine what category of wiring is in use. Therefore, take the data for smaller sites with a grain of salt. Second, it is worth noting that it was difficult at some sites to determine what category of cable is in use. In general, we used the patch panel category designation to determine what the cable was, but there is no guarantee that cable and patch panels match, and some patch panels were not marked. It was also difficult in some situations to read the cable markings on internal wiring, either because of accessibility issues, or because the labeling was not visible, perhaps because the cables were wrapped into bundles without any clear category labels visible.

The other approach to providing data network connections at sites is to use wireless LANs based on the IEEE 802.11 family of wireless LAN standards, also referred to as Wi-Fi. This is becoming more popular as a way to avoid re-wiring, or running new wires, but also as a way to support mobile devices such as laptops and tablets. At many sites, we heard that the priority had shifted from upgrading data wiring and switching to deployment of more robust wireless services. This is likely to continue as a growing trend, and may lead to some rethinking about whether to upgrade wiring at older sites. More info on Wi-Fi use is provided in the section on Wireless LANs.

Internet Connections to Sites

The vast majority of sites in this survey have some type of connection to the Internet. However, there are a lot of variations as to how sites are connected, as summarized in the following outline:

- **Direct**—64% of sites have their own connection to an Internet Service Provider (ISP)
  - via DSL over copper service (circuits always provided by Verizon)
    - using Verizon as the ISP
    - using another ISP (*e.g.,* Cape.com)
  - via cable service (always provided by Comcast)
    - using Comcast as the ISP (default)
    - using another ISP (*e.g.,* MEC)
  - via wireless service
    - using a wireless ISP (*e.g.,* Homeland Security Wireless—HLS)
    - using a 3G or 4G mobile (cellular) data service
- **Indirect**—38% of sites go through another site to get to an ISP
  - via an adjacent site
    - using local inter-site cable, either copper or fiber
    - using a local wireless link
  - via a central town or school site
    - using a town wireless network
    - using a town I-NET
    - using town-owned fiber
    - using OpenCape fiber

Every variation in the above outline was found on the Cape, plus about 3% of the sites had both direct and indirect connections to the Internet. There are also a handful of situations where one site is indirectly connected via another site, which in turn is indirectly connected via a third site. Also, about 1% of the sites have no connection to the Internet—*e.g.,* water towers.

Indirect connections account for a total of 80 sites out of the survey sample. Most of these were via a town or school network using either I-NET fiber or microwave connections. Further details will be provided in the next section on Town and School Network Connections to Sites.

Table 8—Summary of how surveyed sites connect to the Internet

	Direct	Indirect	Both	No Internet	Totals
Barnstable	18	9			27
Barnstable County	4	6			10
Barnstable Sheriff's Office	2				2
Bourne	6	8			14
Brewster	6	1			7
Chatham	1	7			8
Dennis	1	6	4		11
Dennis-Yarmouth Schools	7				7
Eastham	6				6
Falmouth	8	5			13
Harwich	6				6
Independent Schools	4				4
Mashpee	5	5			10
Monomoy Regional Schools	4	2			6
Nauset Public Schools	8				8
Orleans	5	2			7
Provincetown	15			1	16
Sandwich	4	11			15
Truro	7				7
Wellfleet	6	2		1	9
Yarmouth	3	9	3		15
Total	**126**	**73**	**7**	**2**	**208**

Of the 133 surveyed sites that have direct connections to the Internet, eight used a DSL connection, and five were connected via MEC (mostly via T1 circuits provided over Verizon copper). A couple of other ISPs were also used, but each from only one site. The remainders were connected via Comcast, representing about 90% of this sample. Furthermore, some sites connected via another ISP were also connected via Comcast, and a moderate number of sites that were directly connected via Comcast actually had more than one Comcast connection. For example, nearly every library had at least one "free" Comcast Internet connection used by patrons, plus another dedicated connection for CLAMS services. Due to bandwidth constraints on "free" connections (typically, 3 Mbps), some libraries have added another business class Comcast connection to improve patron services.

While satisfaction levels with Comcast Internet service were generally quite positive and service quality was consistently rated as reliable with adequate or expected performance levels, there were chronic complaints of slowdowns during peak usage periods, typically in the late morning to early afternoon periods. These assessments, however, are qualitative and based on interviews of IT managers and on-site staff. We found no situations where the capability existed to quantitatively analyze performance-related issues, or even total availability. Such quantitative analysis is not hard or expensive, but was outside the scope of this survey, especially given that measuring service levels requires connecting into local networks and performing analysis over multiple days. Analytical data can also be collected in an automated manner using network management tools, but we found almost no usage of such tools. Therefore, the answer as to why slowdowns are observed is, *"it depends."*

To briefly explain what some of the sources of performance degradation might be, consider that everything between a user's computer and a remote service can potentially be a bottleneck, starting with the local connection to the Internet. Local firewalls can encounter processor overloads, especially if the firewall is underpowered or is tasked with content tracking. The local connection to the Internet is constrained to specific bandwidth caps as a function of the service levels subscribed to. Bursting over caps may be allowed, but bursting is often based on a pool of excess bandwidth used by the local subscriber base.

In the case of cable Internet service, the cable bandwidth is shared across all users on a local cable segment, the size of which is controlled by the cable provider. Furthermore, cable upstream and downstream bandwidth sharing over the local segment utilizes different approaches, generally resulting in much less total available upstream bandwidth, which means that if a lot of users on a local cable segment are sending data out to the Internet, then there is a greater likelihood that they will interfere with each other. This is also one reason why cable providers impose contractual restrictions on running servers over their cable connections. It is also worth noting that with increased use of VPN (secure tunnel) connections for business use, there is more upstream traffic during prime business hours.

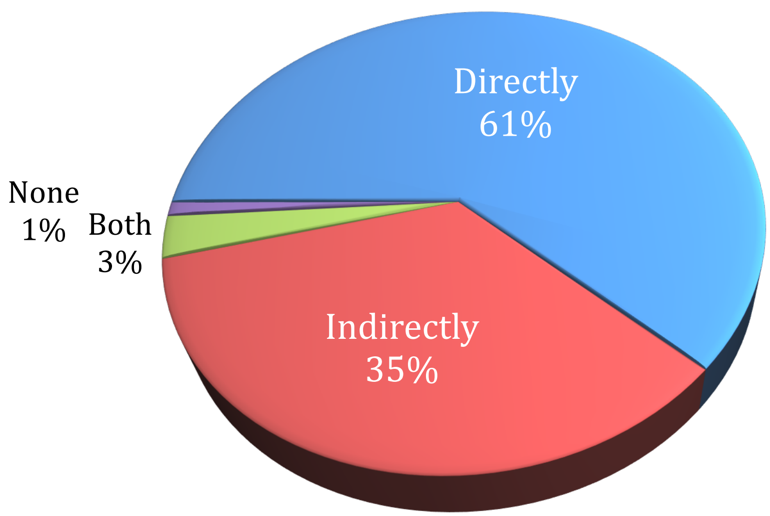

Figure 42—How sites connect to the Internet.

Once Internet packets reach the ISP's routers, then traffic will typically go to a peering point for handoff to other ISPs. Of course, if the destination is on the same ISP, then the traffic can be delivered directly. The *dirty dark secret of the Internet is that there are too few Internet peering points.* For example, most Internet traffic for all of New England is peered through a single site on Manhattan Island. This creates obvious, and quite serious, vulnerabilities in the overall Internet, and these peering points may be bottlenecks during peak usage periods. The reason there are so few peering points comes down to cost. Bandwidth for telcos and large ISPs is very cheap, and so they reduce their costs by peering at fewer locations, even if the traffic has to go out of region. The major academic networks have taken measures to force peering within a more local region, but only large business users take measures to avoid over-concentrated peering points.

Finally, the packets have to get to the ultimate destination—if this is at a major hosting center, then available bandwidth is likely sufficient to handle peak usage periods, but smaller sites may have any of the constraints noted above. For example, if a town is relying on a hosted service, then the service provider might be the source of performance problems if their servers are not located at a well-connected hosting center, or if the servers themselves become overloaded.

There are also application-related issues that come into play. For example, DNS services can become overloaded, which appears to users as long delays getting to web sites or other services. Another example is that a lot of web content is cached by edge service providers, such as Akamai, or by the local ISP. This can result in excellent access to some content, while other sites appear sluggish due to upstream congestion issues. Depending on how video is streamed, this can create complex congestion characteristics, and the potential that local users or neighbors can interfere with even modest traffic usage by other users. Real-time interactive services, such as voice communications (*e.g.,* VoIP or Skype) tend to be very sensitive to delay and jitter (variability of delay), which may have little to do with overall network capacity.

OpenCape is in a position to address some of these performance and quality of service issues for the Cape. However, this is a future scenario, and will depend considerably on just how OpenCape offers Internet services or access to other ISPs. It will also depend on how OpenCape connectivity is used to avoid sending traffic over the Internet. This is a complex problem for which many technical approaches could be used to address some of the quality of service issues affecting users.

Town and School Network Connections to Sites

Nearly every town on the Cape has some sort of town network, and most schools are tied into either their town's network, or a separate school district network. The primary reason for these networks is to allow sharing of data and applications, but sharing voice services or Internet connections are other reason for these networks.

Table 9—Summary of current Town networks and planned upgrades.

Town	Current Network	Planned Network
Barnstable	Microwave (Alvarion)	Town fiber (BFON)
Barnstable County	"Campus fiber" & VPN	Upgrade for resilience
Bourne	Microwave (Canopy)	
Brewster	Some VPN (Most Depts at Town Offices)	Town fiber, leverage OpenCape
Chatham	I-Net (lit service, 100 Mbps)	
Dennis	I-Net (town lights fiber)	
Eastham	VPN	
Falmouth	Microwave (MikroTik)	Town fiber, leverage OpenCape
Harwich	Town fiber	Extend to Monomoy Schools, other sites
Mashpee	Microwave (Proxim)	
Orleans	VPN	Leverage OpenCape, microwave
Provincetown	VPN & limited microwave	Town fiber, leverage OpenCape
Sandwich	I-Net (town lights fiber)	
Truro	VPN	Leverage OpenCape
Wellfleet	VPN & Wi-Fi at Harbor	
Yarmouth	I-Net (town lights fiber)	

Overall, the survey found that only about 13% of sites (out of a sample size of 186 sites) were confirmed as having no town or school network connection, though most of these sites did have an Internet connection. Libraries are one generic example of sites less likely to be connected to a town network. This is because most libraries are connected into the CLAMS network that provides their shared data applications, and could be considered a special *community* network that interconnects the community of libraries. Also, the Nauset Public Schools and the Town of Brewster do not currently have networks tying their sites to each other.

The reason Brewster does not currently have a town network is that most of the Town's departments are located in the Town Office building, and so the Town network is the Town Office LAN. Brewster does plan to add fiber laterals off OpenCape during CY2013, with an initial objective of establishing a town-wide voice system.

The Nauset Public Schools are not currently interconnected for historical reasons, and the school has recently moved to utilizing cloud-based services for email and document sharing. These cloud services have addressed some of their most pressing sharing needs, and the cost has been very low. They do have the ability to deploy VPN tunnels over the Internet to interconnect sites, and may do so in order to support some new shared applications that would have to be hosted locally.

The other towns and school systems utilize one of five approaches to deploying an inter-site network:

1. **VPN Tunnels**—encrypted connections over the public Internet
2. **Microwave**—fixed wireless point-to-point or point-to-multipoint radio links between sites
3. **I-NET Fiber**—dedicated fiber provided by Comcast as part of a cable franchise deal
4. **Private Fiber**—fiber owned and deployed by the town or school
5. **Metro Ethernet**—Ethernet connections between sites provided by a carrier such as Comcast or Verizon, or by OpenCape

VPN Tunnels

The lowest cost option is to establish VPN[8] tunnels between sites, assuming that each site has an Internet connection. Typically, the site's Internet firewall is used to set up one or more VPN connections to other sites, and all traffic between sites is routed over the appropriate encrypted tunnel. Even low-cost firewalls these days are able to support VPN tunnels, so this no longer requires expensive equipment.

In addition to providing confidential communications between sites, VPN tunnels also authenticate the sites to each other so that imposters cannot easily establish their own VPN tunnels to a target site. Firewalls can impose restrictions on which IP addresses are allowed to communicate over each tunnel, further restricting traffic to just what is expressly allowed. It is also possible to configure a firewall so that the only paths allowed out of the site are via tunnels. This means that a site might be able to communicate over VPN tunnels that traverse the Internet, but not have any ability to communicate directly with other destinations on the Internet.

A typical town or school VPN network will have servers located at a central site, and VPN tunnels to other sites where users can then communicate with the servers. For example, this allows all Windows PCs (or Macs, for that matter) to belong to the town's Domain and utilize Active Directory for access to other applications, including file sharing or Exchange email and calendar services. Similarly, a financial package running on a central server could be used from multiple sites to get reports or enter data.

One issue with VPNs is that they can exacerbate some Internet performance or quality of service issues. One particular issue of concern is that the path between two sites within the same town could be very long and convoluted. This is not generally a problem if the sites use the same ISP, but if different ISPs are used, then it is almost a certainty that traffic will go via the major peering point in New York City. For example, if Comcast is used at one site, but Verizon DSL at another site, then the traffic will go through the inter-ISP peering facility. In other words, problems far afield could adversely impact local-town communications.

Another issue with VPN tunnels is that they do not handle *datagram* traffic very well. This primarily affects VoIP (including Skype) as well as some types of video conferencing. Consequently, it would be difficult to support even one VoIP phone at a remote site over a town VPN network.

The towns using VPN tunnels today include Orleans, Provincetown, Truro, and Wellfleet. Each has a central site with VPN connections to other sites to extend services and share applications. These towns have found their VPN networks to be adequate, though each would prefer greater performance and throughput. They are each also interested in providing town-wide voice services, but the VPN approach is not suitable for voice. Provincetown is planning to deploy fiber to most of its sites leveraging the OpenCape backbone, and Truro will leverage its OpenCape connections to achieve similar purposes.

Other towns and schools use VPN connections on more of an *ad hoc* basis to reach sites not on their primary network. For example, Mashpee uses a VPN connection to its second Fire Station because the site cannot be reached via their town microwave network. Harwich is another town using VPNs to extend its core town network to other sites not on their central backbone, and there are quite a few other examples.

Microwave Networks

Barnstable, Bourne, Falmouth, and Mashpee all have town networks based on microwave radios between sites, though each uses a different technical approach and different radio vendors. Satisfaction with these networks is high, and each town feels that the investment in microwave networks has paid off.

Barnstable has the most sites connected via microwave, including most of the schools and major town facilities. Not only do they use this network for data communications, they also extend their central PBX at Town Hall to other sites via their microwave links. This appears to have helped lower phone costs. Most of the microwave equipment is from Alvarion, and operates in unlicensed bands. They have begun to experience some interference from other users of these unlicensed bands. Most links are providing between 20 to 30 Mbps of throughput. Barnstable is also in the midst of deploying its own town-wide fiber optic network to 48 sites. However, the Town plans to continue to operate its current wireless network as a backup to the new fiber network.

Figure 43—Bourne uses the Buzzards Bay water tower near Town Hall as the hub of their microwave network. A corner of Town Hall appears in the foreground. The microwave radios are located on the railing at the very top of this tower, while there are also cellular radios mounted on the rings below the tank.

Bourne utilizes a Motorola Canopy system for its microwave links between major sites. The Canopy radios are generally point-to-multipoint. Town Hall has a point-to-point link to the nearby Buzzards Bay Water District tower, and from there they have line of sight to most other key sites in Bourne. However, they also have one two-hop link via an intermediate fire tower to reach the Sagamore Fire Station. In addition, it appears that MEC has deployed separate microwave links from the High School to the School Administration building and to the Bournedale School. Only data services are provided over this network. The Town has been very satisfied with the reliability and throughput of their microwave network, and their only reliability problem occurred when another party deployed a similar radio on the same channel they were using that pointed toward their water tower. This was resolved, and there have been no problems since.

Falmouth has contracted with Homeland Security Wireless (HLS), a local wireless ISP, for their wireless network, which is also maintained by HLS. There are some tower sharing arrangements with HLS that allows them to provide ISP services to Woods Hole Oceanographic Institute. HLS is also Falmouth's primary ISP, though they also use Comcast for some purposes. Three radio towers at the Fire Headquarters, Police Headquarters, and DPW site are used, along with the new water tower at the Falmouth Technology Park. Most of the radios are MikroTik models, though there are also some Cisco radios. They utilize the 4.9 GHz band for links to the Fire and Police towers, as this band is reserved for public safety purposes, and hence avoids interference problems with other users. The hub of their Town network is at Fire HQ, where the Town's central PBX is located. They have at least one remote gateway off this PBX to extend voice services to the DPW site, which is connected over the wireless network. A total of 13 sites, including most of the schools, are connected to the microwave network.

Falmouth also uses VPN connections to some sites not reached via microwave links, and they have existing fiber between Town Hall, Fire HQ, and the Main Street Library. In CY2013, Falmouth intends to augment this network with OpenCape connections, including additional laterals the Town will acquire. Like Barnstable, they anticipate keeping the microwave radio network for backup.

Mashpee liked their original Proxim microwave network so much they bought a second one. The original network was deployed in the

2005 timeframe, and three years later, Mashpee added a second set of newer Proxim microwave radios in parallel with the original set for added capacity and reliability. The newer radios are capable of transmitting at up to 180 Mbps. Both sets of radios operate in the 5.8 GHz band. Topologically, the Mashpee and Bourne networks are very similar. Mashpee also connects their Town Hall via microwave links (two in parallel) to the nearby water tower, and from there, they connect to other sites in town using point-to-multipoint microwave. A VPN connection is used to reach the one Fire Station that cannot be reached from the water tower.

Figure 44—Mashpee parallel radio links from the Senior Center to the Town's central water tower hub.

Recently, Mashpee acquired a new Avaya IP-capable PBX that extends over their microwave network to other sites. This gives Mashpee an excellent town-wide voice system. Of particular interest, this voice network includes the schools, which is the only instance of an integrated town/school voice network we encountered on the Cape. Mashpee is very satisfied with their microwave network and town-wide voice system.

As a final comment on microwave networks, it is worth noting that the cost of microwave radios and associated equipment has dropped significantly over the past half decade, in many cases by more than a factor of 10. At the same time, new chip technology is coming to market that will further improve speeds and reliability, as well as opening up new radio bands (*e.g.,* the 60 GHz unlicensed band and "TV whitespace"). The region could also explore acquiring licenses for other bands. Microwave technology will remain a viable option, and may be the best option for backing up fiber connections to critical sites.

I-NET Fiber Networks

Back when there was actual competition for cable TV franchises, some cable companies offered to build out fiber optic networks for towns as an inducement to be granted franchises. These cable-provided town networks became known as I-NETs for "institutional networks," although there are other variations of town networks that also use the I-NET term. There is no clear definition of what an I-NET is, and even the spelling and capitalization conventions are inconsistent. As a matter of historical interest, it appears that all of the I-NET arrangements on the Cape were with cable franchisees that preceded Comcast, but that have since been acquired by Comcast.

The towns of Chatham, Dennis, Sandwich, and Yarmouth have fiber-based I-NETs today. Both schools and town buildings are included on these I-NETs, although schools may operate an isolated network over dedicated fiber strands.

There are two types of fiber-based I-NETS, *"lit"* fiber and *"dark"* fiber. The only lit fiber I-NET on the Cape is Chatham's. This means that the cable company provides the equipment used to communicate over the fiber, and hands off copper Ethernet connections at each site connected. In the case of Chatham, their I-NET is lit at only 100 Mbps, and they currently have no flexibility to increase speeds or make other changes to the way the fiber is used.

