STATE OF NEW HAMPSHIRE

BEFORE THE

PUBLIC UTILITIES COMMISSION

DT 07-011

Joint Petition by Verizon New England, Inc., et al.
and FairPoint Communications, Inc.
Transfer of New Hampshire Assets of
Verizon New England, Inc. et al.

Rebuttal Testimony of Douglas C. Sicker, Ph.D.
On Behalf of
FairPoint Communications, Inc.

September 10, 2007

Summary: Dr. Sicker's testimony describes the appropriateness of Digital Subscriber Line (DSL) as an evolutionary technology path for FairPoint Communications, Inc. (FairPoint) to serve the Verizon customer base upon acquisition of related assets in Maine, Vermont and New Hampshire. Dr. Sicker discusses why DSL is the appropriate technology now and how it provides the base for future expansion as the needs for bandwidth grow. In addition, Dr. Sicker comments on FairPoint's broadband deployment plan, concluding that the plan is sound and reasonable for the State of New Hampshire.

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INTRODUCTION

Q. Please state your name and business address.

A. My name is Dr. Douglas C. Sicker. My business address is ECCR1B54, 430 UCB, Boulder, CO 80309-0430.

Q. What is your position and by whom are you employed?

A. I am the Director of the Interdisciplinary Telecommunications Labs and an Assistant Professor in the Department of Computer Science at the University of Colorado and am employed by the University of Colorado.

Q. Please provide your educational background and professional experience.

A. Prior to becoming a professor I was Director of Network Architecture at Level 3 Communications. And prior to this, I was Chief of the Network Technology Division at the Federal Communications Commission (FCC). I worked on numerous broadband rulemakings and acted daily in an advisory capacity to the Common Carrier Bureau, Commissioners and Chairman on such pertinent topics as broadband deployment, unbundled network elements, network reliability and DSL compatibility. I received my Ph.D. and M.S. in Telecommunications and my B.S. in Natural Sciences from the University of Pittsburgh.

Q. On whose behalf are you testifying?

A. I am testifying on behalf of FairPoint.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to describe how FairPoint's broadband plan benefits the residents of the State of New Hampshire. I will also provide information on the appropriateness of Digital Subscriber Line (DSL) as an evolutionary technology path for FairPoint to serve the Verizon customer base upon acquisition of related assets in Maine, Vermont and New Hampshire. I will testify as to why DSL is the appropriate technology now and how it provides the base for future expansion as the needs for bandwidth grow.

Q. Please summarize your analysis.

A. Based on my extensive experience as an academic and professional in the field of communications technology and my evaluation of information about both FairPoint's current broadband deployments and its initial plans for Northern New England, as well as interviews with FairPoint's internal subject matter experts, I conclude that DSL is a logical solution for New Hampshire (and is in fact the technology of choice), and that it provides a prudent migratory path toward even higher-rate data services such as Fiber To The Home ("FTTH"). I also conclude that the goal of increasing broadband deployment is not well-served by ordering a specific deployment with specific data rates, specific technology and specific timelines. To do so would fail to provide the flexibility that a carrier requires to evolve its network in response to consumer demands, financial factors and technology evolution.

Specifically concerning the FairPoint broadband deployment plan, I conclude that: (1) the FairPoint's plan is sound given the economics of broadband deployment; (2) the plan is consistent with the technologies currently being deployed by other operators in the

United States and abroad; (3) the plan is designed to ensure a significant and wide-spread build-out to large numbers of additional customers; (4) the plan will provide appropriate broadband capacity for current uses and the network can be evolved as needed to meet even higher-speed customer needs; and (5) the plan will position the infrastructure required to meet the needs of particular high-capacity customers.

Q. Could you provide a simplified description of the Internet and explain how technologies like DSL and FTTH fit into the Internet?

A. Technologies such as DSL and FTTH are part of the network system that is the Internet. It is important to understand how that system is designed in order to understand the value of different access technologies (technologies that provide end-users with access to the network). Just as putting racing tires on an old car won't make it go faster, the network's performance and an Internet user's experience are based on many parts. Modern telecommunications systems are moving to "network convergence," meaning that subscribers' voice, video and data network services are provided by a single common connection to the Internet. DSL and FTTH are network access technologies that connect a home or business (endpoint) to a network provider.

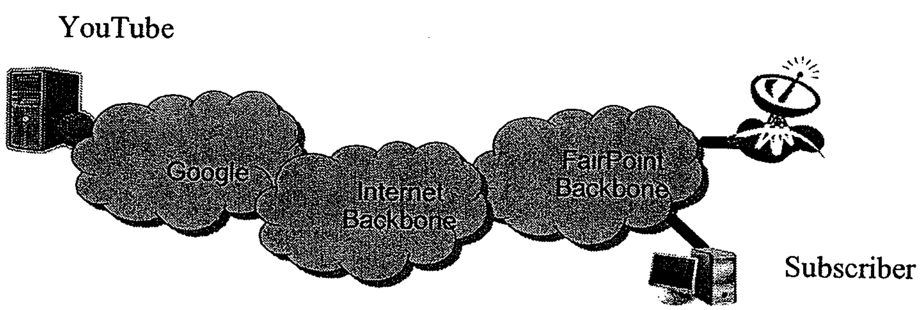
Q. How does an access network fit into the Internet?