A dark fiber I-NET, on the other hand, provides fiber strands to the community that can be lit with any equipment the community provides. Therefore, Dennis, Sandwich, and Yarmouth have a lot of flexibility, and could, for example, upgrade link speeds to 10 Gbps or faster at modest cost. In each of the dark fiber I-NET cases, six-strand (3-pair) fiber cables are run between a central hub site and other connected sites in a star topology. Two pairs are available to the local community, and one pair is reserved for local access TV broadcast and channel distribution.

With all of these fiber I-NETs it is important to note that the cable company continues to own and maintain the fiber, which is effectively leased to the community as part of the franchise agreement. When these agreements are re-negotiated, the I-NET arrangements are part of the negotiation. Also worth noting is that local access TV arrangements typically use the same I-NET fiber cables for TV broadcasting and channel feeds to the cable head end, though the TV channels operate over separate fiber strands.

Chatham's lit fiber I-NET has been used quite successfully for over a decade, and is shared by the town and schools, connecting to a total of seven sites. The hub for this INET is at the Elementary School. All links are operated at 100 Mbps.[9] The Town utilizes a Cisco VoIP PBX with VoIP phones deployed throughout the town via the INET. With the exception of the Police Department and Schools, all Internet access is through the firewalls at the Town Office site. Local access TV presumably utilizes the same fiber, and the Town can broadcast from several sites, though only the Town Annex is currently used for live broadcasts. This system has worked well, and the Town feels it has received a lot of value from its I-NET and voice system. The only major facility not on the I-NET is the new wastewater treatment plant, so the Town uses a VPN connection to that site.

Dennis has a dark I-NET that is a star topology with Town Hall at the nexus (hub). It reaches 18 sites in the Town, and is associated with a town-wide local access TV arrangement that uses dedicated strands in the I-NET fiber cables, with the potential to broadcast from any location. The Town is in the process of upgrading the switches at Town Hall used to manage traffic over the I-NET, and plans to upgrade switches at other sites as well. Although the Town has a fairly recent NEC Univerge IP PBX at Town Hall, and IP-capable PBXs at Police and Fire headquarters, they do not currently network these PBXs over the I-NET, though this is being considered. The TV studio in Town Hall is where the fiber is currently terminated, and provides a convenient point for accessing fiber links to all locations, as well as fiber for receiving live TV broadcast feeds.

Yarmouth has an I-NET that is nearly identical to the Dennis I-NET. The nexus of the star topology is at Town Hall, and all fiber connections can be accessed from this site. Local access TV is also supported over dedicated strands within the I-NET fiber cables. This system has been in place since 2000, and reaches 22 sites. The Town has allocated one pair for shared Internet access, and another pair is used for internal data and VoIP use. The Town has three Vertical Wave PBXs operating in a distributed cluster, with most remote sites using VoIP phones. This provides improved resilience, and could survive the loss of one of the Vertical Wave sites. Some links are operating at 100 Mbps, while others are at 1 Gbps. Some buildings are reached using wireless links from adjacent buildings. The Town is very satisfied with this overall system.

The **Dennis-Yarmouth Regional School District** is in the desirable situation of having I-NETs in both towns. However, the Dennis I-NET is not currently used to reach the two schools in Dennis. Instead, T1 links are used from the D-Y School Administration site to the two Dennis schools, even though both schools are on the Dennis I-NET, but apparently do not use it. The Yarmouth schools *do* use the Yarmouth I-NET, though with dedicated school-provided switches at Town Hall so that there are no connections between the Town and School networks. Since OpenCape is connecting to both Town Hall I-NET hubs, there is the obvious potential to replace the two T1 links with an OpenCape connection between the I-NETs. This could be a quick way to get some savings by eliminating the monthly costs of the T1 circuits (probably about $400/mo for each T1 circuit).

Sandwich has another dark fiber I-NET similar to the Dennis and Yarmouth I-NETs. However, the Sandwich schools use a separate Comcast "I-Link" service to connect the High School to the other three Sandwich schools. In total, there are about 12 sites on the Sandwich I-NET. Sandwich's I-NET used to be hubbed out of the Town Annex building, which was also where servers were located. However, the Town has just moved the I-NET hub to the main DPW site, which puts it on higher ground, and provides generator power. The servers have been moved to the Recreation building (a.k.a., the "Lodge"). These changes should harden the I-NET somewhat, and provide better facilities for IT operations.

Private Fiber Networks

Another option for building community networks is to deploy private fiber cables between sites, either using the existing utility poles on streets, or community-provided conduit. This provides the greatest flexibility and control for the community, including the ability to utilize more resilient topologies than the star topologies of the I-NETs. The Town of Barnstable, the Barnstable County Complex, and the Town of Harwich all have private fiber networks. Falmouth also has a small fiber optic ring between their Town Hall, Fire HQ, and Main Street Library.

The Town of **Barnstable** is in the midst of bringing their new Barnstable Fiber Optic Network (BFON) online. The Town decided some number of years ago to avoid going with a Comcast I-NET, and instead banked a percentage of cable franchise fees to fund building out its own private fiber network based on single-mode fiber. BFON now connects 48 buildings in a star topology with Town Hall at the nexus (hub). About half of these buildings are also reached via the Town's existing microwave radio network (see above discussion under Microwave Networks). This will allow the Town to have some redundancy for sites with both microwave and fiber links, though both networks are centered on Town Hall. All new switches are being deployed at BFON sites as part of this initiative, and 22 of the sites will be connected at 10 Gbps, with the remainder at 1 Gbps. Once BFON is in place, the Town plans to upgrade their phone system, with the intention of establishing a town-wide voice system. The Barnstable Schools are also on BFON, and many of the schools also have radio links. However, the schools manage their own inter-school network. It is worth noting that the High School and Middle School are already interconnected with private fiber in underground conduit. There is also existing fiber in conduit between Town Hall and the School Administration building next door.

The **Barnstable County** Complex has a private fiber network deployed as a ring in underground conduit. This network links all the buildings in the Complex, and the ring topology can survive cuts in any one fiber link or failure of one of the switches. All links are currently operated at 1 Gbps, and the fiber is mostly single-mode. All Internet traffic uses the fiber ring for shared firewall access to the public Internet via the First District Courthouse. County servers are currently located in the former "Jail" at the top of the hill, though presumably some servers will also be located in the new Regional Computing Center (RCC) next door. The County has a Cisco VoIP PBX that serves about 500 phones in the Complex, though about half are for State employees working in the two Courthouses. This is the largest government VoIP deployment on the Cape.

Harwich is unique in that the Town Water Department laid conduit for fiber in the streets connecting the Public Safety complex at one end all the way to the Community Center at the other end (see Figure 37). This conduit reaches intermediate points at the school buildings, Town Hall, and the Brooks Library. Currently, there is fiber that connects the Public Safety complex to Town Hall and the Library, though at the time of our survey, it was only lit between Town Hall and Public Safety. The Town has a ShoreTel IP voice system that is deployed in a distributed manner between Town Hall and Police HQ that also serves the Fire HQ. Harwich uses VPN connections to get to other Town sites not reached via the current fiber connections.

The new **Monomoy Regional School District** combines the Chatham and Harwich schools into one District. The Chatham schools are currently connected via Chatham's I-NET. Assuming that

Monomoy leverages the existing conduit between the two Harwich school sites (three schools in total), it should be feasible to interconnect the Chatham and Harwich school buildings via OpenCape. Since a new High School is planned, it is likely that the funding can include building out these fiber connections.

Metro Ethernet Networks

In recent years, communications carriers have introduced a new generation of Ethernet services, often referred to as *Metro Ethernet* or *Carrier Ethernet.* The Metro Ethernet Forum[10] has coordinated standards for this new technology. While called "Ethernet," this is a much more robust set of network protocols that can better manage bandwidth utilization and guarantee service levels—features that are not available with Internet services. Metro Ethernet services can be configured to provide point-to-point Ethernet connections between sites, or connect multiple sites onto what appears to be a shared Ethernet segment, with the customer able to configure VLANs in the same way they can with private networks. Both Comcast and Verizon offer Metro Ethernet services today, and OpenCape will likely offer similar services over its network.

The **Barnstable Sheriff's Office** is currently using a Comcast-provided Metro Ethernet service to interconnect the Sheriff's Office and Emergency Communications Center (both located on Otis AFB) with the County Complex in Barnstable Village. The Sheriff's Bureau of Criminal Investigation is located at the County Complex, and they have a large radio deployment in the basement of the recently refurbished RCC facility.

Looking forward, many communities may be utilizing OpenCape services in a manner similar to the way that the Sheriff's Office is using their Comcast Metro Ethernet service. For example, communities may locate servers at the RCC facility, and use OpenCape services to essentially extend their community network to the RCC site. Furthermore, standardization efforts have made it feasible to interconnect Metro Ethernet services provided by different carriers, as well as with private Ethernets. This means that Comcast or Verizon services could be used to reach some sites not served by OpenCape.

Telephone Services and Systems

The towns and County make use of several services for voice telephone communications provided by several carriers. Verizon, as the incumbent local exchange carrier (ILEC), is the largest provider, but wireline services are also provided by competitive local exchange carriers (CLECs) such as Earthlink Business (formerly One Communications) and Windstream (formerly PAETEC). Wireless services are primarily provided by Sprint-Nextel and Verizon Wireless with some use of AT&T Mobility.

The majority of towns make use of Verizon Centrex services, but not all use it in the same way. Centrex was originally created as a way to provide PBX-like services using the central office switch instead of customer premise switching systems. This proved useful to municipal governments as it allowed multiple sites to be part of the same telephone system, so long as they were connected to the same central office. Verizon was, for a time, very actively promoting Centrex as its flagship offering, but it is now considered obsolete, though the tariffs (usage rates) may still be attractive.

The features available from Centrex have not always proven competitive with modern PBX systems, and the service itself does not provide any customer premises equipment, including telephone sets. Thus Centrex sites still need telephone equipment. In many cases Centrex lines are attached to key telephone systems, and in some sites they are attached to PBX systems and used as trunk lines. This allows calls within the Centrex group to be made without paying local usage charges, even if the lines are otherwise configured for measured service. However, flat-rate local service is common in Barnstable County.

Windstream and Earthlink provide bulk telephone service to PBX systems via the ISDN Primary Rate Interface (PRI), which is a digital circuit carrying up to 23 simultaneous calls. This service makes use of the CLEC's own switching systems (located elsewhere in the state) and Verizon's "T1" transmission lines to reach the customer site.[11] These carriers also sell a modest number of analog individual telephone lines, but these appear to actually be Verizon lines on a resale contract. Once OpenCape is in service, it may become possible for these and other CLECs to make use of its facilities to provide service without using Verizon facilities.

While Comcast provides telephone service to mass-market customers in Barnstable County, it is primarily just a supplier of Internet service to the towns. However, Comcast is the provider of ISDN PRI telephone services to several sites on the Cape, including Provincetown Town Hall and the Upper Cape Technical School. Comcast also provides the Cape Cod Lighthouse Charter School, with POTS[12] telephone service at its new facility in East Harwich. There are also several water districts that use Comcast voice services.

Table 10—Summary of known monthly costs for telecommunications services

Community	VZ fixed voice	VZ voice usage	CLEC used	CLEC fixed voice	CLEC/IXC usage	Wireline voice total	Mobile Carrier	Total Mobile	Comcast Internet	Other Internet	Total Internet
Barnstable	$3,613.65					**$3,613.65**				$5,333.01	**$5,333.01**
Bourne	$2,562.02	$823.92				**$3,385.94**	VzW	**$2,129.47**			
Brewster	$1,592.78	$404.87				**$1,997.65**	(Sprint)	**$2,028.81**	$598.68	$104.97	**$703.65**
Chatham	$963.78	$96.39	Windstream	$1,361.93	$125.43	**$2,547.53**			$771.43		**$771.43**
Eastham	$2,748.86	$276.30				**$3,025.16**			$566.22	$29.68	**$595.90**
Falmouth	$3,118.00		Qwest (IXC)		$129.67	**$3,247.67**	Sprint, VzW	**$3,553.26**	$684.50	$795.00	**$1,479.50**
Harwich	$1,778.01	$58.21	Earthlink	$153.74	$109.11	**$2,099.07**			$111.39	$691.05	**$802.44**
Mashpee			Earthlink, Windstream	$4,401.54	$513.81	**$4,915.35**					
Orleans	$1,326.30	$351.80				**$1,678.10**	VzW	**$2,340.91**	$488.65		**$488.65**
Provincetown	$2,844.25	$325.75	Comcast	$173.80		**$3,343.80**	Sprint, VzW	**$2,774.11**			
Truro	$773.67	$59.30				**$832.97**	VzW	**$1,563.89**	$424.85		**$424.85**
Wellfleet							VzW	**$559.20**	$701.48	$83.33	**$784.81**
Barnstable County			Earthlink	$2,878.54	$1,264.21	**$4,142.75**	VzW, AT&T, Sprint	**$6,436.55**	$4,647.98	$2,562.64	**$7,210.62**
Identified totals	**$21,321.32**	**$2,396.54**		**$8,969.55**	**$2,142.23**	**$32,730.57**		**$14,949.65**	**$8,995.18**	**$9,599.68**	**$16,094.61**

Notes:

1. **Data is incomplete for most towns, and may not include schools, water districts, public safety, or other entities.**
2. **Monthly snapshots were captured, so seasonal variations cannot be observed from this data, and these may be significant.**
3. **Barnstable and Falmouth Verizon voice costs are derived from annual totals, though Barnstable Verizon costs do not include public safety, schools, or fire/water districts.**
4. **Internet costs were not captured for Bourne and Mashpee, and are known to be incomplete for Barnstable.**
5. **Mobile (wireless) services are often provided by multiple carriers, and some smaller bills for entities listed above have not been captured.**
6. **The County also has some Verizon charges, but the associated bills have not been captured.**

Usage vs. fixed costs

The price per minute of telephone calling has come down substantially over the years, and fixed line charges now dominate the monthly bills, not usage charges. Verizon has a statewide contract (often referred to as "COMA" pricing) that allows towns to purchase service with intrastate usage at under 4¢/minute, with a separate Verizon subsidiary (Verizon Select) providing interstate usage at about 3¢/minute. This is reasonably competitive, though a large enterprise may be able to get lower prices nowadays. CLEC usage pricing is usually almost identical to these rates. However, note that some town phone bills do not reflect these contract prices, as indicated below.

Calls between non-adjacent areas on the Cape are rated as toll calls. While this is not a major cost item, if OpenCape were to offer inter-municipal phone services essentially bypassing the telephone carriers, then these telco charges could largely be eliminated on calls across this system, though presumably there would be some compensation to OpenCape.

Note that fixed and usage charges seen on town phone bills presented in Table 10 and explained further below may exclude certain fees and taxes, which are itemized on the bill but not by whether they are based on fixed or usage charges. Thus the total phone bill may be somewhat higher than the sum of the numbers shown in Table 10.

Use of VoIP PBX Systems

Voice over IP is becoming a more common feature of telephone systems, and most new PBX systems support it, as well as some older PBXs.[13] VoIP PBXs actually include both pure VoIP systems that only support VoIP phones and hybrid systems that support other types of phone instruments. The latter are preferable, as they can support fax machines, ordinary telephone sets, and digital (non-IP) feature phones. The primary advantage of the non-IP feature phone is that it runs over ordinary "Category 3" 4-pair telephone wire, or even older 2-pair wiring, while VoIP phones generally require Ethernet-grade wiring, usually at least Category 5. Non-IP phones also have slightly lower latency and generally offer users all the same features and options as VoIP phones.

Table 11—Summary of Town voice systems (not Schools), with checkmarks indicating the towns with at least some multi-site PBX capabilities. Green checkmarks indicate the community has recently upgraded their system, or feels it is adequate.

Town	Current Voice System	Plans for Voice
Barnstable ✔	NEC PBX (old), town wide system	Upgrade after BFON
Barnstable County ✔	Cisco VoIP (~ 500 VoIP phones)	
Bourne	Centrex, mix of old and new systems	
Brewster ✔	VerticalWave VoIP PBX (new), Centrex rates	Interconnect PBXs via fiber net
Chatham ✔	Cisco VoIP, uses I-Net for VoIP trunking	
Dennis	NEC PBX at TH, Centrex + Key Systems	VoIP over I-Net
Eastham	Centrex, Key Systems (old)	
Falmouth ✔	Avaya IP PBX (old), VoIP trunking	Upgrade to VoIP over fiber
Harwich ✔	ShoreTel VoIP at TH & PS via Town fiber, Key Systems elsewhere (old)	Extend ShoreTel to other sites
Mashpee ✔	Avaya IP Office (new), VoIP trunking	
Orleans	Centrex, Mitel IP PBX, Key Systems (old)	
Provincetown ✔	ShoreTel PBX (new), VoIP capable	Roll out VoIP over fiber net
Sandwich	Centrex, Key Systems (old)	
Truro	Centrex, Key Systems (old)	Deploy voice over OpenCape
Wellfleet	Centrex, Key Systems (old)	
Yarmouth ✔	VerticalWave VoIP PBX (new), T1s, I-Net	

Most of the non-IP telephone systems in the County are very old. Some are becoming hard to find parts for. Many are overdue for replacement and most will need to be replaced within a few years.

This represents an opportunity to consider wholesale upgrades, perhaps leveraging a regional system deployed over OpenCape.

An advantage of IP-based phone systems is that they are easier to use between multiple buildings or sites, assuming suitable networking is in place. However, performance is often degraded when VoIP traffic is sent over the public Internet, especially if communicating sites are on different ISPs. Performance within a town's own private network, though, can be very good, so long as proper precautions are taken, such as the use of VLANs or other Quality of Service mechanisms to isolate voice flows from other, more variable-rate data traffic.

No towns today are using "VoIP Centrex" systems, in which a Centrex-like common PBX system belonging to a service provider provides services on a per-line basis, much like Centrex does.[14] However, we were told that some water districts may be using such services. This could be evaluated as a potential OpenCape service.

Cellular (Mobile, Wireless) Service Providers

Several towns reported that they have been using Sprint wireless services for voice communications, but are migrating at least some users to Verizon because of coverage issues.[15] Sprint's coverage has substantially more gaps than Verizon's. Thus current information about wireless provider billing may be obsolete due to migration. AT&T Mobility has a modest presence among the surveyed entities. No other mobile carrier was noted.

As a complicating factor, there is also some use of cellular data services, especially by police departments. Charges associated with data use tend to be considerably higher than standard cellular voice services.

Internet Service Providers (ISPs)

Comcast is the predominant provider of Internet services everywhere on the Cape, and most of the municipal sites that are connected to the Internet use Comcast. Satisfaction with Comcast service seems to have improved in recent years based on information provided during interviews. One common complaint, though, is that Comcast billing is often incorrect, and that it can be difficult to resolve billing problems. This may be due to special pricing offered to some of the towns as a result of franchise agreements.

Other service providers are used as well, including MECnet (often referred to simply as MEC, originally Merrimack Educational Center), Earthlink, HSL, Cape.com (MegaNet), and even Verizon for some DSL connections to small sites. The Town of Barnstable also uses Xand, formerly Access Northeast as one of its primary ISPs.

The cost data that has been captured for ISP services is summarized in Table 10, though this data is incomplete.

Individual town voice systems and services

Barnstable (Town)

Barnstable has an old (*c.* 1999) NEC PBX at Town Hall. This provides service to several other locations across the present microwave network; these sites are equipped with NEC remote gateway cabinets. The Town's BFON fiber optic network is well along in construction, connecting a far larger number of sites. This will facilitate the planned replacement of the old PBX with a new town-wide system. Avaya, InterTel and ESI phone systems are at the various fire districts' stations. Panasonic systems are noted at most schools and libraries; the high school has an Iwatsu phone system.

We were unable to examine the Town's telephone service bills. It appears that the schools are mostly on a Centrex system. Barnstable has three Verizon central offices (Hyannis, Barnstable, and Osterville), so a town-wide Centrex would require a special arrangement, and we could not confirm if that exists. BFON will moot this issue, but perhaps only with replacement of the NEC PBX system with newer technology that can leverage the BFON network.

Most wireless service is procured from Sprint. A few locations have used AT&T. The police have a mix of Sprint and Verizon Wireless service, primarily for air cards. We do not have information about the Town's wireless bills.

We were provided with a total FY2012 cost of $43,363.80 for Verizon wireline phone charges, but exclusive of the School and Police Departments, as well as the Fire and Water Districts. This equates to a monthly average cost of $3,613.65.

Bourne

Bourne's telephone service is primarily Verizon Centrex; some schools are included. While the town is divided among three Verizon central offices (Buzzards Bay, Sagamore, and Cataumet), the bulk of the public facilities are in Buzzards Bay and reached by that one Centrex. Police and fire headquarters each have a Samsung iDCS IP-capable hybrid key-PBX system. We did note an NEC PBX at the Sagamore fire station (thus not served by the Buzzards Bay CO) and a Panasonic key system at the Jonathan Bourne Public Library. There is also a new Vertical Wave PBX system that was deployed as part of the new Bournedale Elementary School construction.

Bourne's fixed Verizon wireline bills during the sample month of June totaled $2,562.02; Verizon usage was $823.92

Bourne makes extensive use of Verizon Wireless services. Their June bill totaled $2,129.47.

Brewster

Brewster has a new Vertical Wave IP-capable PBX at Town Hall. Most town offices are at that site. Separate Vertical Wave PBXs have been deployed at Police Headquarters, Fire Headquarters (also serving the adjacent Council on Aging site) and the Brewster Ladies Library (which is technically independent but primarily town-funded). A planned town fiber network should allow these to become one transparent multi-site system, probably hubbed at the Police site. Most of the telephone sets are non-IP digital, using older in-building wiring. Individual Verizon phone lines go to the other small sites.

Brewster's fixed Verizon wireline bills during the sample month of April were $1,592.78; usage totaled $404.87. Although Brewster does not make use of Centrex services in lieu of a PBX, they use still utilize Centrex for telephone trunk lines to connect their Vertical Wave PBXs into the phone network, as this is more cost effective than using non-Centrex services.

Brewster uses Sprint but we understand it is phasing in Verizon Wireless. In April-May, the Sprint bill was $2,028.81; Verizon Wireless bills had not yet been seen. As an aside, Brewster leases its antenna tower to the cellular operators, and uses this revenue to offset the costs of wireless services used by the Town.

Chatham

Chatham has a Cisco VoIP telephone system serving Town Hall and some nearby buildings. These are interconnected by the town I-NET over Comcast fiber. Police and Fire headquarters have separate PBX systems.

Chatham's primary PBX trunk provider is Windstream (formerly PAETEC). The fixed bill in May was $1,361.93; usage was $125.43. Verizon still provides lines to many sites in the town; the fixed bill in May was $963.78, with usage charges of $96.39.

We did not see Chatham's wireless bills.

Dennis

Dennis has an NEC Univerge IP-capable PBX serving Town Hall and the new Annex, which is near the Police Headquarters. Their I-NET (over Comcast fiber) provides connectivity. Trunks are provided by New Horizons Communications, though the underlying carrier is not clear.[16] The Police have an IP-capable PBX, and Fire has a separate key system for phones. While we do not have the telephone bills to verify it, it appears that a number of other sites are interconnected via Centrex lines. The Town has not yet interconnected phone systems via its I-NET, but is planning to do so.

Telephone bills were not provided so we do not have the total expenditures, and have not identified what carriers, other than Verizon, may be in use.

We did not see Dennis' wireless bills.

Eastham

Eastham's telephone service is based on Verizon Centrex, with a number of recent-model Panasonic key systems. We did note one minor oddity on one Verizon bill (5976 146 008). It charged 1.1 cents/call plus 3.2 cents/minute for "Zone 1" local calls. This is roughly double the normal rate, though the total was only $6.00. Another bill had only one itemized toll call but the per-minute rate was higher than on other towns' bills. However, the large roll-up bill was at the usual COMA rate.

The Verizon fixed monthly bill totaled $2,748.86; usage totaled $276.30.

We did not see Eastham's wireless bills.

Falmouth

Falmouth has an old Avaya PBX at Fire Headquarters serving several other sites including Town Hall and Police Headquarters. Several schools have a newer Avaya IP-enabled system. The Town has a microwave network connecting most major sites, managed by Homeland Security Wireless, which also provides Internet services for its $795/month fee for much of the Town. Town-owned fiber runs from Town Hall to Fire Headquarters and the main Library.

We do not have Falmouth's fixed wireline bills except for the schools, but the monthly totals averaged $3,118 over an 11-month period. Long distance service is provided under a separate agreement with CenturyLink/Qwest, for which the May bill was $129.67.

Falmouth's Sprint bill for March was $3,367.43 fixed, $43.78 for voice usage and $29.75 for data/messaging. Its Verizon Wireless fixed bill was $100.80; usage totaled $11.50. Falmouth may be transitioning some Sprint users to Verizon for coverage reasons.

As an observation, Falmouth IT staff have been clever in several approaches they have taken to containing communications costs, and this community has a better handle on all of their telecommunications costs than any other community we interviewed.

Harwich

Harwich has a modern ShoreTel VoIP telephone system at Town Hall, and another ShoreTel system at the Police headquarters that also serves the adjacent Fire headquarters. Harwich also has 84 Verizon Centrex lines serving several locations. These are at the normal COMA rate

Earthlink Business provides a T1 to Town Hall that is listed as a data service but whose bill includes a long enumeration of long-distance calls. Some of the calls are rated at zero, others at a more conventional contract rate. This may actually be a combined voice/data circuit. The total is indicated on the February bill as $153.74 for fixed voice costs, $109.11 for voice usage, and $516.05 for data. The Verizon bills, mostly Centrex, for May totaled $1,778.01 fixed and $58.21 for usage.

We did not see Harwich's wireless bills.

Mashpee

Mashpee has a new Avaya IP Office telephone system, installed in 2011. It also has a microwave network tying together most of the town buildings. This provides the town with some of the most comprehensively integrated non-Centrex service on the Cape. Furthermore, the Town and Schools share this system for complete town-wide coverage, an approach not taken elsewhere on the Cape.

Earthlink Business provides telephone lines to a number of town locations, including the Police and Fire departments, but these analog lines are most likely resold from Verizon. The June bill totaled $839.25 fixed and $34.96 for usage. Windstream (a.k.a. PAETEC) provides trunks to the Avaya IP Office system, with PRIs at Town Hall, Police and Fire Headquarters. They also supply several apparently resold analog lines. The April fixed bill totaled $3,562.29, with $475.85 in usage charges. The town does not make use of Verizon wireline service except via these CLEC resale arrangements.

We did not see Mashpee's wireless bills.

Orleans

Orleans has a number of PBX and key systems in its various buildings, largely interconnected via Centrex. Town Hall has a fairly modern (2007) Mitel SX-200 ICP CX VoIP PBX, while Police HQ has an older (1998) Mitel PBX. It may be possible to use the Town Hall system over new OpenCape fiber to interconnect their major sites.

Per-minute rates on the consolidated Verizon bill (617 815 7715) are far higher than the norm; a few local calls are rated at 3.2¢/minute and some regional toll calls are rated at about 8¢/minute. This does not appear to be under the COMA contract. The specific bill we reviewed was from February, and included charges of $1,326.30 fixed and $186.78 usage. Thus while the usage total is not large it may indicate a billing or contract issue. The Verizon Select Services (VSSI) bill, including interstate and intrastate, was labeled COMA but was also at higher intrastate rates than found elsewhere, though interstate calls were at a lower rate than intrastate (which is the norm; intrastate is typically higher, though there is no longer any actual justification for this in Massachusetts). Apparently Verizon-Massachusetts (the ILEC) charges a lower usage rate than VSSI, to which these lines' "local toll" was presubscribed. This bill totaled $165.02 in March.

Orleans' Verizon Wireless bill in May was $2,340.91.

Provincetown

Provincetown has a new ShoreTel IP-capable PBX. While it initially serves Town Hall, its reach will be extended as new town fiber is installed. At present, though, a mix of older key systems and PBXs are found in town buildings, some linked via Centrex. One interesting twist is that Provincetown has extended VoIP phone service from the Town Hall ShoreTel system to the Freeman Street facility, where the tourist office and Provincetown TV studios are located. Since they did not have fiber between these buildings, they used Comcast Internet service. However, they did need to install another Comcast cable modem connection at Town Hall dedicated to VoIP use in order to get reliable services. They have also deployed a few VoIP phones at the School.

Verizon wireline monthly voice charges in the March-April time frame totaled $2,944.25. Usage was $325.75. This included intraLATA toll rates at about 8c/minute plus 1c/call, again roughly double the usual COMA rate. Provincetown should examine its wireline trunking contracts as it expands its new PBX service. The town also has the highest identified cost of service per employee, largely because of the large number of individual business telephone lines at various buildings. Four locations also have Comcast telephone lines.

Provincetown's Verizon Wireless bill in April was $1,753.52. Its Sprint bill totaled $1,020.59.

Sandwich

While Sandwich has an I-Net dark fiber network for data purposes, its voice network is largely Centrex with old Avaya (ex-AT&T) Merlin key systems. Mitel and Iwatsu PBXs provide service to some schools.

We were unable to examine Sandwich town telephone bills. We thus could not confirm whether or not Sandwich was getting the best contract rates from Verizon.

We did not see Sandwich's wireless bills.

Truro

Truro has Verizon analog lines with a number of key systems, primarily Avaya (ex-AT&T) Merlin. We suspect there may be a Centrex arrangement but cannot verify that from what bills we have. Bills identify the lines as measured business service. The town's only school has a Samsung IDCS 500, now renamed the OfficeServ 500, which is a relatively modern, IP-enabled PBX system, however the phones used with this system by the school are no longer manufactured, and the school has had problems replacing failed phones.

We identified Verizon wireline fixed monthly fees of $773.67, and usage costs of $59.30 for the March or April usage period. Usage appears to be at the usual contract rate, including the tariffed 1.6¢/minute local measured usage charge.

Truro’s Verizon Wireless bill for April was $1,563.89.

Wellfleet

Wellfleet has a number of Avaya Merlin key systems. Police and Fire headquarters share a WIN 440 hybrid key/PBX system; this is a relatively recent (this century) digital system though not designed for IP.

We were unable to examine any of the town’s wireline telephone bills. We cannot confirm whether there is a Centrex arrangement among the lines, or what usage rate is being paid.

Wellfleet has a Verizon Wireless bill for $559.20 in April.

Yarmouth

Yarmouth has installed a Vertical Wave IP-enabled PBX across a number of buildings. Police and Fire headquarters as well as the water department are on the Town Hall system. Windstream (a.k.a. PAETEC) trunks are at both Town Hall and Police Headquarters; the systems function as a single cluster and thus the trunks at the two locations provide redundancy. Some other sites on the I-NET have IP phones served by the Vertical cluster, though others still have their own small systems.

We were unable to review Yarmouth’s telephone bills. We cannot confirm what usage rates are being paid, or what types of carrier facilities are in use.

We did not see Yarmouth’s wireless bills.

Barnstable County

The Barnstable County complex in Barnstable Village is served by a Cisco IP-based telephone system, with County-owned fiber optics connecting the buildings together into one large system. Other small county government sites have standalone telephone key systems. We note that the County telephone system also services state employees on site, as the courts are now state facilities. About 500 phones are supported throughout the County complex, all of which are VoIP phones. This is the largest local government VoIP system on the Cape.

Earthlink Business (formerly One Communications) is the County’s primary local exchange carrier, with fixed monthly billings of $2,878.54 in September. Usage was $1,264.21. Earthlink provides the County with three ISDN PRI trunk circuits, presumably delivered over Verizon wholesale facilities. With the included volume discount, long-distance rates are close to, though not lower than, what Verizon typically charges; local usage rates are somewhat lower than Verizon rates. Earthlink also provides Internet access, $563/month for its “Multi-Megabit Internet” product.

The County does not generally make use of Verizon’s fixed services, though AmeriCorps has Verizon local service.

The County’s Verizon Wireless fixed monthly bill for September-October was $4,647.98. Voice usage added $142.82; data added $608.87.

Dennis-Yarmouth Regional School District

The two Dennis-Yarmouth schools located in Dennis have Vodavi IP-capable PBX systems. The high school, in Yarmouth, has a rather dated Mitel PBX while the school administration has an NEC SV8100 IP-capable hybrid PBX.

We did not see the Dennis-Yarmouth Regional Schools’ phone bills.

Nauset Public Schools

The Nauset Regional district includes Brewster, Eastham, Orleans and Wellfleet, and Truro sends its grade 7–12 students to the Nauset Middle and High Schools. Nauset Regional High School in Eastham is the largest school belonging to the district. It has a 1990s-vintage Comdial DXP PBX system, soon to be replaced. Nauset Regional Middle School in Orleans has a Panasonic KX-TDA200 PBX hybrid IP-digital PBX system. The district administrative office in Orleans has a

Panasonic key system. The elementary schools have key systems (Panasonic and Avaya).

No phone bills were provided from Nauset.

Table 12—Summary of shared use of networks and voice systems between Towns and Schools

Town (School)	Do Town & Schools share systems?	
	Data Network	Voice Systems
Barnstable	Yes (microwave & BFON)	No Schools use Centrex
Bourne	Yes (plus MEC microwave links)	N/A
Brewster (Nauset)	N/A	N/A
Chatham (Monomoy)	Yes (shared "lit" I-NET)	?
Dennis (D-Y)	Yes (share I-NET, separate switches)	No
Eastham (Nauset)	No	N/A
Falmouth	Yes for 6 of 8 (microwave)	No
Harwich (Monomoy)	No (Town conduit to 4 of 6 schools)	No
Mashpee	Yes	Yes
Orleans (Nauset)	No	N/A
Provincetown	Yes	Yes
Sandwich	Yes (share I-NET, separate switches)	No
Truro	No (but only one school, no town net)	N/A
Wellfleet (Nauset)	No	N/A
Yarmouth (D-Y)	Yes (share I-NET, separate switches)	No

Monomoy Regional School District

Chatham and Harwich have merged their schools into the Monomoy Regional School District. We do not have information about their future plans for telephone service. Chatham does have a town-wide I-NET that is hubbed out of the elementary school, while Harwich has its own conduit system that could support new fiber interconnecting the Monomoy schools in Harwich. A new High School is being built in Harwich, and there will be some re-alignment of current school buildings.

Charter Schools

The Sturgis Charter School in Hyannis added a second campus at the beginning of the 2012–'13 school year. The original "East" campus has a Nortel phone system.

The Cape Cod Lighthouse Charter School also moved from Orleans to new facilities in Harwich for the start of the 2012–'13 school year. It has an small old Merlin telephone system; it uses Comcast as its CLEC, not Verizon. They have one additional outside telephone line at the new school, and stated that their Comcast phone bill is $300/mo versus ~$500/mo with Verizon at their original site with one less line.

Technical schools

Cape Cod Technical High School in Harwich has an old, but large, Avaya Merlin telephone system that appears to be capable of supporting nearly 150 phones.

Upper Cape Regional Technical School in Bourne has an eOn Millennium hybrid IP-capable PBX system.

Observations on telephone services and costs

Comparing the estimated wireline cost per phone and the cost per employee for wireline and wireless service, we see major variations, though some towns' totals may be low due to incomplete data. Both wireline and wireless service costs have room for optimization, primarily via improved scale. Verizon's Centrex rates in many cases are covered by a Commonwealth-wide contract (COMA), which is reportedly going to expire soon. Alternatives, however, may become available via OpenCape as well as from other CLECs and managed service providers. It may also be possible to reduce wireless costs by negotiating a bulk contract. While the Verizon Wireless network has gained market share due to its superior coverage, it may be possible to arrange a lower price for the use of that network via indirect means, such as a contract with a Multiple Virtual Network Operator (MVNO). However, Sprint is the leading MVNO-supporting carrier, and their share is declining.

The combination of OpenCape and municipal networks also opens the possibility to replace the older PBX systems with multi-site systems. These are generally more cost-effective, as they reduce the number of carrier trunks or individual site telephone lines required. They are also likely to have lower maintenance costs, and provide faster adds, moves, changes for existing phones.

Network Equipment at Sites

The following summary of site survey data relating to use of network equipment assumes the reader is familiar with the introduction to network equipment presented in the "Field Guide" section.

Ethernet Switches

Over the past two decades, Ethernet switches have comprised the foundation of most network deployments, and the product category has expanded as more features and capabilities have been added to switches. Once merely dumb systems whose sole purpose was to exchange packets over copper cables so that devices on different cable connections could communicate with each other, today's switches now provide much of the intelligence used to control and manage modern networks.

As expected, Ethernet switches are widely deployed by communities across the Cape. The survey teams encountered just about every type of switch, ranging from ancient hubs that predate modern switches to the latest high-end, high-density, full featured switches. Equivalent costs for switches range from less than $40 for small 5–8 port basic bridging switches to large switch frames that might approach $40,000. Some switch frames are capable of supporting as many as 288 ports operating at 1 Gbps speeds with PoE on every port, and support additional functions that provide quality of service support, better traffic isolation, and routing capabilities.

Figure 45 shows how switches are distributed by vendor (brand) over the sites that were surveyed. What is striking is how popular the HP ProCurve brand is, especially since HP switches were found at every size, from 8 ports to the largest switch frames. Note that the percentages shown in this chart reflect unit counts, not cost. Since HP switches also dominated the higher end deployments, a distribution based on acquisition costs would show HP with an even more commanding share. It is also worth noting that HP has acquired 3Com, so 3Com's share could be added to HP's slice of the pie. The factors that probably contribute the most to HP's dominant position are that their switches tend to have lower recurring costs due to lifetime warranties and HPs policy of not charging for software upgrades.