A. The devices in a home are connected to an access network that is provided by a broadband network provider. That network provider also has a backbone network that connects all the different access devices and provides access to other networks. The Internet is a "network of networks," allowing different broadband providers to access the same content.

Q. Could you give an example of how information might travel across this "network of networks" giving different access networks, including broadband providers, access to the same content?

A. For example, the following diagram provides a schematic illustration of how subscribers to FairPoint's network might access content from YouTube.

Figure 1. From YouTube to Your Tube



The subscriber (represented by the PC and monitor) directly connects to the FairPoint network; that network connects, or peers, with other Internet backbones. In order to receive a video from YouTube, the data will flow from the computer located at a Google datacenter, through Google's internal networks, across the Internet backbone networks, through FairPoint's network and then to the subscriber's PC. Data travels through the network at the speed of the slowest link – since "backbone" networks combine traffic from many subscribers, those backbone networks must also be well designed.

Q. Does all information necessarily travel across the full Internet?

A. Not all data traverse the full Internet. For example, video services for a broadband network may originate at a regional satellite dish farm (see Figure 1) and then be distributed through a broadband provider's network to subscribers. The power of the Internet is that it allows various kinds of content (e.g., video or information) to be distributed from broadband provider networks or distant Internet providers, such as YouTube.

Q. Please explain how the design of "backbone networks" can affect the performance and cost of broadband services?

A. The design of the backbone networks can influence greatly the cost and performance of broadband services. Some Internet backbone networks arose by adapting existing telecommunication networks that were primarily designed for voice traffic. These networks use technology called Asynchronous Transfer Mode (ATM)[1] to establish "virtual circuits" through the telecommunications network. This technology approach was a direct outgrowth of the design of the local telecommunications networks in which telephones were connected by "circuits" to a central office. Once data enter a "circuit," the information doesn't exit until it reaches its endpoint, no matter how many "switches" it may traverse. Adapting these networks to transport Internet data involves adding "abstraction layers" that hide the "circuit like" nature of the network.

New network deployments use "IP networking," which uses Internet Protocol (IP) to move or route data. The main differences are that most "IP Networking" equipment

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1 From the NTIA glossary, "Asynchronous Transfer Mode (ATM): A high-speed multiplexing and switching method utilizing fixed-length cells of 53 octets to support multiple types of traffic. Note: ATM, specified in international standards, is asynchronous in the sense that cells carrying user data need not be periodic."

moves larger "chunks" of data, such as multicast data[2] and the path that data takes through the network is much more flexible than in ATM networks (leading to higher efficiency). It is easiest to understand this difference by way of analogy:

Railroads (ATM) and Freeways (IP)

Traditional ATM telecommunications networks are like railways, while IP networks are more like freeways. In a rail network, trains enter at specific points on the network and have uncontested rights-of-way to their destinations; however, it is difficult and expensive to add new "exits" to a rail line. By comparison, cars make "routing decisions" at each roadway intersection, and it is relatively simple to add new intersections to serve new homes because of this design choice. It is also possible to design roadways, like Interstate highways, that are more efficient as a result of limiting the number of on ramps and exits.

The analogy falls short for one important kind of Internet traffic: IP multicast. Multicast data originates from a single location (such as a TV satellite) but is directed to multiple different receivers. Multicast mechanisms are the basis for delivering TV services efficiently over IP networks. In an IP network, the router and switches that make up the "intersections" of the highway are designed to duplicate multicast data directly, and are shown in Figure 2.

Figure 2. Digital Railways and Digital Freeways - The Benefits of Native IP Multicast

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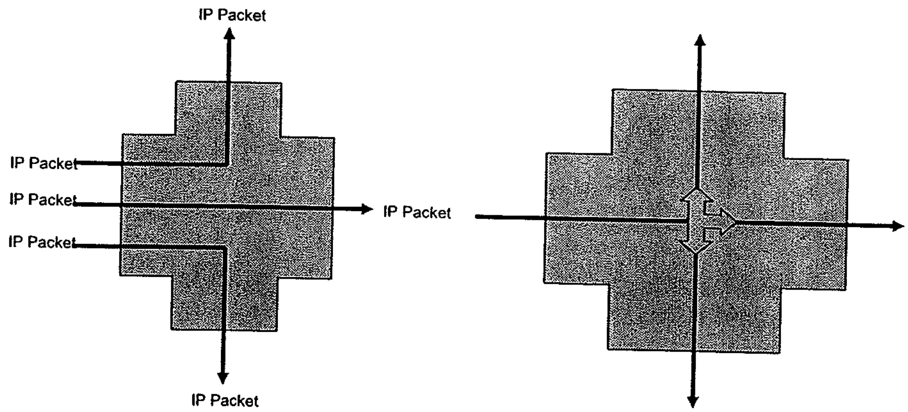
[2] Multicast data originates from a single location (such as a TV satellite) but is directed to multiple different receivers.