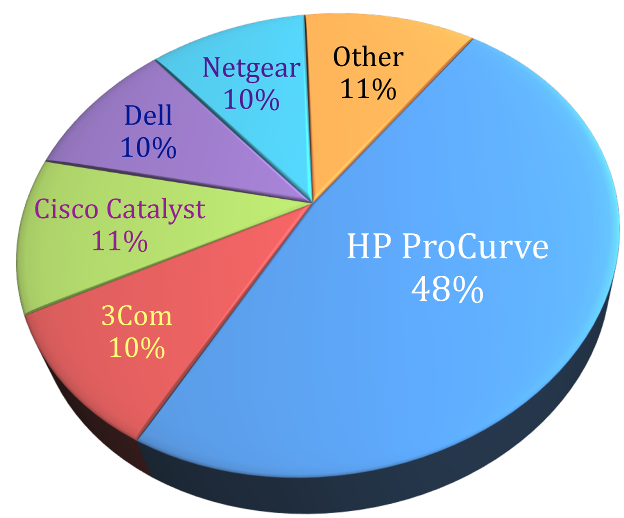

Figure 45—Distribution of switches by vendor over sites surveyed

Table 13—Switch deployments by vendor and community

Switch Vendors	3Com	Adtran	Cisco	Dell	D-Link	HP	Linksys	NetGear	Other	Totals
Barnstable	1	1	10			33		4	3	52
Barnstable County		1	28							29
Bourne	2		2	2		85		1	1	93
Brewster	7		1					3		11
Chatham			10			10				20
Dennis			3			13				16
Dennis-Yarmouth Regional School District				49		19		4		72
Eastham		5						4		9
Falmouth	3			9	1	5			4	22
Harwich	1			1		26		6		34
Independent Schools	3	1			4	20		4		32
Mashpee		2				18	2	2	1	25
Nauset Public Schools					12	16				28
Orleans			1			7	3	2		13
Provincetown	1		2			8	1	6	2	20
Sandwich	36	1	10		7	25			1	80
Truro	2		1		3	4		5	1	16
Wellfleet					1		1	5		7
Yarmouth	3		2			4	1	19	2	31
Total	**59**	**11**	**70**	**61**	**28**	**293**	**8**	**65**	**15**	**610**

This is in sharp contrast to the pricing models used by Cisco for their Catalyst line, where annual maintenance fees are required to be able to update firmware. A general impression is that Cisco switches are being displaced by newer models from other vendors. The survey teams saw very few instances of new or recent Cisco deployments.

NetGear is quite popular on the Cape in the lower end of this product space—*i.e.,* for switches ranging from 4 to 24 ports. This is likely due to the relatively low cost of these switches, as well as their general availability in the market. These switches are easy to acquire and easy to deploy.

Dell switches are likely being acquired based on the popularity of their servers, and their pricing can be fairly aggressive in the mid range. Their business model is closer to HP's than Cisco's. Dell has also recently acquired SonicWALL, the most popular firewall vendor for Cape communities (see below).

Table 13 presents the count of switches found during the survey by vendor and community. This helps to show which vendors are preferred by community and the relative distributions. Again, unit counts can be deceiving, given the extreme breadth and diversity of switch types deployed. While HP's numbers are high in terms of the unit counts, there is strong evidence that their relative position would be even greater if the distribution were to be based on acquisition cost or port counts.

Wireless LANs

Wireless LANs are clearly growing in popularity, especially in schools. However, we heard from all types of communities about plans to expand wireless LANs, or growing demand for more wireless services. There are two factors driving interest in wireless systems, (1) the increasing popularity of all types of mobile devices, and (2) the ability to provide data communications to more locations without having to rewire or upgrade in-building wiring.

Table 14 shows how many sites in each community were determined to have wireless or Wi-Fi support, and whether public Wi-Fi access is provided. We also show how many sites claimed not to have any wireless support. For the most part, libraries offer public Wi-Fi access, usually leveraging the "free" Comcast Internet connection. Town Halls also commonly offer public Wi-Fi, as do many schools and various other sites, such as community centers or Councils on Aging.

Table 14—Distribution of sites supporting Wi-Fi by community

	Wi-Fi support	Public Wi-Fi	No Wi-Fi
Barnstable	16	7	6
Barnstable County	7		
Bourne	8	7	2
Brewster	6	3	1
Chatham	8	7	3
Dennis	6	4	4
Dennis-Yarmouth Regional Schools	3		4
Eastham	5	3	1
Falmouth	8	4	2
Harwich	7	5	1
Independent Schools	4	2	
Mashpee	8	6	2
Nauset Public Schools	6		2
Orleans	5	2	1
Provincetown	7	2	
Sandwich	12	5	3
Truro	5	4	
Wellfleet	6	3	
Yarmouth	7	3	1
Total	**134**	**67**	**33**

The push toward greater use of wireless LANs is a broad industry movement that is being fueled with technological advances and better products in the market. It is becoming easier to deploy wireless access points (APs), and easier to integrate them into a more comprehensive network. As one illustration, the Barnstable schools have been deploying some HP ProCurve MSM317 wireless APs, which replace the jacks in a standard wall outlet box with a wireless AP and a 4-port switch. The result is what appears to be a new wall jack panel, but where there are now five jacks where there might have previously been only one, plus the wireless AP is hidden inside the wall. The appeal of such a device in a school hobbled with older wiring is obvious. Other vendors are offering similar integrated solutions.

There is increasing interest in deploying many wireless APs within a single building or campus, but where all APs operate in a coordinated manner, potentially allowing users to roam within the building or across a campus. This generally requires some system for controlling the wireless APs, a feature that is now becoming common on higher end Ethernet switches, or as modules that can be added to existing switch frames, or even as standalone controllers. The survey team encountered a moderate number of schools that have already deployed wireless controllers, and a couple of schools have maxed out the number of wireless APs that can be supported by a single controller. The raw survey results can be used to find the locations where wireless controllers have been deployed, as well as the models used. Most wireless controllers encountered during the survey were HP, either standalone controllers, or modules added to HP switch frames.

Alternatives to wireless controllers include new breeds of "controller-less" wireless APs. The Cape Cod Technical High School has deployed Aerohive controller-less APs and has found them to work well in a demanding environment. The Wellfleet library has deployed OpenMesh wireless APs that also operate without controllers. Both product families are also able to utilize mesh wireless links to extend a network without the requirement to run wires to every AP.

One challenge the survey teams encountered was actually finding wireless APs, never mind counting them. In many cases, wireless APs were located where reception was best, which might be above ceiling tiles or on top of a tall bookcase. In schools, the APs are frequently hidden to reduce the temptation for students tampering with these devices. Often the people escorting us within their buildings did not know what type or brand of wireless AP they used. Therefore, the data captured is not as detailed as for other types of equipment.

Figure 46 shows the distribution of wireless APs by vendor observed by the survey teams. While the actual percentages might vary somewhat with better data, the overall situation would probably be similar.

Again, HP is the dominant vendor, with most of the HP wireless APs deployed in schools. HP also accounts for the majority of APs used with central controllers.

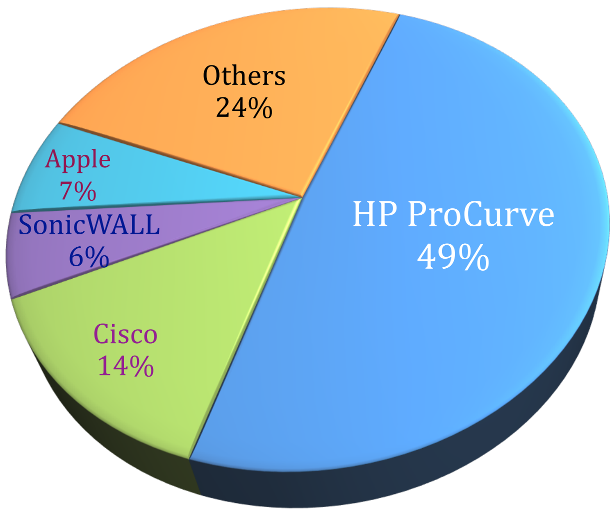

Figure 46—Distribution of wireless access point models by vendor.

The Cisco brand also includes some Linksys models. Most of these were standalone models, even though Cisco is a popular vendor for centrally controlled wireless APs. We did not encounter many Cisco wireless controllers, though. However, the County Complex does use a Cisco wireless controller, and many of the wireless APs deployed in the Complex appear to be centrally controlled Cisco models.

Apple wireless "Airport" models are popular with some of the schools, and these models are very easy to set up and manage. They also have solid reputations for better than average performance and reliability.

SonicWALL wireless devices were the only other brand to rise above a couple of percentage points. There are two types of SonicWALL wireless products, the SonicPoint family of basic wireless APs, and SonicWALL firewalls with wireless support built in. Both were encountered, but the latter type makes good sense for smaller sites where a firewall is needed anyway. These integrated firewall-plus-wireless devices also include built-in switches supporting a half dozen ports further enhancing their utility for small sites. Some of the "other" types of wireless APs were also integrated firewall devices.

Two other Wi-Fi deployments are worth noting. The Wellfleet Library uses OpenMesh wireless access points (see Figure 19 in the Field Guide), which are controller-less, but able to operate as a unified system. The Cape Cod Regional Technical School uses Aerohive wireless access points that also operated as a unified wireless system without a central controller.

Firewalls

Wherever there is a connection into the public Internet, there should be a firewall. For the most part, the survey confirmed that firewalls were deployed wherever expected, though there were a few outlier situations where a Comcast Internet connection was used without any firewall, but these situations were typically only found for libraries where the free Comcast connection was made directly available to the patrons.

In general, there were two strategies used by communities for deploying firewalls. Firewalls were either deployed on a per site basis, or at a central site with other sites connecting over a town or school network to access the Internet via the central firewall. While it is also possible to centrally manage firewalls distributed at remote sites, we did not encounter anyone doing this.

The per-site model is also frequently associated with use of VPN tunnels to connect a site to a town/school network. In addition to providing Internet access, the same firewall also establishes the VPN tunnel to one or more other sites.

At central sites, or sites with a heavy Internet traffic (*e.g.,* a large High School), it is common to also provide application-aware firewall services, such as email spam filtering, web content controls, malware detection, and intrusion prevention. Frequently, these functions are distributed across multiple network appliances, which are essentially specialized servers. For example, Barracuda appliances are popular for spam filtering and sometimes for web content filtering, including malware blocking.

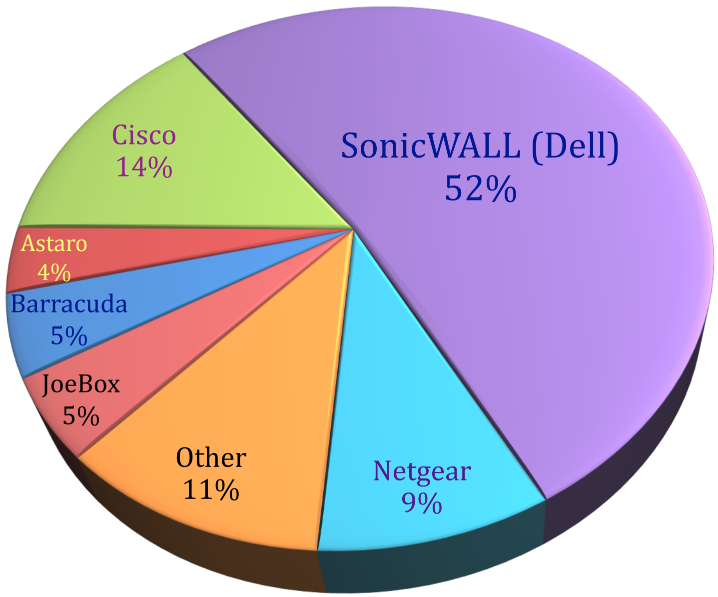

Figure 47—Distribution of firewall models by vendor.

Another point worth noting with firewalls is that some sites rely on a firewall management service. This is essentially a remote organization that handles configuration of the firewalls, as well as monitoring, log reviews, and updating firmware and databases used to scan for spam, malware, or inappropriate content. This makes sense as managing firewalls is a time-consuming activity that requires specialized expertise. Bourne and Dennis are examples of towns that utilize an outside service for managing their firewalls. However, MEC also bundles this service with their Internet service offering for schools. MEC uses a "JoeBox" appliance for this service, which is unique to MEC and one other similar ISP. This is essentially a branded network appliance running a Linux firewall software suite, and is similar to the Astaro or SonicWALL firewalls in this regard.

The distribution of firewalls by vendor for the surveyed sites is shown in Figure 47. As can be seen relative to the other vendor distributions, HP does not offer competitive firewalls, and so they are completely absent from this summary of vendors. Instead, SonicWALL takes the top spot, with approximately half the deployments by unit count. As a reminder, Dell has acquired SonicWALL, so this indicates that Dell's profile in network equipment is bolstered by this move, at least as far as Cape communities are concerned.

Cisco is the next most common vendor for firewall deployments; noting that in this case, Linksys models were counted separately from Cisco. The ASA 5505 and 5510 firewalls were the most common Cisco models observed.

NetGear is again popular in the lower end, and their firewalls are frequently used for VPN connections as well.

Most of the Barracuda models deployed were spam filters or web malware filters. These are not traditional network firewalls, but are application firewalls deployed as network appliances.

The JoeBox showed up in about 5% of the total units. However, these are only associated with MEC Internet connections.

Astaro has a loyal following, and is a well known Linux firewall with a long feature list. However, they have been acquired by Sophos, and the Astaro name is disappearing.

Security Cameras

While use of video cameras for monitoring purposes is primarily an application, deployment of cameras often involves special network deployments, and so these video systems are treated as specialized network equipment. Certainly, video cameras can be thought of as special-purpose network appliances.

We have used the common term *security cameras,* as this is what most people use to describe these video systems. The more accurate *surveillance cameras* or *video surveillance* terms are not politically correct, and the term *video monitoring* has not really caught on. It is just worth noting that many network-connected video cameras are not used as traditional security cameras, and most actually have multiple purposes.

As a general observation, most camera systems are deployed independently of other systems, often with dedicated wiring and separate network switches and servers for video control and recording. Some are managed under contract using companies that specialize in these types of video camera systems.

Nearly every police station has cameras, which are practically required these days for recording police interactions with suspects and for monitoring prisoner lockups. Another example of where security cameras are being required is at revenue collection points, such as beach parking lots.

A somewhat different application of cameras we encountered on the Cape is for monitoring harbors and marinas, as there is generally only one harbormaster who cannot possibly keep track of an entire harbor, never mind multiple harbors. Somewhat related are cameras used to monitor environmentally sensitive locations. These are large areas to keep tabs on; yet the potential for serious environmental damage from a single incursion is great.

By far, the largest deployments of cameras were at schools, and some of these camera systems were quite large, with dozens of cameras spread around the interior and exterior of a school. The recent sad events in Newtown will probably lead to even more camera deployments at schools. In particular, high schools and middle schools were more likely to have cameras, while elementary schools less likely. That will probably change as communities respond to concerns relating to the Newtown tragedy.

Table 15—Sites with or without security cameras by community. The Total column is provided to indicate how many sites have available data.

Security Cameras Deployed?	yes	no	Total
Barnstable	10	17	27
Barnstable County	1	3	4
Bourne	3	13	16
Brewster	5	2	7
Chatham	6	4	10
Dennis	3	7	10
Dennis-Yarmouth Regional Schools	7		7
Eastham		6	6
Falmouth	3	4	7
Harwich	2	5	7
Independent Schools	3		3
Mashpee	9	1	10
Nauset Public Schools	3	5	8
Orleans	1	4	5
Provincetown	9		9
Sandwich	3	11	14
Truro	4		4
Wellfleet	2	2	4
Yarmouth	2	7	9
Total	**76**	**91**	**167**

The survey teams attempted to determine where cameras were deployed, and to get rough counts. For smaller sites, it was often possible to get a reasonable camera count, as we could count the panels on the camera monitor display. However, at sites with large camera deployments, this was not a feasible option, and the people we spoke with generally did not have accurate counts of cameras, though a common answer to "how many cameras do you have?" was simply, "lots!"

We also attempted to capture information about whether cameras were IP based, or if they were analog cameras that relied on some sort of video converter to get onto a network. The majority appeared to be analog cameras, but in many cases, baluns were used to operate these cameras over the same category cabling used for data connections instead of running coax to the cameras.

Finally, we also noted when cameras were being recorded. This is typically done with a digital recorder, often using one or more servers with a lot of disk storage. However, there might be situations where the recorder for cameras at one site is actually located at another site.

Table 15 presents a summary of how many sites in each community were determined to have cameras, or not, but out of a sample size of 167 sites where we able to make a clear determination.

Cable TV Usage

The survey teams also tried to determine which sites do, or do not, use cable TV services. This turned out to be somewhat more difficult than expected. While it is relatively easy to see if amplifiers and cable splitters are deployed at the cable demarc point in a building, the real question is whether the TV cable distribution is actually used. In other words does anyone watch TV at that site?

In quite a few instances, it appeared that cable TV was distributed within a building, but when speaking with people locally, we often learned that TV has not been used for many years at the site, if ever.

This was particularly true at schools, where it seems that the cable company was happy to wire the building for TV in every classroom, but the schools haven't used TVs in years.

In other cases, we saw no sign of a video distribution system, but learned that a site did have cable TV in a break room.

Table 16 summarizes the number of sites using, or not using, cable TV by community. This is for a sample of 132 sites where we felt we could make this determination. The most common sites using cable TV are Firehouses, schools, and some DPW offices.

Table 16—Sites by community that use Cable TV. The Total column is provided to indicate how many sites have available data.

Is Cable TV used at Site?	yes	no	Total
Barnstable	3	17	20
Bourne		16	16
Brewster	7		7
Chatham	10		10
Dennis	3	6	9
Dennis-Yarmouth Regional School District	4	2	6
Eastham	5		5
Falmouth	5	2	7
Harwich	7	1	8
Independent Schools	2	1	3
Mashpee	3		3
Nauset Public Schools	7	1	8
Orleans	6		6
Provincetown	3		3
Sandwich	5	1	6
Truro	3		3
Wellfleet	2		2
Yarmouth	5	5	10
Total	**80**	**52**	**132**

Land Mobile Radio Systems

Every town, as well as the County itself, makes extensive use of land mobile radio (LMR) systems. These are largely the dispatch-type two-way radio systems that are the traditional backbone of public safety communications, and which are also used extensively for other mobile workers, including water departments, public works, parks departments, and even school districts. Unlike cellular-type systems, which are shared among many users, these are generally privately licensed, single-purpose systems operating on their own licensed frequencies.

The FCC license database notes over a hundred licenses issued to the County and towns, collectively covering thousands of individual radios, both mobile and base stations. These operate on several different frequency bands, each of which is subject to its own rules, and which have their own advantages and disadvantages. It appears that many of these licensed systems are no longer in active use, as most public safety users have migrated to a newer system operated and maintained by the Sheriff's Office, while many public works and other employees are making more use of commercial mobile radio systems (*e.g.,* cell phones) and are less dependent on LMR. Towns typically maintain their licenses even if they no longer need them. Nonetheless these systems play a crucial role in delivering emergency and routine services to the public.

Some issues exist, however, about transitions from locally-owned to regional or even national systems. While police and fire departments have adopted the 800 MHz radio system operated by the Sheriff's Office as the primary system, many individuals we spoke to incorrectly believe that OpenCape is building a new 700 MHz system. Originally, OpenCape was seeking a waiver to deploy a 700 MHz LTE cellular system for public safety and commercial use. However, a recent Federal initiative, FirstNet, plans to build a new nationwide public safety "broadband" network on the same 700 MHz band, and so no further waivers are being granted, and FirstNet will be the sole owner/operator of this new national system. This should support both voice and data applications, including interactive video. While FirstNet promises interoperability amongst its users, the existing Sheriff's system already provides voice radio interoperability across the Cape, so the immediate need is for an interoperable wireless data network spanning the Cape.

Ownership of radio systems is also related to undecided issues concerning a proposed Regional Emergency Communications Center (RECC), which will handle 911 calls for the entire county. Since the decision to move forward with an RECC has only recently been taken by the chiefs, much is up in the air until plans become firm.

Adding to the confusion is the fact that FCC rules require that LMR systems operating between 150 and 470[17] MHz adopt new narrowband standards as of January 1, 2013. This has obsoleted many existing radios and forced the purchase of newer equipment in the present time frame. Thus licensees have been forced to invest in upgraded systems that could have a relatively short economic lifespan. While LMR radios built since 1997 have generally been narrowband-capable, we note that many of the existing radios are even older, so replacement was overdue.