Without multicast, three packets must traverse the backbone

Native IP switching needs only a single message to deliver multicast content

Source: Author's construct

ATM networks are at a disadvantage for multicast traffic. The switches that make up most of an ATM telecommunication network don't "see" the IP multicast data directly, and thus can't duplicate the traffic in the network. This requires more data to be sent through the network backbone, leading to yet more overhead – it is as if the train is carrying cars, but is unable to benefit from the advantages of cars.

The design of backbone networks is important and integral when planning `high-speed access networks. Modern "high speed" access networks allow throughput of 25-100 megabits per second (Mb/s) of downloadable data. If a thousand customers use a 100 Mb/s network at the same time, a typical OC-3 of 155 Mb/s used for backhaul would be

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Multicast mechanisms are the basis for delivering TV services efficiently over IP networks.

exhausted. Therefore, it is imperative that carriers properly evolve both their backbone and access networks as they attempt to bring higher data speed products and service to their customers. As part of that network evolution it is important to keep in mind that the efficiency of IP backbone networks can provide significant performance benefits and cost advantages beyond older network designs.

Q. Could you give an overview of the bandwidth demands of different common applications?

A. Yes. Most broadband providers are focused on the "triple play" of providing voice, video and data networking to subscribers. Of these services, voice uses the least amount of bandwidth (less than 100 kilobits per second (Kb/s)). The necessary bandwidth demands of data or Web networking are more difficult to quantify because "more is better," up to a point. If we have a gigabit access network, Web data will be received no faster than the web server can provide it. In most cases, 20-30 Mb/s is considered more than sufficient at the upper end for Web access.

Video data would appear to be the most demanding kind of traffic. Industry reports advocating the deployment of high-speed fiber networks point out that uncompressed video consumes tens of megabytes of bandwidth. The bandwidth available in cable networks largely is used to transmit multiple video streams. However, video transmitted in modern IP networks uses compression technology to achieve the same video fidelity with much less bandwidth. As would be predicted by Moore's Law,[3] video compression

[3] "..(T)he first microprocessor only had 22 hundred transistors. We are looking at something a million times that complex in the next generations—a billion transistors. What that gives us in the way of flexibility to design products is phenomenal." Intel founder, Gordon E. Moore, in 1965. Moore's Law is invoked more generally to describe the tremendous expansion of speed and capacity by all kinds of computer-like devices.

technology improves with time, leading to less bandwidth consumption with each iterative improvement.

The following table summarizes the bandwidth needs for two generations of video compression technology. The first, MPEG2, is the technology used in DVD movies. The second, H.264, is the technology used in the HDTV, HD-DVD and Blueray video formats.

Figure 3. Improvement in Video Compression

	SD Video	HD Video
MPEG2	4-6 Mb/s	~30 Mb/s
H.264	1-2.5 Mb/s	6-9 Mb/s

Thus, a subscriber wanting to use voice, data and view a single HD video stream all at the same time would need as little as 12 Mb/s of bandwidth (6-9 Mb/s for the video stream with 3-6 Mb/s for data and voice). If 50 Mb/s were available, the subscriber could simultaneously watch 3-4 HD videos, provide two voice streams to each of the family's 5 children and browse the web using an 8 Mb/s connection (as fast as the most up-to-date cable modems). Obviously, despite some advocacy of "gigabit to the home," existing Internet applications would be unable to make use of most of that extraordinary bandwidth.

Q. How do access networks differ in the physical infrastructure they employ?

A. One of the Internet's design goals was to permit the user to operate over many different physical networking media. Different network technologies have been used by businesses, incumbent telecommunications, cable companies and others. Each technology offers the same capabilities, but at different performance and cost. There are many technologies to consider, and those technologies continue to evolve in terms of performance (speed) and cost.

Q. Please review the specific different types of access technology and their primary characteristics.

A. There are five main types of access technology, Ethernet, Digital Subscriber Line (DSL), Cable Broadband, Wireless Broadband, and Fiber. I will briefly describe each one.

Ethernet

Ethernet is used within most business premises and some homes, multi-unit dwellings and increasingly for distribution in "edge networks." Because the technology is a widely adopted commodity standard, components can be relatively inexpensive. Ethernet over copper cabling has limited range (<1km and ~100m for 1 gigabit speeds). Ethernet using fiber has longer distance limits, providing 1 gigabit and 10 gigabit speeds to distances exceeding 20km. Ethernet is used in some high-speed broadband deployments, but adoption of the technology for residential broadband is limited by the rapidly-improving capabilities of existing incumbent wiring technologies (i.e., DSL and Cable Modems) and the lack of a large market for gigabit residential connections. Ethernet technology is being deployed in some "greenfield" networks such as the Utopia network in Utah.

Digital Subscriber Line

DSL is a family of technologies developed to use the existing telephone wiring access plant. All of the technologies are designed to work in conjunction with existing voice telephony services. The most commonly used variant of DSL is called ADSL (asymmetric digital subscriber line), which uses the available bandwidth to provide up to 6 Mb/s of downlink connectivity and up to 640 Kb/s of uplink connectivity. Many subscribers are limited to the G.lite version of ADSL, which constrains downlink bandwidth to 1.5 Mb/s and uplink bandwidth to 256 Kb/s.

The majority of DSL deployments in the U.S. use ADSL and ADSL G.lite. Many countries, including France, Sweden, Japan and South Korea, have begun to deploy VDSL, and some countries started deploying VDSL2 in 2007. Recently, Texas Instruments developed a technology called UDSL (uni-DSL) that allows the different DSL standards to be deployed over the same physical plant, reducing the cost for technology changes.

Figure 4. Distances for Various DSL Technologies

DSL Type	Range (kft)	Downstream Rate	Upstream Rate
ADSL G.lite	18 kft	1.5 Mb/s	0.256 Mb/s
ADSL	12 kft	6.0 Mb/s	0.640 Mb/s
VDSL	3.2 kft	26 Mb/s	3.0 Mb/s
	1 kft	52 Mb/s	6 Mb/s
VDSL2	3.2kft	50 Mb/s	50 Mb/s
	1.63kft	100 Mb/s	100 Mb/s
LR-VDSL	16 kft	1-4 Mb/s	0.600 Mb/s
ADSL2+	3 kft	24 Mb/s	1.1 Mb/s
	12 kft	6 Mb/s	0.512 Mb/s
UDSL		Same as VDSL2	

The different types of DSL support provision of broadband at various distances from the network switching equipment. The enhancements in speed and distance over time are based on the innovation and technology improvements of the equipment located at the end of the copper wires.

In the DSL marketplace, distances are usually specified in kilo feet (1 kft is approximately 300 meters). The distances in the DSL specifications are from the point of distribution, which can be either a central office or a remote distribution point in a multi-dwelling unit (MDU), business or neighborhood. Thus, if a group of customers lives far from a central office, it may be more cost effective to run fiber to a distribution unit near their homes and then use the existing copper infrastructure to deliver 100 Mb/s VDSL2 connections to the homes, rather than to provide new fiber connections to each home. The highest-speed DSL technologies, such as VDSL and VDSL2 are being adopted in the United States. In order to achieve the higher speeds provided by VDSL, most providers are overlaying a fiber network to individual MDUs or neighborhoods. This is done to balance the cost of deploying new infrastructure to each residence when the existing telephone infrastructure is capable of 100Mb/s speeds.

In short, DSL is an evolving standard because the performance of the electronics and the physical architectures permit meaningful improvements to copper-based speeds if the loop lengths are shortened and more advanced versions of DSL are deployed.

Cable Broadband

Cable broadband services are provided by cable television providers using an existing coaxial cable plant (coax). The DOCSIS standards ("Data Over Cable Service Interface Standards") govern the physical and logical signaling over the coax plant. Just as DSL standards work in conjunction with existing voice signals on a phone line, the DOCSIS standards work in conjunction with existing standard-definition (SD) and high-definition (HD) television signals over the coax infrastructure.

The current DOCSIS 2 standard provides performance of up to 42 Mb/s downstream and 30 Mb/s upstream using a single 6 MHz channel. That bandwidth is shared between multiple users and individual usage is usually "capped" at 8 Mb/s downstream with 384 Kb/s upstream. Equipment meeting the recently released DOCSIS 3 standard can theoretically achieve downstream performance of 160 Mb/s using multiple channel frequencies (although it is not certain that this technology will operate at these rates in the field). Unlike earlier DOCSIS standards, the entire 160 Mb/s theoretically may be made available for a single user. As with DSL networks, data signals are distributed to cable modem termination equipment using a fiber network (forming a so-called hybrid fiber-coaxial network).

Wireless Broadband

Broadband Fixed Wireless (BFW) refers to various technologies used to provide high data rate wireless services to users whose locations are fixed. BFW can be viewed as a substitute in some applications for other current broadband access technologies, such as DSL and cable modem (although BFW is not necessarily a true substitute). In the recent past, BFW has most often been deployed through technologies such as Local Multipoint Distribution Service (LMDS) and Multi-channel Multipoint Distribution Service (MMDS). The initial rollout of BFW technologies did not result in the market penetration that many observers anticipated. Some of the reasons for the shortfall included high deployment costs, poor service availability and complications from the use of proprietary technology. The development of new standards, including 802.16 (also called WiMAX), may breathe new life into the BFW market.

The 802.16 standard has only recently been deployed. Speeds of 6 Mb/s have been measured at distances of 6km (19kft).

Fiber

Unlike basic ADSL technologies, solutions using optical fiber that extends all the way to the customer's premises require a new physical plant to be installed. Most fiber services being deployed in the United States use *passive optical networking* or PON networks. In these systems, a signal is modulated by a laser at a central office or a local distribution center. Different variants provide different speeds and ranges. The current BPON and EPON services provide a total of 1.2 Gb/s bandwidth at distances up to 20 km (65 kft). Recent standards such as GPON increase the bandwidth to 2.5 Gb/s at distances of up to 60 km. The bandwidth is shared among as few as 16 and as many as 256 users, resulting in a per-user bandwidth of 75 Mb/s to 4.6 Mb/s, depending on the number of subscribers for EPON/BPON. GPON rates would double the throughput. As with coaxial cable TV distribution systems, passive optical networks allow additional broadcast distribution of TV signals by simply splitting the fiber to multiple homes. By comparison, *active* fiber networks use switches throughout the network to deliver peak speeds of up to 1 GB/s to individual users. Active fiber networks lack the ability to broadcast a common signal using passive optics; instead, active fiber networks must use switch protocols such as IP multicast. Generally, active fiber networks are thought to cost more to deploy than passive networks due to these additional switches and lasers.