Two methods of narrowbanding are common. One is to continue to use FM technology, just with a narrower bandwidth, which results in a small loss of performance. Each radio then operates in a single 12.5 kHz instead of occupying a 25 kHz wide channel. The alternative is to move to a multiplexed digital system. The most common domestic standard for this is known as P25 (for APCO Project 25), which allows several simultaneous users to share a single 25 kHz channel by using low-bit-rate digital voice. While digital, P25 is based on aging (1990-era) TDMA technology. Given the greater complexity and much higher price of P25 radios, it is understandable that most users on the Cape have instead opted to remain with updated FM to meet the narrowbanding requirement.

Radio bands in use

LMR systems operate on several bands in the VHF (30-300 MHz) and UHF (300-1000 MHz) spectrum. As a general rule, newer systems operate on the higher UHF frequencies, most of which were reclaimed from television broadcasting use at some point over the past 30 years. We have noted operations by Barnstable County towns in all of these bands.

VHF Low Band 30-50 MHz

This band is the oldest one and lowest LMR frequency in general use today. It is largely seen as obsolete, as it is not well-suited for hand-held radios. More often it is used with larger vehicle-mounted (*e.g.,* police cruiser, fire truck, DPW truck) radios with large external antennas. Its other major disadvantage is that it is prone to interference from *skip* (ionospheric reflections of signals from up to 2000 miles away), especially during peaks of the 11-year sunspot cycle. But it is the least sensitive to rough terrain and obstructions, and thus may reach mobile units out of range of other systems. This is rarely a problem on the Cape, though it has been noted in hillier parts of the Upper Cape. Due to low demand, low band has not been subjected to narrowbanding requirements, so older radios can continue to be used in 2013.

Low band licenses are still extensively assigned to the Cape, with almost every public safety entity, and most water and public works departments still holding them. Most of the public safety systems have been retired, but low band is still widely used, especially by water and public works departments.

VHF High Band 150-174 MHz

This band is widely utilized, as it has good building penetration while being suitable to both hand-held and vehicle-mounted mobile uses. Non-narrowband radios have to be retired. Non-public safety users on the Cape holding licenses include highway departments, public works, harbormasters, and schools. We are not sure how many of these are still in use but it is likely that some number of narrowband radios have been procured for most of these activities.

UHF 450-512 MHz band

The UHF band is a workhorse of public safety, but nowadays has been largely relegated to a backup role on the Cape, as the 800 MHz system operated by the Sheriff's Office is now the primary system. In addition to public safety, this band is used on the Cape by water departments, among other town activities. Compared to lower bands, it is somewhat more dependent upon repeaters (relays operating at high places), but its building penetration is still better than the higher frequencies now being deployed.

700 MHz band

The 700 MHz band consists of frequencies removed from television broadcasting with the DTV transition. While most was auctioned off to mobile carriers, two blocks (both paired for full duplex use) were dedicated to public safety. One, the narrowband public safety block (PSB), is used for voice, and is licensed to and used statewide by the state police. The other, the broadband PSB, was allocated nationally to FirstNet in 2012. This block has long been subject to controversy, and the FirstNet plan is no exception. It is supposed to be funded by an "incentive auction" of television broadcast channels, in which (to over-simplify) TV stations may auction off their channels to mobile carriers, proceeds to be shared with the government. (A single DTV transmitter can carry multiple standard-definition programs at once, so stations can share a channel rather than go off the air.) Since the success of this auction is speculative, so may be the anticipated federal funding for FirstNet.

800 MHz band

The 800 MHz band, which sits adjacent to the original cellular frequencies, is now a workhorse of LMR. The Sheriff's Office operates and maintains an 800 MHz simulcast system for the entire cape, including licenses that cover several channels and over 3000 mobile units from about a dozen tower sites. This operates in a *trunked* mode, wherein one of a group of channels is allocated dynamically, by the repeater, to mobile users when they activate the push-to-talk button. Mashpee's water district also operates a trunked system. However, several police departments on the Cape operate conventional repeater systems in the 800 MHz range. (These radio systems are all new enough to have been built to current narrowband standards.)

Some fire departments have expressed concern about depending upon 700-800 MHz systems due to relatively poor in-building coverage. Whether this can be fixed by having better repeater locations, or whether lower-frequency radios will continue to be needed, may not yet be clear.

LMR Systems issues

In addition to the narrowbanding problem, less urgent but nonetheless serious issues impact many of the dispatch systems. Among these is the age of the radio consoles used by the dispatchers. Most are so old that they no longer receive manufacturers' support. An example of this is the Motorola Gold console, which is widely deployed, but no longer supported. Replacement may be deferred, however, pending a decision on the RECC, which could displace or relocate local dispatch positions.

Some systems, including the Sheriff's, make use of *simulcast* in order to cover a wider area than a single tower can. This generally involves having leased line transmission circuits connect multiple sites to a single control unit. All of the transmitters send the same signal on the same frequency. Each tower's receiver picks up the mobile unit's signal, if it can; a *voting* unit then selects the strongest received signal and uses that on the repeater. In order to avoid mutual interference problems between adjacent transmitters, the transmitters need to be phase-locked to the same frequency source (now typically GPS satellite signals), and the delay between the controller and each transmitter must be precisely tuned and held steady. The latter function is relatively easy to accommodate over terrestrial "T1" leased transmission lines.

Some vendors (notably Cisco, Raytheon, and Zetron) have been promoting Radio over IP, but this has been somewhat touchier in the field. As the cost of Verizon T1 circuits rises and their reliability deteriorates, it may be necessary to look for alternatives. OpenCape may be able to support this to the sites along its fiber; so could some I-NETs, depending on how they are lit. Some but not all microwave radios may also be suitable. Low-cost Ethernet microwave radios do not have the fixed latency (low jitter) required to support simulcast.

We have not been able to capture much information about the leased lines used within the Cape's current dispatch and simulcast networks, or circuits used for other LMR systems.

Note that FirstNet is based on LTE cellular technology, not simulcast. Thus a given mobile unit will connect to a single tower at any given time, with automatic *handoff* as the mobile unit moves between towers' coverage areas. This permits greater frequency reuse than simulcasting. It is thus possible that FirstNet may have spare capacity that it may lease out, on a secondary basis, to commercial users.

Application Platforms

The survey found a broad variety of server systems deployed throughout the County. We captured information about server vendors and models, and other details that could be observed by looking at the servers. We also asked for, and captured some details on the operating systems deployed on these servers, and whether or not virtualization is being used to allow a single server to host multiple virtual machines.

One point is worth noting about the servers actually deployed. Several communities were in the process of consolidating servers with the intention of decommissioning some of their older servers. There are also servers that have been kept around as repositories of older systems that are no longer in active use. For example, some of the police departments have transitioned to the IMC records management software in recent years, but they may still have the server that ran their older records management software available, should they need to search for older records. There are similar examples for some of older accounting packages where a newer accounting package is running on a newer server, but the older package is kept on its original server for possible recovery of data from prior years.

Figure 48 shows the distribution of server unit counts by vendor for the survey data collected. Dell has the largest count of servers with 44% of the total, but many of the Dell servers were older models. HP came in at 34%, but many of the HP systems are newer, and there was a general trend toward use of HP for higher end servers. For example, there are several instances of HP blade servers installed, but no examples of Dell blade systems that we observed. IBM servers represent 11% of the total, but as with HP, the IBM servers were relatively newer and tended to be higher end systems, though we did not see any instances of IBM blade systems.

The miscellaneous category includes a smattering of brands and systems ranging from older desktop tower systems being used as servers to custom-built generic server boxes, to some servers optimized for running Unix variant OSs. There are also some servers that are essentially network appliances running application gateways.

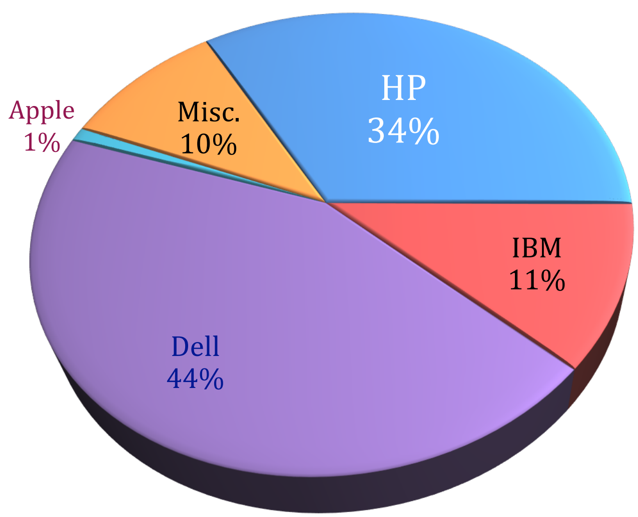

Figure 48—Distribution of servers by unit counts

In Figure 49, summary data showing the distribution of server operating systems by instance counts is shown. We were not always able to get accurate information about the operating systems running on servers, so this data may be skewed. What is clear, though, is that Windows Server 2003 is dominant, at least in the survey data. Again, since many towns and schools are upgrading servers and retiring older systems, it is likely that Server 2003 will decline in overall percentages. For the most part, it is being replaced with Windows Server 2008 R2, though some communities may start acquiring systems with Windows Server 2012, though we saw no instances of Microsoft's latest server OS during the survey. This is not surprising, as Server 2012 was only introduced in October.

The trend toward increased use of virtualization further complicates how server OS instances are counted. A single server system could be hosting multiple virtual machines, with each potentially being a different OS. A single virtualized blade system could be running dozens of virtual machines.

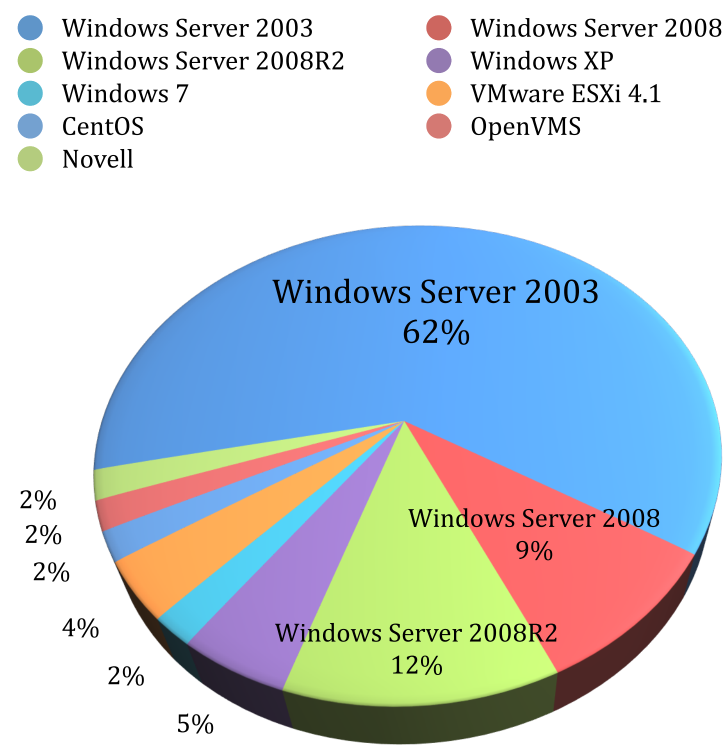

Figure 49—Distribution of Operating Systems by instance counts.

Information on the virtualization systems in use by the various communities was captured as shown in Table 17, and we believe this reflects the current usage throughout the County. In other words, we are not aware of any other communities employing virtualization other than those listed in the table.

Table 17—Use of virtualization platforms by Towns and Schools.

Town or School	Virtualization Platform	VMs
Barnstable, Town	VMware (Blades)	2003, 2008R2
Barnstable, Schools	ZENworks (Novell)	SLES 11, OES 11
Barnstable County	VMware (Blades)	2003, 2008R2
Bourne	VMware	2003, 2008R2
Brewster	HyperV on 2008R2 VMware on 2003	2003, 2008R2
Chatham	VMware	2003
Dennis	Citrix XenServer	2008R2
D-Y Schools	Citrix XenServer	2003, 2008R2, Netware
Mashpee	VMware on 2008R2	2003, 2008R2
Provincetown	VMware on 2008R2	2003, 2008R2
Truro	Citrix XenServer	2008, CentOS

Perhaps the key point of all of this is that the majority of towns are based on Microsoft Windows servers and client systems. Schools, on the other hand, are more likely to use non-Microsoft systems, both for servers and client systems, though Microsoft platforms are still quite prevalent in schools. Note, however, that some schools no longer use servers in the traditional sense, and have instead moved to "cloud" services.

Although we did capture information on client systems and the operating systems being used for clients, the data is so inconsistent it is not meaningful to aggregate. For some towns or schools, we have accurate numbers, but for other communities, the data is spotty. One key takeaway is that towns are a mix of Windows XP and Windows 7, with almost no instances of either Windows Vista or Windows 8 (again only introduced this past Fall), and only rare instances of Apple Mac OS. For the most part, towns are upgrading to Windows 7 as newer PCs are purchased to replace older PCs, though some may start introducing Windows 8. The budget challenges of the past few years have put several towns behind on their normal upgrade cycles, which has left a lot of Windows XP systems in active use.

The corresponding takeaway point for schools is that there is a mix of Windows PCs, Apple Macs, and tablets, both iPads and Android tablets. For PCs and Macs, the distribution across the County is about even. For tablets, it is a bit early to call trends, though iPads are more common at this time.

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Applications and Services Used by Communities

This subsection provides an analysis of the data collected about the applications deployed and services used by the communities of Barnstable County. We identified a total of 241 distinct applications used across the County. For each application we attempted to gather information about its use, initial cost, annual maintenance cost, version, and information about how the application is deployed (*e.g.,* standalone, client/server, or as a service). We were unable to get complete data, so the summary results are indicative, but not fully representative of the actual use of applications and services.

Recurring Costs

A summary of recurring application and service cost data collected by community is presented in Table 18. Note that this excludes costs of operating system software and common desktop applications (such as Microsoft Office), so the actual costs are higher. Furthermore, we were unable to get complete software recurring cost data for many applications, and no cost data at all from some towns and school systems. Therefore, the total costs by community and for the County as a whole are much higher than what is presented in this summary.

However, one application (MUNIS) accounts for more than 60% of the identified countywide recurring software expenditures. Furthermore, a total of 19 applications account for 90% of the County's recurring software expenditures based on the data available. This is summarized by application in Table 19 where applications with total costs above $10,000/year are listed along with totals.

One item worth noting is that if we had all cost data for IMC (police records management), then it would likely represent the second largest annual cost countywide, though still much less than MUNIS.

Another observation is that collectively, the financial and accounting software is the most expensive category, especially if cost data from school administrations were to be fully represented.

Recurring cost data exists for a total of 63 of the applications and services identified. Twelve of these applications each cost less than $1,000 per year across the County for software maintenance, and some applications and services have no recurring costs.

Table 18—Recurring software costs by community. Note that this reflects incomplete data, and so does not indicate the true cumulative costs.

Community	Recurring S/W Costs
Barnstable	$249,748
Barnstable County	$33,496
Bourne	$81,320
Brewster	0
Chatham	$106,208
Dennis	$207,194
D-Y School District	0
Eastham	$33,344
Falmouth	$21,884
Harwich	$64,824
Independent Schools	0
Mashpee	$152,739
Nauset Public Schools	0
Orleans	$62,198
Provincetown	$19,303
Sandwich	0
Truro	$57,821
Wellfleet	$ 54,954
Yarmouth	$77,242
Grand Total	**$1,222,275**

Applications Deployed Across Multiple Communities

Many applications are utilized by more than one community. Perhaps obviously, Microsoft Office and related programs, and versions of Windows, Windows Server, and Exchange Server are broadly deployed. Similarly, some services are popular across multiple communities. For example, the Google Gmail and Docs services are used by many schools, and some towns, probably more than indicated by the data currently in hand.

Table 19—Summary of major applications by total countywide annual recurring costs. Note this table reflects incomplete data.

Application	Category	Annual Cost
MUNIS	Financial & Accounting	$ 659,417
Vadar	Financial & Accounting	$ 59,147
PK	Assessor applications and services	$ 52,270
IMC	Public safety	$ 47,249
GeoTMS	Permits, licenses, inspections, beach passes	$ 38,424
SoftRight	Financial & Accounting	$ 36,400
ArcGIS	GIS	$ 23,550
Virtual Town Hall	Web sites and constituent electronic access	$ 23,470
Laserfiche	Document/content management	$ 20,142
Microstation	CAD/CAM	$ 17,006
Cisco Call Manager	Infrastructure	$ 15,000
Municity	Permits, licenses, inspections, beach passes	$ 13,973
AmbuPro	Public safety	$ 13,395
firewall		$ 12,300
Hawkeye	Permits, licenses, inspections, beach passes	$ 12,000
Blackboard Connect	Presentation systems	$ 10,200

The non-infrastructure and non-productivity software applications that are most broadly deployed are IMC, CLAMS, ArcGIS, MUNIS, PK, Bonsai Logic, and Laserfiche. Table 20 lists those applications that are deployed in more than three communities (with infrastructure and productivity software in gray text). Of the total number of applications identified across the County, 161 are only used by a single community. This does not include the many home-grown applications we learned about during interviews.

Table 20—Applications in use by community with infrastructure and productivity applications shown in gray.

Application	Category	# Communities Using Application
Office	Productivity	20
Windows 7	O/S	20
Windows XP	O/S	20
Windows Server	O/S	18
Windows Vista	O/S	18
IMC	Public safety	16
CLAMS	Library services	14
Access	Productivity	13
Exchange	Infrastructure	13
ArcGIS	GIS	11
MUNIS	Financial & Accounting	10
PK	Assessor applications and services	10
Bonsai Logic	Permits, licenses, inspections, beach passes	8
Laserfiche	Document/content management	8
ArcView	GIS	6
GeoTMS	Permits, licenses, inspections, beach passes	6
ImageTrend	Public safety	6
Destiny	Educational software	5
Gasboy	Public Works	5
Gmail	Productivity	5
MacOS	O/S	5

Application	Category	# Communities Using Application
Virtual Town Hall	Web sites and constituent electronic access	5
AmbuPro	Public safety	4
BackupExec	Management	4
Edline	Educational software	4
Firehouse	Public safety	4
Google Apps	Productivity	4
Rediker	Student Information Systems	4
Symantec Endpoint Protection	Infrastructure	4

Applications by Category

In order to make it easier to assess the data about applications, they have been grouped into categories. These categories, along with the associated applications are listed below. However, this is only a first level categorization, and in several cases, it would help planners to introduce subcategories.

- **Assessor applications and services**
  - AssessPro
  - PK
  - PK (online)
  - TaxMap
  - Vision Appraisal
- **CAD/CAM**
  - AutoCAD
  - AutoCAD Civil 3D
  - MicroStation
  - OrthoPro
  - PCDraft
  - TransCAD
- **Document/content management**
  - BrownTech image-plugin
  - Laserfiche
  - OmniForm
  - Pharos
- **Educational software**
  - Destiny
  - Edline
  - Edline
  - Lexia
  - Moodle
  - Smart Notebook
  - Study Island
- **Financial & Accounting**
  - BillMaster
  - BMSI
  - ComStar Billing
  - DataNational (WTI)
  - FundSense/Unifund (Tyler)
  - Government Revenue Management
  - Harpers Payroll
  - Infinite Visions (Tyler)
  - InvoiceCloud
  - MUNIS (Tyler)
  - QuickBooks
  - SoftRight
  - TENEX (Harris Computer Systems)
  - Vadar
- **GIS**
  - ArcGIS
  - ArcGIS Server
  - ArcInfo
  - ArcView
  - CommunityViz
  - GeoCortex Essentials
  - GeoMedia
  - LP360 for ArcGIS Basic
  - MapGeo
  - MapsOnLine
  - MapSource
  - PeopleForms
  - PeopleGIS
  - Trimble GPS Analyst Extension
- **Human resources**
  - SoftTIME
  - Telestaff
- **Library services**
  - 3M Self Checkout
  - CLAMS
  - Envision
  - LIMS
  - OCLN
  - SIP
  - Winnebago Spectrum
- **Infrastructure**
  - Astaro
  - AVG
  - Barracuda
  - Barracuda Virtual Spam Filter
  - Blackberry Enterprise Server
  - Cisco ASDM
  - DNS Made Easy
  - Exchange
  - SharePoint Server
  - SonicWALL
  - Sophos AV
  - SQL Server
  - Symantec BE
  - Symantec Endpoint Protection
  - Terminal Server
  - Terminal Services

- FatCow
- Forefront
- GFI Mail Essentials
- Kaspersky AV
- Kerio Connect
- LanGuard
- LogMeIn
- Malwarebytes
- MX Logic
- Norton AV
- OpenDNS
- PageNet
- PowerBroker
- Project Server
- RetroBDR
- RetroEYE
- Retrofit Backup
- Trend Micro Anti-Virus
- Unified Comm. Call Center
- Vipre
- VM Protect
- VMware OLP Windows Server
- VMware vCenter Server Std.
- VMware vSphere Enterprise
- vSphere Enterprise Licensing
- VSS Essentials ESX
- VTP
- Web Server
- WebEx Enterprise
- Windows Server Update Svcs.
- WorkgroupShare
- XenApp
- XenServer
- ZenWorks

- **Management**
  - BackupAssist
  - BackupExec
  - Carbonite
  - Deep Freeze
  - InterMapper
  - ManagerPlus
  - Mozy
  - Rove Mobile Admin Pro
  - Spiceworks
  - Support Central
  - vCenter
  - Veeam
  - Vueworks
  - WebSense
  - WhatsUp Gold
- **Mobile device management**
  - Maas360
- **Nutritional programs and cafeteria services**
  - Meal Pay Plus
  - NutriKids
  - NUTRIKIDS POS
- **O/S**
  - iOS
  - MacOS
  - OES
  - SLES
  - VMware
  - Windows 7
  - Windows Server
  - Windows Vista
  - Windows XP
- **Permits, licenses, inspections, beach passes**
  - AIMS
  - Bonsai Logic
  - GeoTMS
  - GeoTMS Permits On-Line
  - Hawkeye
  - Municity
  - Retrospect
  - WinWam
- **Presentation systems**
  - Cablecast
  - Carousel
  - Carousel BB
- **Productivity**
  - @mail
  - Access
  - Acrobat
  - Acrobat Professional
  - atmail
  - BusinessObjects
  - Creative Suite
  - Crystal Reports
  - Dragon
  - Dynamics CRM
  - FileMakerPro
  - Gmail
  - Google Apps
  - Google Calendars
  - Google Docs
  - GoToMyPC
  - GroupWise
  - InDesign
  - MailRoom Tool Kit
  - Office
  - Office Professional
  - OpenOffice
  - PhotoShop
  - Project Professional
  - SketchUp Pro
  - SPSS
  - Visio
  - Visual Studio
  - WS_FTP Professional
- **Public safety**
  - AmbuPro
  - CAMEO
  - Coastal Medical Billing
  - FireHouse
  - iMAS Vitals
  - IMC
  - IMC CAD
  - RA

- FirePoint
- ImageTrend
- RescueNet
- SNAP Health Center

- **Public works**
  - Comet Tracker
  - Equipment Tracker
  - Flex Web
  - FuelMaster
  - Gasboy
  - InOutTracker
  - SepTrack
  - Track Star
  - Track-It
  - WasteWorks
  - Water and Sewer tracking
- **Recreation**
  - Campground Master
  - Chelsea POS
  - DigitalRez
  - Jencess
  - ROS2006
  - SportsMan SQL Hosting
  - Tee Time
  - Vermont Systems Rec Trac
- **Specialized town services**
  - Access-based apps
  - CIMS
  - Cornerstone
  - DicksonWare
  - HyPack Max
- **Student Information Systems**
  - Aspen X2
  - Atlas Curriculum Mapping
  - PowerSchool
  - Rediker
  - RS4
- **Web sites and constituent electronic access**
  - Apache
  - Blackboard Connect
  - Cape Cod E-Com
  - CivicPlus
  - DreamHost
  - InHANCE
  - MyRec.com
  - MySeniorCenter
  - MyTownGovernment
  - OldCapeCod.com
  - OldCapeCod.net
  - Virtual Town Hall
- **Miscellaneous**
  - Bertram Consulting
  - CapeView
  - Case
  - ProjectWise
  - SchoolDude
  - TCS EBCTS
  - TrafficWare
  - ViewCommander
  - Vue Xstream
  - ZEPLAY

As can be seen from this list, there are a lot of applications and services, but there are also a lot of categories of applications in use. This application diversity represents a significant challenge for all communities, but is especially pronounced for towns. Town IT staff face a significant challenge dealing with such a broad base of applications.

Application use by category and community

This subsection presents a series of tables that show how application use is distributed across the communities by application categories. This same data can also be viewed in the full application data spreadsheet, where more elaborate analyses can be performed. Note that the following tables only list applications that are used by *more than one community.* However, the totals include all applications included in the associated category, which explains why some totals are higher than what is indicated in the table.

Table 21—Document/content management

Applications \ Communities:	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	Eastham	Falmouth	Harwich	Mashpee	Orleans	Provincetown	Sandwich	Truro	Wellfleet	Yarmouth	Grand Total
Total	**1**	**1**	**1**	**1**		**1**		**2**	**1**	**1**		**1**				**1**	**11**
Laserfiche	1		1	1		1		1	1			1				1	8

Laserfiche is the only document/content management application in wide use. This application was frequently characterized as “underused.” The reasons appear to often relate to a combination of reticence by some departments to embrace paper elimination, plus budget constraints that have put some projects on hold that were converting existing paper records to electronic documents.

Falmouth is an example of a Town taking some different approaches to addressing the problems of too much paper.

Table 22—Assessor Applications

Applications \ Communities:	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	Eastham	Falmouth	Harwich	Mashpee	Orleans	Provincetown	Sandwich	Truro	Wellfleet	Yarmouth	Grand Total
Total	**1**		**1**	**2**	**1**	**1**	**1**	**1**	**1**	**2**	**2**			**2**	**1**	**1**	**17**
PK			1	1	1	1	1		1	1	1			1	1		10
PK (online)				1						1	1						3
Vision Appraisal	1															1	2

Paul Kapinos (PK) Systems is widely used by assessors' offices on the Cape, along with their online service that allows constituent access to assessor databases. It is noteworthy that assessors and appraisers seem to place a high value on this application, and they regard PK Systems as a responsive vendor that they rely upon for more than just software and services.

Vision Appraisal was the only other significant application used by assessors and appraisers.

Table 23—Educational software

Communities: / Applications	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	D-Y Schools	Eastham	Falmouth	Harwich	Mashpee	Nauset Schools	Orleans	Provincetown	Sandwich	Truro	Wellfleet	Yarmouth	Grand Total
Total		**1**	**2**				**2**		**3**			**3**		**1**	**1**	**2**			**15**
Destiny			1				1		1			1				1			5
Edline			1									1		1	1				4
Moodle							1		1										2
Study Island												1				1			2

The category of educational software is complex with many diverse products. It would probably be worthwhile to convene a set of educators to better define this category and come up with further subcategories. From a planning perspective, it would help to determine which applications are important to the future of education, versus applications that are declining in relevance.

With the move toward greater use of cloud services by schools, it would be worthwhile to understand if any of these applications will move further into the cloud, or be displaced by new cloud services.

Table 24—Financial and accounting applications

Communities: / Applications	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	D-Y Schools	Eastham	Falmouth	Harwich	Mashpee	Nauset Schools	Orleans	Provincetown	Sandwich	Truro	Wellfleet	Yarmouth	Grand Total
Total	**1**	**1**	**1**	**4**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**1**	**1**	**1**	**2**	**2**	**3**	**1**	**27**
BillMaster				1											1				2
BMSI				1													1		2
Harpers Payroll																1	1		2
MUNIS	1	1				1		1		1	1		1	1		1		1	10
QuickBooks				1							1				1				3
SoftRight			1									1							2
Vadar				1	1												1		3

Financial and accounting software was found to be the “big ticket” application, with by far the highest price tags seen in the County. Tyler Technologies dominates with MUNIS, but also owns FundSense and Infinite Visions, accounting applications popular with schools. Further discussion of this category is provided in the next subsection.

SoftRight and Vadar are the direct competitors to MUNIS, with DataNational (WTI) only used by Sandwich.

Quickbooks is used widely, but on a more *ad hoc* basis. Some departments use it as a reporting tool for local management, while other departments use it for parallel accounting. We understand that some independent Water districts use QuickBooks.

Table 25—Graphical Information Systems (GIS)

Applications / Communities:	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	Eastham	Falmouth	Harwich	Mashpee	Orleans	Provincetown	Sandwich	Truro	Wellfleet	Yarmouth	Grand Total
Total	**7**	**5**	**1**	**1**	**4**	**1**	**2**	**2**	**1**	**3**	**1**	**1**	**2**	**1**	**1**	**1**	**34**
ArcGIS	1			1	1			1	1	1		1	1	1	1	1	11
ArcInfo	1	1															2
ArcView	1	1	1			1	1				1						6
MapsOnLine					1			1									2
PeopleForms					1					1							2
PeopleGIS					1		1			1							3

GIS is widely deployed in the County, but as with document management, it was frequently described as underutilized. The reasons appear to relate strongly to lack of staff trained to use this tool. Another factor is that GIS is of interest to multiple departments, but in most towns, no one department has the critical mass of expertise to make effective use of GIS. Towns that have dedicated GIS resources able to work across departments seem to be better able to leverage GIS tools and databases.

ESRI is the dominant vendor, with both standalone Arc-family products as well as a couple of instances of client-server system deployments.

The online services that allow constituent access to GIS information are popular, though their future is uncertain.

Table 26—Permits, licenses, inspections and passes

Applications / Communities:	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	Eastham	Falmouth	Harwich	Mashpee	Orleans	Provincetown	Sandwich	Truro	Wellfleet	Yarmouth	Grand Total
Total	**1**	**1**	**2**	**1**	**1**	**2**	**1**	**1**	**2**	**3**	**2**	**2**		**1**	**1**		**21**
Bonsai Logic			1			1	1		1	1	1			1	1		8
GeoTMS				1	1	1			1	1	1						6
Hawkeye			1									1					2

With the countywide “ePermit” pilot underway, there is a “wait and see” attitude toward existing applications that handle permits, licenses, inspections and passes. Due to the revenue generating nature of these applications, they rate as important to the Towns.

Bonsai Logic, GeoTMS, and Hawkeye are the only applications that were used by more than one town (based on survey results), but there are several other applications used in this category, as illustrated by the Total row.

Table 27—Public Safety applications and services

Applications \ Communities:	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	Eastham	Falmouth	Harwich	Mashpee	Orleans	Provincetown	Sandwich	Truro	Wellfleet	Yarmouth	Grand Total
Total	**2**		**2**	**2**	**3**	**2**	**3**	**5**	**2**	**5**	**3**	**1**	**3**	**3**	**3**	**2**	**41**
AmbuPro			1						1	1	1						4
CAMEO								1					1				2
Firehouse					1	1	1				1						4
FirePoint										1			1				2
ImageTrend				1	1		1							1	1	1	6
IMC	1		1	1	1	1	1	1	1	1	1	1	1	2	1	1	16
SNAP Health Center	1							1									2

Overall, public safety applications represent the second most costly category after financial and accounting.

Records management applications are vital to modern law enforcement practices, and the police department on the Cape have all adopted IMC (TriTech), thereby facilitating information sharing. Furthermore, the Sheriff's Office operates an "IMC Hub" that allows limited online access to data across jurisdictional lines.

The new mandates for Electronic Patient Care Reporting (EPCR) have forced Fire Departments to adopt new applications for use by ambulances and rescue trucks. This appears to have resulted in elimination of older applications that focused on fire response tracking. Most fire/rescue departments expressed some dissatisfaction with the state of their applications and suitability to their needs.

Table 28—Public works applications

Applications \ Communities:	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	Eastham	Falmouth	Harwich	Mashpee	Orleans	Provincetown	Sandwich	Truro	Wellfleet	Yarmouth	Grand Total
Total	**1**	**2**	**3**	**1**				**4**		**2**	**3**	**2**	**1**	**1**	**1**		**21**
DataNational								1					1				2
Gasboy			1	1						1		1		1			5
WasteWorks			1								1				1		3

Public Works probably represents the largest labor and expense category after schools. The survey came across a plethora of applications in use, including some home-grown applications, often based on Microsoft Access.

Given the complexity of this category, further analysis would benefit from dividing this category into multiple subcategories, such as fuel management, vehicle maintenance, waste management, engineering, project management, and human resources tracking.

Table 29—Recreation applications and services

Applications / Communities:	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	Eastham	Falmouth	Harwich	Mashpee	Orleans	Provincetown	Sandwich	Truro	Wellfleet	Yarmouth	Grand Total
Total	**1**							**1**	**1**				**2**	**1**	**1**	**1**	**8**
ROS2006								1					1				2
Tee Time									1							1	2

Applications that help communities manage recreational resources and activities are of considerable importance to the towns of Barnstable County, where recreation is an important part of community life, and the local economies. Some recreational activities are revenue generators for the towns, especially golf and beach passes or parking.

The only applications identified by this survey that are in use by more than one town are golf course management services. However, the MyRec.com application is also used by two towns, though it has been categorized as "constituent access."

Table 30—Web sites and constituent electronic access services

Applications / Communities:	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	Eastham	Falmouth	Harwich	Mashpee	Orleans	Provincetown	Sandwich	Truro	Wellfleet	Yarmouth	Grand Total
Total				**2**	**2**	**1**	**1**			**3**		**2**	**2**		**1**		**14**
MyRec.com										1			1				2
Virtual Town Hall					1	1	1			1					1		5

Every town seems proud of its web site, and relies upon web services to improve constituent access and information sharing. Several town managers commented on the importance of the web as a way to stay in touch with seasonal residents, and to allow summer renters to order passes in advance of their arrival.

Virtual Town Hall is the only web service used by more than one town. Attitudes toward this service are mixed, with some disappointment in performance and cost.

Chatham's use of "MyTownGovernment" is noteworthy.

Financial and Accounting Applications

As already noted, the category of financial and accounting software turned out to represent the most expensive category by far, with the MUNIS application from Tyler Technologies representing the largest source of software maintenance recurring costs across the County. The directly competing packages from SoftRight, Vadar and WTI (DataNational) appear to have annual maintenance costs that are in the same ball park as MUNIS.

The cost data for this category reflects only financial/accounting software used by town administrations, and not the schools. It would appear that many schools use their own financial software, and these costs were not captured. The regional school districts of Dennis-Yarmouth, Monomoy (Chatham and Harwich) and Nauset need their own financial systems, as do the regional technical high schools and the independent charter schools. There are also at least a couple of cases where town school systems use their own financial packages.

Similarly, water districts and fire districts operate autonomously in many cases, and so need separate financial systems. However, there is often a requirement to integrate with town systems in order to coordinate billing and tax accounting.

The Town of Falmouth warrants further discussion, as they have for many years independently maintained their own version of the MUNIS software. When MUNIS decided to leave the VMS platform back in the early 1990s, Falmouth invoked their option to take over maintenance of the software, and they have been running their own independently maintained version of MUNIS ever since. For the past 13+ years, Falmouth's MUNIS variant has been running on the Town's Alpha server under OpenVMS. A separate OpenVMS installation operates at the High School for use by the School Administration. While Falmouth has not incurred vendor maintenance fees over the past two decades, they have had to invest IT staff labor in maintaining this software themselves. Faced with staffing cutbacks and the increasing complexity of modern financial and accounting software and more reporting mandates from the Commonwealth, Falmouth has decided to transition to a commercial package that will be supported by the vendor. However, their procurement process extended past the data collection phase of this survey project, and so new cost information is not available to include in this report.

One additional point worth noting about Falmouth is that the Town has been able to better integrate their version of MUNIS with other applications used by Town Departments. During the interviews, some Falmouth Departments noted that they have benefited directly from integration they felt could not have been achieved with a different model. As a result of its unique experiences, Falmouth could probably share useful lessons that could be helpful in new planning initiatives.

While there seemed to be a general consensus that financial and accounting software is expensive, this application category is absolutely vital to town, school, and water district administrations. Furthermore, it has evolved to become complex software that often does much more than just keep accounting records. For example, budgeting is an integrated capability in most of these packages, as are human resources and labor tracking. There is clearly significant benefit being provided to the communities from use of these software packages, including productivity benefits. In some cases, the productivity gains may not be visible, as new requirements and State mandates have increased the administrative burdens on local communities, but with reduced impact due to the productivity benefits provided by these modern applications.

Given the outsized cost of MUNIS relative to all other applications, the survey team made a concerted effort to acquire actual invoices from each of the towns using this application. These invoices provided much more detail on the many optional modules actually used by the towns. Each option has its own annual cost, which is detailed in Table 31. The distribution of costs for MUNIS options in aggregate across the County is shown in Figure 50.

The standout option in terms of cost is hosting of MUNIS by Tyler, which the towns of Dennis and Truro have elected to use. These towns do not have MUNIS running on their own local servers, and instead utilize servers operated by Tyler, with the Internet used for access to these servers. This reduces the burden to these two towns for supporting MUNIS locally, but the annual cost for this service is soberingly expensive. In fact, the data indicates that this is the most expensive option on a countywide basis, with just two towns. At the same time, several towns expressed a desire to outsource operation of MUNIS, but felt that the cost was beyond what they could justify in operational cost savings or other benefits. Several town managers/administrators expressed interest in consolidating MUNIS operations at a County level as a way to achieve outsourcing benefits in an affordable way.

A final point worth noting is that Tyler Technologies has acquired other software firms that provide administrative applications used by some departments. In particular, FundSense (UniFund) has been acquired and integrated into another acquisition, Infinite Visions, which is used by a couple of school systems. As a result, the role of Tyler as a vendor is even more significant.

Figure 50—This bar chart shows how the various MUNIS optional modules and services are distributed in terms of annual cost on a countywide basis. Note that in several instances, only one or two communities are using an option.