However, active networks also enable flexible networking organizations that allow companies to allocate dedicated bandwidth for specific tasks and services, such as providing reliable VoIP, Internet and TV services over the same infrastructure.

Q. Please summarize how these various access technologies are suited to different situations.

A. The key insight in the short summary above is that there are several very viable and cost-effective technology options that all provide high data rates up to 100 Mb/s or 150 Mb/s per residence and the "appropriate" technology depends on various factors, including density, geography, likely customer demand, the presence or absence of existing facilities and their condition, and financial issues.

Q. According to your assessment, is DSL still a viable technology, or should other access technology be mandated?

A. It is a fallacy that DSL is a "dead-end" technology and that DSL and fiber technologies are in opposition. Each technology has a place in the deployment of Internet technologies, as has been shown in deployments in South Korea and Japan. South Korea largely has deployed VDSL and VDSL2. Japan has a combined deployment of VDSL and fiber-to-the-home: DSL technologies are used when existing physical plant is available, while fiber is used when greenfield networks are possible or when economics warrant the build-out. In short, mandating a particular technology, such as fiber to the home (FTTH), is not a wise choice. Illustrating this principle, some telecommunications providers are deploying passive optical networking, which is a technology with its own limitations, as it may not be able to offer gigabit speeds to individual users. Switching to active optical networking would require additional investment, highlighting that technologies (even those such as FTTH) are in evolution and that it is prudent to build networks that can be evolved.

Q. Is the FairPoint technology deployment strategy consistent with that of other broadband providers both in the U.S. and abroad?

A. The FairPoint broadband deployment plan, which I describe in more detail below, is consistent with the technologies currently being deployed by other operators in the United States and abroad. There are some areas in the U.S. where companies are deploying FTTH, but those regions typically are either greenfield developments or areas where deployment costs are low relative to the potential returns (more urban and suburban, high population density regions).[4] Almost all major telephone company broadband projects in the United States use DSL and cable modem technology (and, to a lesser extent, wireless) as the primary "last mile" connection to customers. In fact, it is well documented that DSL is the technology of choice for most telephone companies investing in broadband and that FTTH comprises only a small percentage of the deployed broadband.[5] According to the Organization for Economic Cooperation and Development (OECD), the breakdown of broadband technologies globally in December 2006 was as follows:

- DSL : 63%
- Cable modem : 29%
- FTTH/FTTB : 6%

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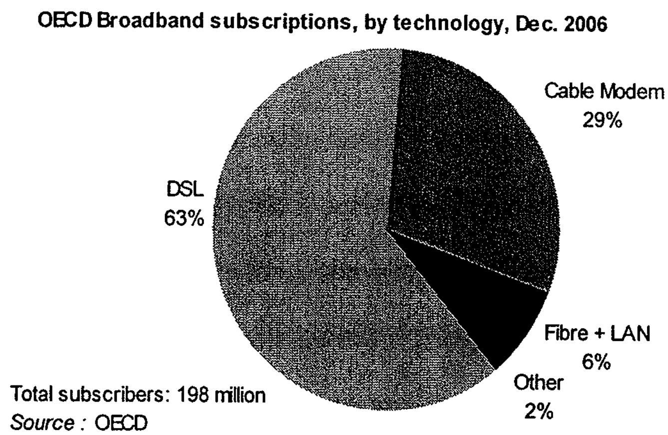
[4] "Broadband access evolution Pathways beyond ADSL", Alcatel Technology White Paper.

[5] http://www.oecd.org/document/7/0,3343,en_2649_37441_38446855_1_1_1_37441,00.html

- Other (e.g. satellite, fixed wireless, powerline communication) : 2%

Figure 6. Broadband Access Technologies



Q. Can you summarize the economic and deployment issues facing broadband?

A. Yes. It is understood that the cost of deploying technology varies greatly and that different technologies have different strengths based on a variety of demographic considerations.[6] Therefore, the decision regarding the broadband technology in which to invest requires an understanding of a complex and evolving number of variables. Investment decisions are based on engineering, economics and market conditions. These decisions are not being driven by explicit government obligations. At the end of the day, a fair-minded analysis is required. The decision how far to push fiber toward the customer is based on an evaluation of whether the market will support the deployment cost.

[6] See "Broadband access evolution Pathways beyond ADSL", Alcatel Technology White Paper. This article provides data on the relative capex required to deploy a variety of broadband access technologies and shows how DSL is a logical migratory path to FTTH.

Q. Given such varying economic and technical factors, would it be wise to implement a policy mandate regarding what architecture of services should be adopted?