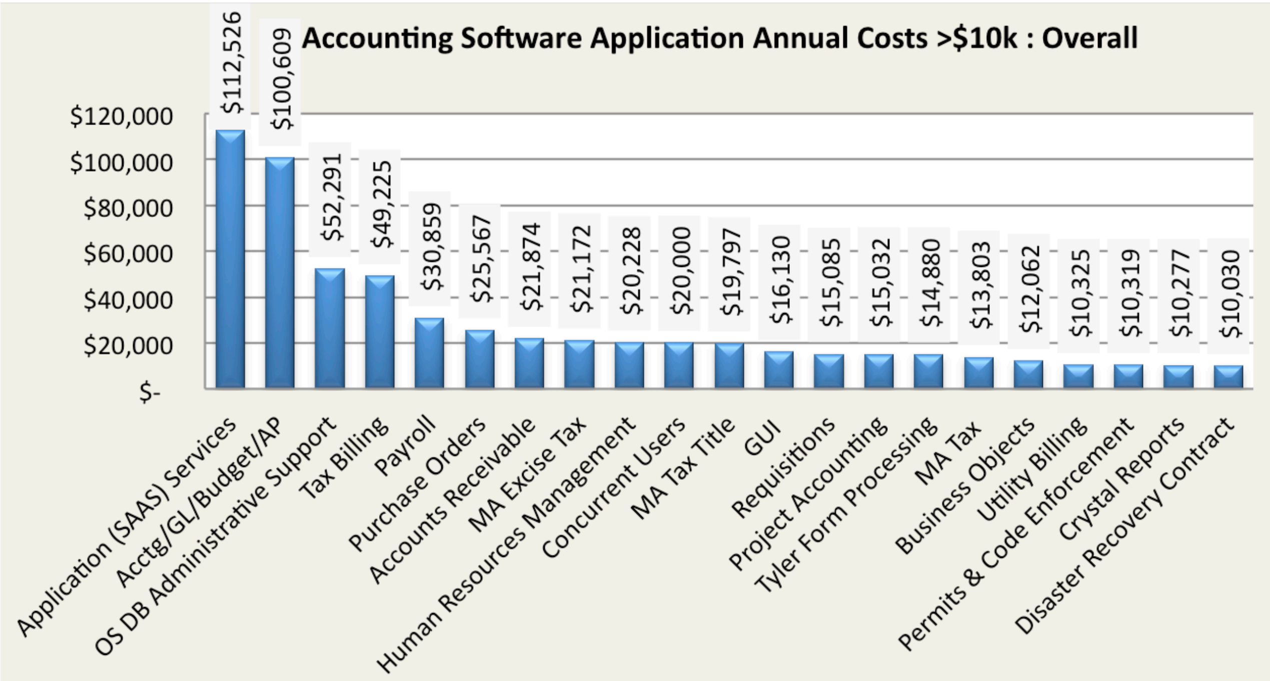

Table 31—Summary of annual costs per Town for MUNIS broken out by option/service.

Town	Barnstable	Barnstable County	Bourne	Brewster	Chatham	Dennis	Eastham	Falmouth	Harwich	Mashpee	Orleans	Province-town	Sandwich	Truro	Wellfleet	Yarmouth	
How run (server, SAAS, self)	server	server	server	server	server	SAAS	server	self	server	server	server	server	server	SAAS	server	server	
Annual support bill through	?	Dec-12	n/a	n/a	n/a	Jun-13	Feb-14		Oct-12	Jun-13	Jul-12	Jun-13	n/a	Jan-13	n/a	Jan-13	
MUNIS Application	MUNIS	MUNIS	SoftRight	Vadar	Vadar	MUNIS	MUNIS	MUNIS (Self)	MUNIS	MUNIS	MUNIS	MUNIS	Data National	MUNIS	Vadar + BMSI	MUNIS	Totals
Accounts Receivable	$ 9,769					$ 2,495	$ 975		$ 1,516	$ 2,653	$ 884	$ 928				$ 2,654	$ 21,874
Acctg/GL/Budget/AP	$ 42,455	$ 6,995				$ 10,962	$ 2,913		$ 6,662	$ 12,603	$ 2,642	$ 2,774				$ 12,604	$ 100,609
Applicant Tracking	$ 2,123																$ 2,123
Application Services (SAAS fee, billed quarterly)						*$ 80,841*								*$ 31,685*			$ 112,526
Boat Excise	$ 2,211					$ 1,490	$ 968		$ 962	$ 1,106	$ 878	$ 921				$ 1,106	$ 9,642
Bid Management		$ 530															$ 530
Business & Vendor Self Service		$ 945															$ 945
Business Objects	$ 8,041															$ 4,021	$ 12,062
CAMA Bridge												$ 1,106				$ 1,474	$ 2,580
Citizen Self Service																$ 2,654	$ 2,654
Concurrent Users						$ 20,000											$ 20,000
Crystal Reports		$ 1,291				$ 2,709			$ 1,914	$ 3,134	$ 1,230						$ 10,277
Disaster Recovery Contract		$ 5,000									$ 5,030						$ 10,030
Employee Self Service		$ 1,134														$ 1,448	$ 2,582
Fixed Assets											$ 1,011						$ 1,011
General Billing	$ 3,377	future				$ 1,134	$ 382		$ 689							$ 1,206	$ 6,788
GUI	$ 6,000	$ 1,650					$ 720		$ 1,500	$ 1,650	$ 960	$ 950				$ 2,700	$ 16,130
Human Resources Mgt.	$ 4,824	$ 1,858				$ 4,347	$ 1,951		$ 1,768	$ 1,854	$ 1,769					$ 1,858	$ 20,228
IBM (Informix) IDS V10									$ 2,933							$ 0	$ 2,933
MA Excise Tax	$ 7,036					$ 2,980	$ 1,618		$ 2,106	$ 2,211	$ 1,468	$ 1,541				$ 2,212	$ 21,172
MA Tax						$ 9,933	$ 3,870										$ 13,803
MA Tax Title	$ 5,863					$ 2,980	$ 1,548		$ 2,106	$ 2,211	$ 1,404	$ 1,474				$ 2,212	$ 19,797
MUNIS Office		$ 664				$ 1,890	$ 697		$ 1,149	$ 2,050		$ 663				$ 2,051	$ 9,164
OS DB Administrative Support		$ 4,761					$ 4,465		$ 9,819	$ 12,702	$ 5,030	$ 3,571				$ 11,943	$ 52,291
Payroll	$ 7,960	$ 2,798				$ 6,237	$ 2,938		$ 2,665	$ 2,798	$ 2,665					$ 2,798	$ 30,859
Permits & Code Enforcement	$ 10,319																$ 10,319
Project Accounting	$ 7,236	$ 796							$ 1,378	$ 2,412		$ 796				$ 2,412	$ 15,032
Project and Grant Accounting						$ 2,268											$ 2,268
Purchase Orders	$ 11,338	$ 1,858				$ 2,911			$ 1,768	$ 2,894	$ 1,011	$ 893				$ 2,894	$ 25,567
Requisitions	$ 8,443	$ 1,206				$ 1,890			$ 1,134	$ 2,412							$ 15,085
Role Tailored Dashboard Maint.																$ 1,530	$ 1,530
Tax Billing	$ 20,269								$ 7,020	$ 7,371	$ 3,510	$ 3,686				$ 7,370	$ 49,225
Treasury Management										$ 1,800							$ 1,800
Tyler Content Manager		future								$ 2,412						$ 2,858	$ 5,270
Tyler Form Processing	$ 4,020	$ 2,010				$ 1,575			$ 1,914	$ 2,680						$ 2,680	$ 14,880
Tyler Postal Xpress									$ 1,781								$ 1,781
Utility Billing	$ 3,497								$ 3,331							$ 3,497	$ 10,325
Utility Billing CIS											$ 1,654						$ 1,654
Utility Billing Interface									$ 1,011							$ 1,062	$ 2,073
	$ 155,012	$ 33,496	$ 36,400	$ 0	$ 54,779	$ 154,147	$ 22,069	$ 0	$ 53,608	$ 64,301	$ 30,262	$ 18,375	$ 0	$ 31,685	$ 15,196	$ 74,588	**$743,918**

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Planning Opportunities

The primary purpose for conducting this survey of communications and information technology on a countywide basis is to facilitate planning by the individual communities, by groups of towns or schools, or on a regional basis. The quantitative information gathered about what is currently deployed, the applications in use, and services utilized should help with overall assessments, and in determining the scope and scale of new plans. Qualitative information about what is working, or not working, as well as needs of the various communities and the challenges they are confronting, should help determine where plans are needed, as well as in setting priorities.

The survey team has also been asked to comment on the role that regional planning could play in constructively setting directions for new communications and information technology initiatives, and to offer suggestions for specific planning initiatives the region might consider pursuing. The purpose of this section is to characterize the role of planning, to propose some key goals and objectives, and to offer suggestions for areas where planning could have a positive impact on the local institutions (towns, schools, etc.) and the region as a whole.

The Planning Imperative and Challenges

The fundamental planning imperative is to *substantially improve the ability for local institutions to capture information continuously, manage information over potentially long life cycles, and make information readily accessible.* Local institutions are vital conduits for highly relevant and necessary information, but efficiently capturing information has been a challenge. Unlike the commercial world, governments are responsible for maintaining information over long, and even very long life cycles—for generations and perhaps millennia. And, as democratic institutions, information captured and maintained must be accessible to citizens and businesses, as well as to other government agencies, with exceptions where individual privacy must be protected or sensitive information maintained.

What is new is the need to plan comprehensively for the effective use of *information technologies and communications.* Yes, we are well into the information age, and local governments and institutions have reaped many benefits from the changes, but it is proving difficult to keep up with the transformations taking place throughout our society. Perhaps the greatest concern is that local governments and institutions are not benefitting as much as they should from modern information and communications systems. With budgets continuing to be tight, new ways must be found to improve efficiency and the value of services provided to constituents.

Towns are geographically fixed so they cannot move to where operations would be less expensive or easier to conduct.

Some of the challenges that must be confronted in devising strategies for improving the utility of information systems include:

- Achieving consensus on goals and objectives
- Factoring political concerns and realities into the planning process
- Establishing a holistic approach to planning that engages everyone
- Finding the leadership to drive and coordinate planning efforts
- Maintaining currency of information needed to inform the planning processes
- Planning for sustainability

None of these challenges are new to local governments. In fact, one could argue that dealing with these challenges on the local level is the role of government, or, put differently, governments represent our society's approach to dealing with these issues. In fact, our local governments and institutions have valuable resources and unique perspectives that provide inherent advantages in pursuing this planning imperative. The trick is to be able to effectively leverage these assets in pursuit of the goals.

One of the core strengths of local governmental institutions is their jurisdictional authority and established presence in the local geographic context. They also own key buildings and facilities, and they own, or have controlling interest in, rights of way. At the same time, they are geographically fixed so they cannot move to where operations would be less expensive or easier to conduct.

Modern communications technologies are enabling many local governments to deploy robust networks as owned assets, but these networks tend to be islands since the local government cannot cast its network beyond its borders.

Their local orientation also creates economies of scale challenges, which can be particularly acute in the case of information technologies relating to both staffing and equipment.

Planning by local governmental institutions for information technologies and communications must necessarily deal with their inherent constraints while seeking to leverage their unique advantages. If the planning scope can be widened beyond local boundaries to consider regional approaches, then more degrees of freedom can be introduced that will improve economies of scale, albeit while introducing jurisdictional complications.

It seems that the communities of Barnstable County are especially well positioned to engage in new planning initiatives to improve the effectiveness of their information systems and regional communications. The OpenCape initiative has established a regional communications backbone that interconnects the islands of municipal and school networks, while introducing the freedom to relocate information systems to achieve economy of scale advantages otherwise available only to the largest communities.

The communities of Barnstable County are especially well positioned to engage in new planning initiatives to improve the effectiveness of their information systems and regional communications.

The survey of information technology and communications assets that has just been conducted provides a useful context for planning efforts, as well as insights into the needs of the towns and school systems. Furthermore, this survey has confirmed broad interest in regional planning efforts, whether to improve matters within a local municipal context or to leverage regional resources.

OpenCape has established a regional communications backbone that interconnects the islands of municipal and school networks, while introducing the freedom to relocate information systems to achieve economy of scale advantages otherwise available only to the largest communities.

Goals and Objectives

Based on the survey team's experience with municipal needs for information and communications systems, as well as input received from many key players interviewed during the survey, the following goals and objectives are proposed for consideration as motivation for new Barnstable County planning efforts:

- Lower recurring costs broadly through improvements in productivity and efficiency gains
- Improve services and the value of investments made in information and communications systems
- Overcome experience and expertise gaps, that are themselves consequences of limited scale, but also the broad scope of issues that must be confronted by local governments
- Reduce or eliminate paper records or paper-based workflows
- Improve resilience and survivability of systems and records, especially in the face of natural threats
- Enable greater control over each community's operations
- Improve support for mobile workers
- Continue to reduce friction associated with citizens and businesses interacting with local governments
- Empower teachers and students to broaden learning experiences and educational effectiveness
- Enable support and services for entrepreneurial growth

- Extend improvements already made in protecting the public's safety

These goals are broad, and affect every department and agency within local municipalities and districts. Improving information and communications systems will not, by itself, achieve these goals. Instead, planning must take a holistic approach that comprehensively addresses total systems at the local and regional levels. It is just as important to ask how each department, and indeed, each employee, can help improve information management and communications, as it is to ask how information systems can improve the support provided to departments and employees.

Planning for information and communications systems should not be treated as a standalone exercise, but must instead be holistically integrated into all planning activities.

The Water Department that finds a way to lay conduit in town streets for fiber optic cables between municipal buildings and schools will be making valuable contributions to these goals. So will the DPW that helps get vital information or communications systems onto electrical power feeds backed up by generators. Or the School that integrates its accounting system with the Town's system to avoid duplicate data entry. Or the employee that scans a document for electronic storage and retrieval, instead of filing the paper. The goals outlined above call for "us" solutions, not "them" solutions.

Going forward, planning for information and communications systems should not be treated as a standalone exercise, but must instead be holistically integrated into all planning activities. Only in this manner will efforts to put in new sewer lines result in more resilient underground communications conduits. Similarly, if new vehicle traffic controls deploy video cameras at intersections, then these cameras should also be available to Police and Fire so they can get real-time traffic assessments to optimize emergency responses.

Just as Schools have learned to bundle technology upgrades into bond initiatives when building or upgrading school buildings, so every new investment needs to consider how information and communications systems might be able to leverage the investment, or enhance the value from the investment. Consider, for example, how some public safety radio towers and water towers have been leased to cellular operators providing additional revenue to the local community while enhancing wireless communications for everyone (and reducing the total number of antenna towers). Even local ordinances need to be reviewed and updated to reflect changing needs for supporting communications services within the communities.

Local governmental institutions must confront some of their disadvantages, while learning to leverage their best assets.

There are as many big and daunting challenges ahead for local institutions as they have faced in the past. One key difference though is that these challenges are being cast in the information age where society as a whole is being transformed in truly profound ways. In this context, local governmental institutions must confront some of their disadvantages, while learning to leverage their best assets.

Suggested Planning Initiatives

The opportunity to survey the communications and information technology assets of Barnstable County has given the survey team the chance to hear what sorts of initiatives local communities would like to see, while gaining insights into where new planning initiatives might have the greatest impact. Suggestions for planning initiatives are outlined below where the opportunities for substantive improvements appear to be greatest. At the same time, it is important to emphasize that many of these suggested planning initiatives are not new, nor are these suggestions novel.

Before outlining planning opportunities though, it is worth reflecting first on the importance of data and metrics to support planning efforts. As the old saying goes, "you can't improve what you can't measure." The survey that has just been completed provides new data and updated perspectives that will inform the planning process. At the same time, it also serves to illustrate the difficulty of capturing this sort of data and keeping it current. Therefore, there are

There is very limited use of system or network management tools by most of the towns or school systems.

two important meta-issues for planners: (1) what data and metrics are truly useful to the planning process, and (2) how can this data be captured and kept current. Even after plans have been developed, execution needs to be assessed in terms of whether or not the anticipated benefits are achieved, which again implies the necessity of being able to measure progress.

The suggestions presented below attempt to be creative by recognizing that plans can be developed that not only address important systemic goals and objectives, but also yield new tools for capturing relevant data and improving measurement of process efficiencies. In essence, this is a bit of planning to make planning more effective, but it seems plausible that multiple objectives can be achieved in this manner.

It is also important to emphasize that these are suggestions for *planning* initiatives, and in no way should these be viewed as suggestions that *anything specific be done.* Let the planners determine what should be done, and when.

Regional System/Network Management Tools

An observation coming out of the IT and communications survey is that there is very limited use of system or network management tools by most of the towns or school systems. In a few instances, there has been some use of the free Spiceworks tool to track PCs and network equipment. There are also a couple of sites where the HP network management tool (again, free for limited use) has been used to manage a set of HP ProCurve switches. And, there are also a couple of instances where commercial management tools have been acquired, or are being trialed, but where busy IT staff have not been able to follow through.

There are several implications of this situation. First, there is little monitoring of actual network and system health or outages. Second, IT staff may not know the actual state of network and system connections, or if anything has been added to their networks. Third, inventories are in spreadsheets or written on pieces of paper, and the accuracy of this information is questionable since it is usually out of date due to the manual effort required to keep such inventory lists updated.

Modern management tools can help unburden over-worked IT staff, while at the same time improving the ability to maintain inventories of systems, operational status, and performance data. If these tools had been in use, the survey just conducted would have been much simpler, and the quality of the data would have been much higher. Even better, the information would be kept up to date in a largely automated manner.

The challenge for current IT staff is the “shoemaker’s children problem.” They have too many tasks on their plates to be able to invest the time to bring on board such tools, and get them initially configured for their environments.

A regional approach to addressing this problem could help overcome these impediments, while creating the opportunity for the region to benefit from the information captured by each community. There would also be tangible economies of scale if management tools were acquired as a regional initiative, along with expertise to initially configure the monitoring for each local community.

Communications Cost Tracking

Another information gap uncovered as part of the survey is the inability to track communications costs for traditional telephone services, cellular voice and data, and Internet charges. Each of the communications service providers offers tools for managing accounts and reviewing actual costs. Most provide additional tools for trending. On the other hand, these online account management tools only provide information for a single provider.

Realistically, recurring communications costs are not huge expenses in the overall budgets of towns and school systems. However, the total bill continues to ramp up, probably due in large part to increased use of wireless services, especially wireless data. Another problem is that it is painful to extract details about what services and lines are actually in use from paper bills. Again, understaffed IT departments have not been able to make it a priority to track communications costs and improve managing telecom accounts.

Given the low cost of leveraging online account management tools, and the benefit of improved visibility into what the actual costs are, as well as what services are actually in use, it seems like it would be worth developing plans for the region to tackle this issue. OpenCape could be a beneficiary of this effort, since it would be easier to quantify any cost savings from using their services, and to make sure that any displaced legacy services actually get turned off so that savings are realized.

This should be a modest planning effort, with modest costs to execute, and high likelihood that these costs could be recovered from future cost avoidance. It would also arm the region with a much more comprehensive view of total communications costs and cost trends.

Countywide Voice Services

During the survey, the potential for displacing telephone services provided by the incumbent carrier came up quite a few times in conversations with town managers and IT staff. OpenCape was frequently mentioned as a potential alternative voice service provider, but there are many opinions as to what this means.

This is a fairly challenging planning exercise. There are issues associated with how phone services in the County could be interconnected with the telephone network, as well as how costs could be allocated, even when these costs are lower than they currently are. At the local community level there are issues relating to how to transition off legacy phone systems, as well as with how replacement phone systems would actually interface into a potential regional voice service.

There will also be challenges associated with how to cover the costs of transitioning off older systems. Not only do key systems and PBXs need to be replaced in many cases, but these changes may also result in the necessity of replacing the older handsets that will only work with these older systems. While it is credible that all of these transitions could be made in a way that eventually lowers costs, it is likely that the transition costs will initially be painful until the savings accumulate. However, many of the savings on usage costs —especially toll charges that Verizon still imposes on many on-Cape routes—could be achieved by attaching existing phone systems to a regional voice network, delivered via OpenCape facilities.

The declining reliability of copper-based telephone services is causing mounting frustrations.

Costs are not the only motivation for moving to alternative voice services. The declining reliability of copper-based telephone services is causing mounting frustrations, especially for Lower Cape communities. The incumbent carrier apparently ceased investing in the current telephone system quite some time ago, and the health of the current infrastructure is degrading. There are also many implications for the planned transition to a Regional Emergency Communications Center (see below).