A. Such a mandate would ignore the complex financial investment and operating cost decisions associated with broadband build out. Such a mandate would also ignore the diversity of complex issues associated with the evolution of the technology. The idea of mandating a specific data rate or technology platform ignores the determinative factors that drive investment decisions. (A similar analysis must be done for a public investment decision.) A specific data rate might be established as a goal, but requiring a carrier to invest when the return on investment is unknown makes poor business sense. It also puts at risk other basic regulatory goals, such as affordability of service and the financial integrity of the provider.

The New Hampshire Public Utilities Commission Staff (Staff) suggests that a condition of approval be imposed upon FairPoint such that FairPoint be required to meet a ninety-five percent (95%) broadband availability to its New Hampshire customer base. One must recognize that very low population density, remoteness and terrain make the provision of DSL or most other broadband technologies to the most remote customer economically challenging. Given these constraints, FairPoint's success in reaching 92% of its current customer base is impressive in my opinion.

By committing to push broadband out to approximately eighty percent (80%) of the New Hampshire customers Verizon currently serves (in addition to serving classic FairPoint customers), FairPoint will do an extraordinary amount to provide broadband services within the State of New Hampshire. Although I am not an economic development expert, I am impressed by FairPoint's approach to the relationship between economic development and broadband, which Mr. Nixon describes in his rebuttal testimony as "connectivity-enabled" economic development. As to the reasonableness of the technology, the few carriers that have adopted a "mainly fiber" model generally have relatively concentrated service areas or are focusing the investment in denser areas - and not areas such as that described in the pre-filed rebuttal testimony of Mssrs. Brown, Harrington and Smee. Given the deployment considerations that I have described, policymakers with plans to promote broadband deployment must consider not only the speed of the broadband network, but also how rapidly the service is deployed, the breadth of deployment within the service territory, the costs of investment, the resultant price of service, the financial health/longevity of the provider, and the ability to upgrade the deployment as the technology and customer demand evolve.

Q. Turning specifically to the FairPoint broadband plan, please describe its basic design philosophy?

A. FairPoint follows the well-understood best practice of first ensuring that the core (backbone) of the network is sufficiently robust to handle the subsequent build out of edge (or access) technologies. In following this philosophy, the company is implementing an Internet Protocol/Multiple Protocol Label Switching (IP/MPLS) core backbone, which will support 10 Gigabit per second data rates. This is a modern technology allowing for more efficient network use and network management. The FairPoint approach makes use of newer technology, namely Gigabit Ethernet, which allows the Ethernet frame from the customer to be more easily routed through the network with less overhead. ATM has over a 20% overhead and Ethernet has a 5-6% overhead due to encapsulation, but Gigabit Ethernet can reduce that overhead to 1%.

Moreover, IP routers and switches are designed to process Ethernet data directly, making for a more efficient network.

A second FairPoint design practice involves choosing the access technology that best matches the customer's needs. After first upgrading the core (backbone) of the network, FairPoint then is able to modernize the edge (or last mile) of the network. In the second tier of its network, FairPoint will make use of Multi Service Access Nodes (MSAN), which is network equipment that can support a range of access technologies, e.g., basic telephone service, ADSL, VDSL and FTTH. FairPoint presently plans to deploy ADSL2+ and VDSL2, which will support up to 25 Mb/s and 100 Mb/s, respectively (depending upon distance). However, MSANs will allow FairPoint to deploy FTTH for greenfield builds, new businesses and other rebuilds.

In its current service areas across the U.S., FairPoint today serves its broadband customers using different access technologies, including copper, fiber, copper/fiber hybrid, and wireless (in the form of radio frequency transmission). More specifically, FairPoint provides broadband service to its customers with FTTH, ADSL, ADSL2+, VDSL and WiMAX. Ultimately, the customer is indifferent to the specific access technology, provided the service offers reliable and appropriate speeds, consistent with the customer's demand.

FairPoint's initial deployment plan in New England anticipates the use of several types of technologies, with a view to supporting a migration toward higher-speed[7] architectures

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[7] More accurately, higher "bit rate," which is the number of bits that are conveyed or processed per unit of time. Bit rate is often expressed as connection speed, transfer rate, channel capacity, maximum throughput or bandwidth capacity.

such as fiber-to-the-home. Part of FairPoint's success in rolling out broadband has been based on the ability to deploy a mix of technologies and tailor technology choices to suit the demands and conditions of each geographic area. The key insight is that FairPoint has the flexibility to evolve its entire network in a way that best ensures meeting the customers' demands in a cost-effective and efficient manner.

Q. Are you able to provide an evaluation of the FairPoint Broadband Network Design Plan (FairPoint Plan) for Northern New England and New Hampshire specifically?