Regional Authentication and Access Control Services

Information security will continue to grow as an area of concern for all information and communications systems and any other systems that rely on information and communications. Not only will these threats continue to challenge local IT staff and management, but individual users will continue to be impacted, either by security problems, or the imposition of countermeasures to deal with these threats.

One area of security management that could be constructively addressed at the regional level is user authentication and access control. There are some tangible economies of scale that can be realized at a regional level, including shared expertise for dealing with what is a technically challenging problem that also requires a lot of user support.

Another compelling reason for planning ways to address this set of problems at the regional level is that it could substantially lower the cost and overhead associated with deploying applications regionally. While individual user accounts would likely continue to be maintained at the community level, it should be possible for an employee from any community to authenticate locally, but then be granted access to applications operated at the regional level, assuming they are authorized to access the application. This could also allow employees from one community to access applications hosted by a neighboring community.

As with some of the other planning initiatives, this has the potential to significantly enhance the region's ability to quantify how many people are authorized to access information systems, as well as potentially capture usage information. In other words, valuable metrics could be acquired as a byproduct of establishing regional solutions to this problem space.

While this will not be an easy planning initiative, there is nothing here that is not common practice elsewhere. Furthermore, the benefits to individual communities, and the reduction of burdens on IT staff could be significant. Finally, this is probably a necessary step toward deploying and operating applications or services on a regional basis. Otherwise, each new application will have to take on the burden of registering user accounts, and dealing with the ongoing headache of managing accounts.

One surprise coming out of the survey was the high cost of software maintenance.

Regional Applications and Services

If there was a surprise coming out of the survey, it was the high cost of software maintenance, especially for a subset of vital applications used throughout the County. At the same time, there is greater commonality of application use for these big-ticket packages than might have been expected. This seems to provide compelling justification for planning at the regional level for how to leverage the common usage of these key applications, while trimming costs.

A brief synopsis of big-ticket applications appropriate for consideration as regional planning exercises is provided below:

Financial Accounting: This category is by far the most expensive application used by all communities. Furthermore, 9 of the towns plus the County use the current version of MUNIS from Tyler Software. At the same time, there are notable differences in how the various communities use this software, with two of the towns opting to outsource MUNIS operations to Tyler. Other towns have expressed interest in such a service, but have balked at the high annual cost of the outsourced service. There are also inconsistencies between towns in terms of what options are used with MUNIS.

Given the cost of accounting software used by the towns and many of the schools as well, and degree of commonality that already exists, it seems like this is an area where planning could bear fruit.

Assessor and Appraisal Systems: While this is another big-ticket application category, it is also generally associated with public-facing services that are highly valuable to towns and their citizens. Here again, a majority of towns are using the same vendor, PK Systems. The headline is the high degree of satisfaction with this vendor and the suite of services PK provides.

Regional planning in this area might consider synergies that can easily be realized by leveraging the commonality of this application, and any economies of scale that could be achieved through central management of the application.

GIS: Graphical Information Systems have broad applicability for local governments. Unfortunately, this is an application that requires significant expertise to use, and many towns simply lack the staffing to adequately support this application or use it effectively. There are also economy-of-scale problems with the way the application is deployed that tend to drive up per-seat costs for smaller towns. For example the ESRI packages tend to be more cost effective if deployed in a client-server configuration, but this is too high a cost hurdle for smaller towns. The net result is that our survey encountered broad concerns that GIS applications were underutilized, or not cost effective given the limited benefits being achieved.

A regional approach to supporting GIS applications could improve the utility and cost-effectiveness of this important application.

This is an area where the County is already providing some leadership, and has a GIS group with considerable experience and access to a full client-server ESRI system. There are several options for taking a regional approach to supporting GIS applications that could improve the utility and cost-effectiveness of this application. Planning in this area seems prudent, and is probably already underway.

Permits and Licenses: The County has already initiated an "ePermits" project leveraging a challenge grant from the Commonwealth. Plans were developed some time ago, and are currently being executed. Hence, this application space is mentioned for completeness, and because it seems likely that plans for subsequent rollout will be prepared.

Law Enforcement Records Management: All police departments on the Cape currently use the IMC records management application provided by TriTech Software Systems. Overall, this is the second most expensive application on an annual recurring cost basis. It is also an essential tool for police departments, and the cornerstone of modern approaches to law enforcement.

The opportunities for planning relate to potential efficiency gains, and enhanced abilities to share information amongst departments, potentially leveraging OpenCape. This will also play a role in the deployment of the RECC (see below).

The caution with this application is that the information managed by this system falls within the policy realm of the FBI CJIS guidelines. This will place additional security burdens on any systems that support this application, however, plans can certainly be developed to address these policy mandates.

Student Information Systems: Every school uses some sort of application for maintaining student information. The most common application in use on the Cape at this time is Rediker. In reality, applications of this type do more than manage student information, and there is growing interest in more comprehensive approaches. In particular, parents are being included more in the overall planning and assessment of their children's needs. This requires public-facing services to facilitate parent engagement.

Planning for this application category could look at broad solutions to the challenges associated with student information systems, or planning efforts could focus more narrowly on the subsets of schools that use Rediker or one of the competing packages.

Libraries: All but a couple of libraries are members of the CLAMS system, which provides essential catalog services, public-facing services, and materials sharing/tracking. CLAMS started out with T1 or frame relay connections to every library, but now uses Comcast services. With every library now also on OpenCape, further opportunities are emerging to plan for expanded services that can leverage CLAMS and OpenCape, and there may well be new services that could be developed for libraries to offer their patrons.

This is an obvious area for planning, and is included for completeness. It is likely that the libraries and CLAMS are already developing plans in this area. However, a broader planning effort could lead to plans that help reinvent libraries and their roles within the communities.

Virtualization

The move to virtualize servers and applications is well established as an industry trend. Virtualization is already being used by some of the towns and school systems as a means to improve manageability of services, and facilitate off-site disaster recovery. Virtualization also facilitates use of denser server systems based on blade enclosures that tend to operate more efficiently in terms of power and cooling.

There are two challenges that planning could address: (1) how to ease the transition to virtualized environments for IT staff already stretched thin, and (2) avoiding balkanization of virtualized environments if all possible vendor combinations are used, as is practically the case today. Note, this is not to imply that convergence on a single virtualization platform is appropriate, merely an observation that planning could determine optimal approaches. After all, the major vendors in this space are also addressing interoperability.

With the introduction of the Regional Computing Center (RCC), it is likely that virtualized environments will be used to simplify transitioning servers from local towns or schools to the RCC. This creates even more compelling arguments for pursuing planning around virtualization approaches.

Paper Elimination

A problem that became apparent from observations and interviews during the survey is the continued reliance on paper records and paper workflows in most town administrations. Note, however, this is not a problem to the same extent for most schools or police departments.

The costs of managing paper records and workflows are pervasive, and result in the inability to retrieve information without considerable effort. For instance, the survey encountered problems capturing cost information for some items simply because it was too difficult to pull invoices from paper files.

The survey team also heard examples of where there had been initiatives to scan paper records as a means of transitioning to all electronic document capture and filing. However, budget cutbacks in recent years put these initiatives on hold, or they were dropped entirely. This will probably result in greater costs in the long term, but is understandable in the context of the significant contraction of budgets for all municipalities in recent years.

The costs of managing paper records and workflows are pervasive, and result in the inability to retrieve information without considerable effort.

Planning efforts toward reducing or eliminating paper could start with a review of success stories and examination of what has worked. For example, Yarmouth has made considerable strides toward all electronic invoicing and billing, and utilizes electronic lock box services to capture and retrieve transactional records electronically. Using a different approach, Falmouth has replaced traditional copiers with scanner copiers, and they have made it easier to scan a document to a file than to copy it. This has apparently helped substantially reduce consumption of paper, while fostering an attitude that electronic documents are preferred.

Once there is consensus on what approaches to take, planning efforts could seek to identify opportunities to lower the cost hurdles for making the transition to electronic documents and workflows. There may also be opportunities to socialize these issues in ways that increase employee support for paper reduction initiatives.

RECC

Recently, the police chiefs on the Cape agreed to proceed with plans to establish a Regional Emergency Communications Center, or RECC. This is a major undertaking that will have a profound impact on many aspects of how emergency communications and 911 calls are handled, as well as the dispatch operations to coordinate responses across the various public safety services.

This planning effort has been underway for some time, and it will continue to be driven by the public safety community. However, the scale and scope of this effort will lead to the necessity to coordinate with other organizations and resources. For example, it is likely that OpenCape communications facilities will play a key role, as it will be necessary to deploy highly resilient and survivable communications systems. Here is also where a Cape-wide voice system could substantially improve the survivability of vital communications services in the event of a major disruptive event.

The purpose for flagging this existing planning effort is to draw attention to this important initiative, and the potential need for other players to lend a shoulder to the effort. At the same time, some of the infrastructure that gets deployed in support of the RECC could have synergistic benefits for other initiatives not directly related to the RECC.

Conduit Policies and Planning

The obvious Achilles heel for current communications and electrical power distribution on the Cape is the near universal reliance on aerial lines (copper and fiber) attached to poles. To illustrate the potential for disastrous impact in the event of certain natural disasters, there is another RECC initiative underway in the northeastern part of the Commonwealth. However, in this case, the chiefs are strongly opposed to reliance on fiber, simply because their experiences from the ice storm of a couple of years ago are still quite painful. Hurricanes and ice storms *will* severely impact aerial cables.

Figure 51—A less than inspiring example of a utility pole that feeds services to a Town Hall. Yes, that is a rope lashing holding some of the cables against the pole, and the same pole has another rope lashing down at the street level.

While microwave is the best near-term alternative to aerial fiber, the long-term strategy should be to move critical fiber routes into underground conduits. However, to put it bluntly, this will not be cheap. It is unlikely that utilities will accept the cost of making such a transition, and so the next best option for the region is probably to develop strategies for gradually introducing conduit on an opportunistic basis over a long timeframe. This will require extraordinary coordination over multiple departments, jurisdictions, and a decade or two of concerted efforts.

Every time a street is dug up, every new water main project, and every new sewer line represents opportunities to lay conduit inexpensively. With careful planning, it should be feasible to knit together many small projects to achieve the long-term objective. This is a planning effort that will have to last, and change the way other initiatives are planned. At least the Cape is mostly sand, and not the piles of rock that exist in most of the rest of the State.

The long-term strategy should be to move critical fiber routes into underground conduits.

Radio Antenna Site Planning

In lieu of conduit to protect critical communications infrastructure, radio communications will be the best alternative for providing resilient, survivable communications. This includes traditional Land Mobile Radio (LMR) used by public safety organizations and DPWs for voice communications, along with cellular wireless systems, microwave point-to-point, and point-to-multipoint systems, and even wireless LAN technologies. What radio systems require are high sites with good line of sight, or near line of sight to the places where signals need to be directed.

What is also needed is good communications to these high sites—ideally, fiber connections with multiple paths, but also high capacity microwave links to other high sites to create a dense mesh of communications interconnecting the high sites. OpenCape has made an excellent start toward implementing this approach with its fiber and microwave backbone. However, if the region is to be protected against the wholesale loss of aerial utilities, then more high sites are going to be needed in order to get microwave links to the police, fire, DPW, shelter, town hall, and medical sites that will need resilient, survivable communications.

Figure 52—The Harwich Water Tower near Cape Cod Technical High School with two public safety LMR radio masts visible. On the right near the top is a microwave radio.

With coordinated planning, the region can further leverage its considerable high site assets (water towers, antenna towers, and some buildings) to establish a network of high sites that can be utilized as needed. At the same time, the concerns of tower owners, such as water districts, should be thoroughly addressed to everyone's satisfaction.

The region can further leverage its considerable high site assets to establish a network of high sites that can be utilized as needed.

The Cape is also fortunate that its geography favors radio propagation, and there are few obstacles to radio signals. Furthermore, geography should help constrain interference in the unlicensed "junk" bands, further increasing options for low-cost microwave connections to many sites.

These efforts might also lead to more effective, denser siting of cellular services to the benefit of municipalities, as well as the citizens and businesses in the region. This could also result in a more competitive environment, which might help keep rates lower. When FirstNet[18] finally shows up to install its nationwide public safety 700 MHz system, the region will be in an excellent position if it can say to FirstNet, "put your 700 MHz LTE radios in these spots and we've already got your backhaul communications in place."

Figure 53—Two radio towers. The tower on the left is a traditional radio antenna mast located in Falmouth, while the tower on the left shows the interior climb to the top of a modern water tower (the Wellfleet tower shown in Figure 35). A qualified tower climber is shown on the left performing maintenance on some Falmouth microwave radios. Obviously, in the dead of winter or a gale, the tower on the right has some accessibility advantages. Note that the Harwich water tower shown in Figure 52 also has interior access to the top via ladders similar to the right hand photo above. The water tanks are giant donuts that allow maintenance workers to climb up through the donut hole.

Wireless LANs

The writing is on the wall that wired LAN environments will gradually lose relevance in coming years as the world continues the transition to mobile platforms. The future will be wireless LANs and other wireless technologies. Furthermore, new wireless technologies, like IEEE 802.11ac, will increase wireless throughput into the speed range currently occupied by wired technologies.

For buildings on the Cape suffering from old wiring that constrains speed or restricts where devices can be located, new wireless LANs will be a boon that will allow communities to avoid the expense of rewiring buildings. At the same time, buildings with adequate wiring will gain the benefits of added mobility. Higher-speed access points may need to be relatively close to their users, or even in the same room; some technologies may end up being more like *cordless* than *wireless* in practice, thereby implying that some wired infrastructure will still be required, just without as many wires.

However, as with any new technology, there will be costs to adopt. There will also be some challenges in learning how to best deploy these technologies that are going to be inherently more complex than predecessor wired and wireless LANs, especially if the objective is to achieve the same throughput and capacity as with wired LANs.

The big advantage of wireless, though, is mobility. However, for devices to be able to roam within a building, new systems will need to be deployed to coordinate handoff between base stations, much like the cellular networks hand off communications from cell site to cell site as subscribers move through.

In addition, security concerns will need to be addressed. This is not so much about encrypting the wireless communications anymore, as that problem has largely been solved. However, the new challenge is how to *authenticate* users onto the network. Here is where the planning effort described above to address regional authentication and access control will come into play. If plans can be effectively developed to address both authentication and wireless system deployments, then it may be possible some day in the next year or two that an employee of one community can visit a County office, or a site in a neighboring community, and walk in with their mobile already connected to the local wireless LAN, but extending their communications back to their home network.

Figure 54—A security camera installed in the lobby of a school. This is actually four cameras within one enclosure.

Video Camera System Support

The survey encountered a lot of so-called *security cameras* already deployed on the Cape, with the vast majority found in schools, though nearly every police department also has video cameras for monitoring the police station and jail cells. Video cameras are also becoming more common for monitoring harbors and sensitive environmental areas, as well as for vehicular traffic control. Some of these cameras are even available to the public through "webcam" applications.

However, these systems have mostly been deployed in a standalone manner with isolated infrastructure and dedicated controllers and recording systems. The costs, especially for schools, have been high, though the survey was unable to quantify these costs. There are also on-going operational and maintenance costs associated with these camera systems.

Based on experiences from other regions, it seems quite likely that there will be increased interest in deploying cameras in a variety of locations in and around the Cape's communities. Historically, the challenge with deploying cameras has been the high cost of communications to pull back the video feeds. However, the availability of town networks and OpenCape should help to reduce these costs for new deployments. If an effective strategy can be put in place to leverage high sites for microwave links, then it could become feasible to put cameras where they are most needed at modest cost, and even have camera systems that could be deployed on an as-needed, *ad hoc* basis.

Regional planning could help address a variety of issues that will emerge with video monitoring, including concerns with security, and the public's legitimate concerns about privacy and potential abuses. However, the real imperative for planning in this space is that the alternative is to continue with one-off deployments that will gradually accrue significant operational costs over time. Furthermore, planning can help to identify synergies that could lead to lower operational and support costs.

Endnotes

[1] SCADA: Supervisory Control and Data Acquisition. This is a standard used to deploy industrial control systems, such as what might be used to control a municipal water plant. The term, "SCADA" is often misused to refer to the entire class of industrial control applications. Due to many security exposures associated with systems based on the SCADA standards, new policies for addressing security concerns with industrial control systems are being defined to directly address SCADA technical issues.

[2] PCI DSS: Payment Card Industry, Data Security Standards. Originally, this was a set of policies applied by the credit card industry intended to apply to retailers and card processors, but is now widely used for financial systems in general. It is worth noting, though, that these policies are intended to protect card issuers, not retailers or card processors.

[3] HIPAA: Health Insurance Portability and Accountability Act of 1996, which includes complex information management and security policies protecting patient records health care information in general. Extensive updates to these requirements were introduced in 2003, which became mandatory in 2005.

[4] A T1 "trunk" circuit multiplexes 23 or 24 digital voice connections over one set of copper wires. T1 circuits can also be used for data services, with speeds up to 1.5 Mbps supported. It is also possible to have a combination of voice and data carried over a single T1 circuit.

[5] In this context, narrowbanding refers to an FCC order requiring that LMR systems that previously used 25 kHz channels of radio spectrum must instead operate within 12.5 kHz channels by January 1, 2013.

[6] "P25" is short for APCO Project 25, a set of standards that define all-digital LMR systems with many advanced features and greater scalability than older systems. Unfortunately, the P25 standards are also getting a bit old from a technological perspective.

[7] http://www.ntia.doc.gov/category/firstnet

[8] "VPN" was originally an acronym for "Virtual Private Network" in the sense that a VPN provides the equivalent of having "private" wires between end points. However, this confuses the two meanings of "private," where it can imply ownership or control over a resource, or confidentiality (privacy). Encrypted tunnels provide confidentiality, but not any ownership or rights over the communications resource.

[9] The minimum link speed for fiber connections these days is 1 Gbps, so 100 Mbps is slow by today's standards, but is still adequate for Chatham's current needs, and better than other readily-available options.

[10] http://metroethernetforum.org/

[11] Verizon T1 circuits are typically delivered to the customer premises over copper cables, though in some cases, fiber circuits might be used to larger sites where there might be multiple T1 circuits (*e.g.,* Barnstable Town Hall).

[12] POTS: Plain Old Telephone Service, a widely used term that implies a traditional telephone circuit with a single pair copper interface. In Comcast's case it is typically a POTS-like service delivered over cable using PacketCable VoIP technology.

[13] For example, the Town of Falmouth has an old Avaya IP PBX and the Town of Barnstable has a late '90s NEC PBX, both of which are capable of supporting VoIP services, at least for communications from the central PBX to remote satellite sites.

[14] These are also referred to as hosted or cloud-based VoIP services, and they are growing in popularity, especially with small to medium businesses.

[15] Sprint/Nextel "push-to-talk" services were popular with public safety and DPW users, however, these services are being discontinued, which takes away one of Sprint's competitive advantages.

[16] Dennis was in the process of transitioning to New Horizons Communications from Valley Communications at the time of our survey.

[17] In December 2012, the FCC suspended the narrowbanding requirement that public safety systems operating in "T-band," 470-512 MHz, noting that these licenses may be terminated in the next few years as those frequencies are reallocated to auctioned services. However, Sandwich is the only public entity on the Cape holding T-band licenses, while two private entities hold licenses "for the use of eligibles".

[18] http://www.ntia.doc.gov/category/firstnet or http://www.fiercebroadbandwireless.com/topics/public-safety