A. Yes. FairPoint's plan for New Hampshire is consistent with FairPoint's plans for Northern New England. FairPoint has been successful in deploying broadband to lower-density areas. Ninety-two percent of FairPoint's current northern New England customers have access to FairPoint broadband. The FairPoint Plan is a reasonable and sound approach to aggressively deploy broadband to consumers throughout the region. FairPoint will enable twenty-two (22) New Hampshire central offices (COs) that do not now support broadband. Additionally, FairPoint will aggressively upgrade four hundred twenty-three (423) digital loop carriers (remote terminals) with MSAN equipment to reach more customers with broadband. The FairPoint Plan is based on an investment approach that targets both improvement of the core network and deployment of broadband services to consumers. Specifically, FairPoint plans to deploy an IP/MPLS backbone network to ensure that its broadband users do not experience major source congestion as data travels to and from other networks. Additionally, FairPoint plans to increase the availability of broadband to a much higher percentage of locations in the region. The FairPoint Plan, which is described in the Joint Rebuttal Testimony of Mssrs. Brown, Harrington and Smee, describes how much will be invested in the network and when the investment will occur. It also describes the types of technologies that will be deployed and how the technology supports migration toward higher-speed architectures such as FTTH.

Q. In summary, what has your research and analysis revealed about the FairPoint broadband plan for New England?

A. FairPoint is approaching the evolution of its broadband service to New England customers in a way that is consistent with well-understood best practices in network design. The company is building out the core of its network to ensure that the architecture is more flexible and that no bottlenecks exist as higher data rate services are deployed at the edge. The company is expanding the reach of broadband to customers in northern New England so that availability is expected to improve markedly from the current level. Finally, FairPoint is designing its network to support a variety of emerging technologies, which will allow for the deployment of various broadband access technologies that match the needs of the customer. To review the summary at the beginning of my testimony, I conclude:

1. *The FairPoint broadband plan establishes a solid network core that can efficiently service customers using a variety of access network technologies that are appropriate to specific locales.*

2. *The plan is consistent with the technologies currently being deployed by other operators in the United States and abroad.*

3. *The plan is designed to ensure a significant and wide-spread build-out to large numbers of additional customers.*

4. *The plan will provide increased capacity for most current uses and can be evolved as needed to meet higher speed customer needs.*
5. *The plan will help develop the infrastructure required to meet the needs of particular high-capacity customers.*

Therefore, I conclude that FairPoint's broadband plan is a sound approach to broadband deployment and that DSL is a reasonable, forward-looking technology.

Consistency with New Hampshire's Broadband Goals

Q. Does the FairPoint plan help achieve the goals enumerated by the New Hampshire Division of Economic Development (DEC) of the Department of Resources and Economic Development?

A. Yes. I understand two (2) of the goals for the Director of the DEC, broadly speaking, are as follows:

1. Identify shortcomings in the deployment of telecommunications infrastructure throughout all parts of the state.

2. Work with providers of telecommunications services, educators, and municipal, county, state, and other government officials to assist efforts to enhance the deployment of telecommunications services.[8]

FairPoint's plan addresses these goals by specifically targeting lower-density, rural, un-served areas. FairPoint has demonstrated success in deploying broadband to such

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[8] RSA 12-A:45 Telecommunications Planning and Development Initiative, see also, The New Hampshire Internet Information Center at http://www.technologynh.com/isp/vwho.php.

lower-density areas, as demonstrated by the high percentage of current FairPoint northern New England customers that have access to broadband services. As discussed above, FairPoint will enable the twenty-two (22) COs in New Hampshire that do not already support broadband to do so. FairPoint will also upgrade four hundred twenty-three (423) DLCs with MSAN equipment to further enable broadband to more customers. Thus, FairPoint plans to upgrade the current telephony infrastructure to deploy broadband services to customers that can be reached, but do not currently have broadband availability through Verizon.

FairPoint's plan also takes into consideration the development of bandwidth, synchronicity, reliability and security. FairPoint's plan calls for intensive infrastructure installation and upgrades, building out a robust core, or backbone network and modernizing the access network, thus providing bandwidth for current needs and the capability to meet increasing future bandwidth needs, including synchronicity (uplink rates equal to downlink rates), as well as providing the reliability and security of a next generation network. Further, as recommended by state witnesses Brevitz and Baldwin, FairPoint helps New Hampshire to reach its broadband availability goals by providing a specific plan for broadband DSL deployment. The FairPoint Plan explicitly states how much will be invested in the network and when the investment will occur. It also describes the types of technologies that will be deployed and how the technology supports migration toward higher-speed architectures such as FTTH.

Q. How do FairPoint's intensive upgrades and extension of DSL availability affect the affordability of its DSL service?

A. Affordability is an important factor in broadband availability. The DEC determined "availability *and affordability*" to be "major concerns of educators, businesses, and economic development leaders"[9] and state witness Baldwin notes the importance of affordability. Impressively, while upgrading the core and access network extensively and greatly expanding DSL availability FairPoint is committing to offer DSL retail rates equal to those charged by Verizon at the time of the transaction closing,

Q. Could you provide the details of how FairPoint's plan meets the goal of providing bandwidth, synchronicity, reliability and security with increasing use of modern fiber optic, IP/MPLS based technology with respect to the core or backbone portions of its network?

A. Yes. FairPoint's planned core network, as described above, will clearly support a goal of developing a next generation network capable of providing bandwidth, synchronicity, reliability and security. It will support the video, Internet, voice and emerging applications that business, education and enterprise will demand. To give a specific example, IP/MPLS and IP/Ethernet backbone architectures allow for IP multicast services such as IPTV. This same multicast capability also can be used for schools and businesses to broadcast video or audio from one location to multiple locations. This can be used to provide for broadcast of lessons from one school location to many and for video conferencing from one business location to several on the network. Including Internet Group Multicast Protocol (IGMP) allows for minimal bandwidth usage on the network and minimizes the risk of network congestion. FairPoint presently offers IPTV services in Yelm Washington and is developing them for use in Missouri across the

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[9] Moving New Hampshire Into the Digital Economy, November 2002, p.2.

IP/Ethernet based network. This service includes 145 plus channels of Video, 45 channels of Music and Video on Demand. Thus, FairPoint's plan supports a goal of next generation networks that satisfy business, education and enterprise and goes beyond by supporting IP multicast services while minimizing any congestion when utilizing this application.

Q. How does FairPoint's plan meet the goal of providing bandwidth, synchronicity, reliability and security in next generation networks capable of delivering video, very high speed Internet, and voice with increasing use of fiber optic technology with respect to the access network portions of its operation?

A. A second FairPoint design practice involves choosing the access technology that best matches the customer's needs. After first upgrading the core (backbone) of the network, FairPoint then is able to modernize the edge (or last mile) of the network. In the second tier of its network, FairPoint will make use of Multi Service Access Nodes (MSAN), which is network equipment that can support a range of access (last mile) technologies, e.g., basic telephone service, ADSL, VDSL and FTTH (Fiber To The Home). FairPoint presently plans to deploy ADSL2+ and VDSL2, which will support up to 25 Mb/s and 100 Mb/s, respectively (depending upon distance). MSAN devices also support the provisioning of fiber to the home utilizing either Gigabit Passive Optical Networks (GPON) or Active Ethernet standard technology to allow 2.4 Gb/s of total bandwidth with an average bandwidth of 75 Mb/s per customer using GPON or up to 1 Gb/s with Active Ethernet.

As stated earlier, MSANs will allow FairPoint to deploy FTTH in the future for greenfield builds, new businesses and other rebuilds. FairPoint has deployed FTTH from this same platform in several new Greenfield subdivisions in Washington, Florida and Missouri using both GPON and Active Ethernet. In its current service areas across the U.S., FairPoint today serves its broadband customers using different access technologies, including copper, fiber, copper/fiber hybrid, and wireless (in the form of radio frequency transmission). More specifically, FairPoint provides broadband service to its customers with FTTH, ADSL, ADSL2+, VDSL and WiMAX. Ultimately, the customer is indifferent to the specific access technology, provided the service offers reliable and appropriate speeds, consistent with the customer's demand. FairPoint's initial deployment plan in New England anticipates the use of several types of access technologies, with a view to supporting a migration toward higher-speed architectures such as FTTH. Part of FairPoint's success in rolling out broadband has been based on the ability to deploy a mix of technologies and tailor technology choices to suit the demands and conditions of each geographic area. The key insight is that FairPoint has the flexibility to evolve its entire network in a way that best ensures meeting the customers' demands in a cost-effective and efficient manner. The FairPoint Plan is a reasonable and sound approach to aggressively deploy broadband to consumers throughout the region. The FairPoint Plan also is based on an investment approach that targets both improvement of the core network and deployment of broadband services to consumers through the access network.

Q. Will FairPoint's plan to expand its access network to such an extent preclude other access technology to unserved or under served areas of New Hampshire?

A. State witness Baldwin notes that wireless providers should not be opposed. While FairPoint's broadband deployment plan offers vast improvements in broadband performance and greatly extends DSL availability, it recognizes that other access technologies, such as wireless may be better suited to some populations. In particular, there are very remote areas where currently it is nearly impossible to provide DSL or extremely sparsely populated areas where it is not economically reasonable and a solution such as wireless access technology would be appropriate.

CONCLUSION

Q. Why do you conclude that FairPoint's plan for broadband deployment in New Hampshire is sound and reasonable?

A. Specifically, FairPoint plans to deploy an high data rate, IP/MPLS backbone network to ensure that its broadband users do not experience major source congestion as data travels to and from other networks. Additionally, FairPoint plans to increase the availability of broadband to a much higher percentage of locations in the region by upgrading central offices and remote terminals that connect to the access network. The FairPoint Plan explicitly states how much will be invested in the network and when the investment will occur. It also describes the types of technologies that will be deployed and how the technology supports migration toward higher-speed architectures such as FTTH.

FairPoint is approaching the evolution of its broadband service to New England customers in a way that is consistent with well-understood best practices in network design. The company is building out the core of its network to ensure that the architecture is more flexible and that no bottlenecks exist as higher data rate services are deployed at the edge. The company is expanding the reach of broadband to customers in Northern New England so that availability is expected to improve markedly from the current level. Finally, the company is designing its network to support a variety of emerging technologies, which will allow for the deployment of various broadband access technologies and allow the provisioning of more enhanced services and data rates as they are requested.

Q. Does this conclude your rebuttal testimony?

A. Yes. Thank you.