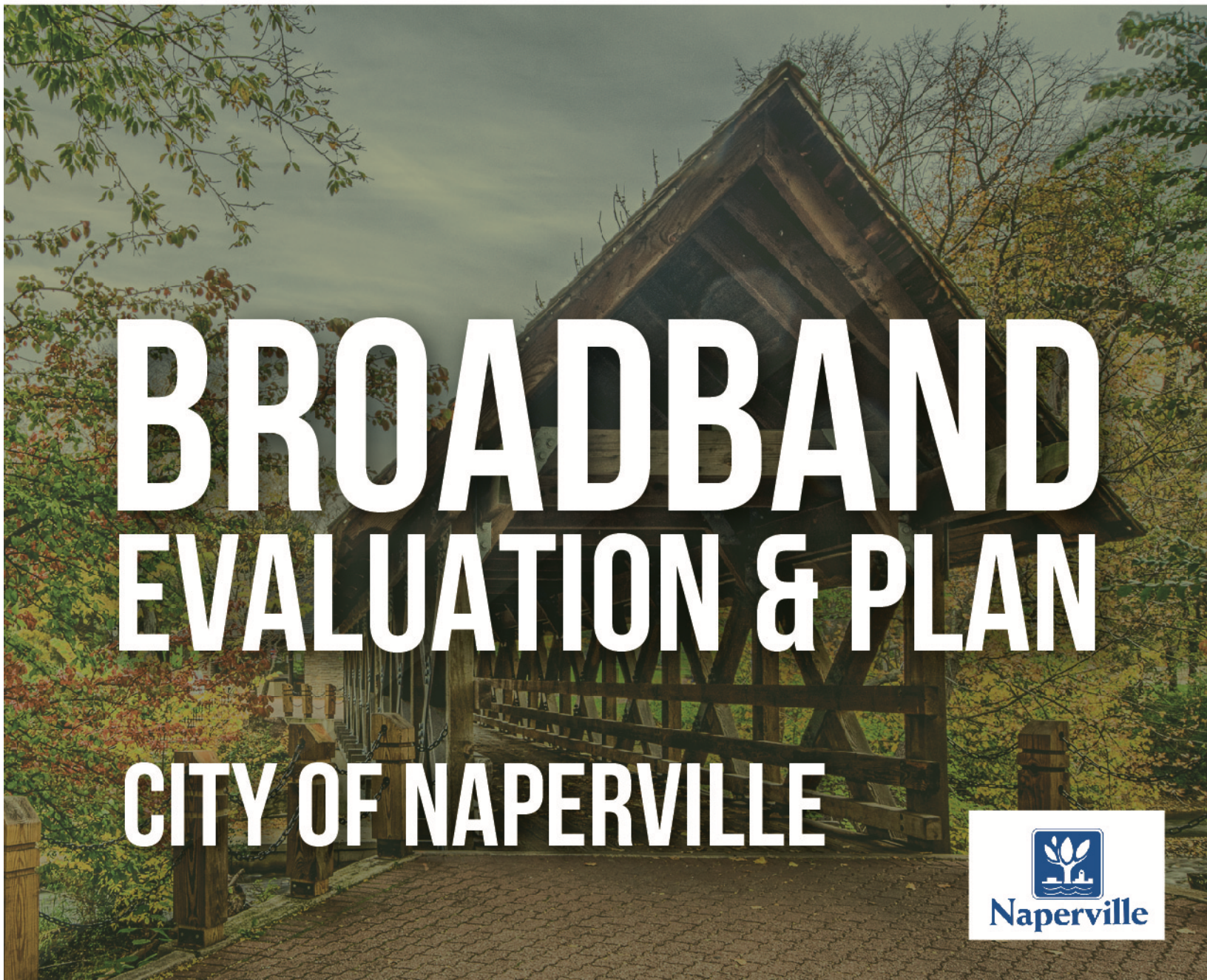
March 2018

Magellan ADVISORS

www.magellan-advisors.com

FINAL



BROADBAND EVALUATION & PLAN

CITY OF NAPERVILLE

Naperville

Broadband Evaluation and Plan

CITY OF NAPERVILLE, IL | MARCH 20, 2018

ACKNOWLEDGEMENTS

The City of Naperville would like to acknowledge the contributions of multiple individuals and organizations who have provided valuable insights and information that have contributed to the development of this Broadband Evaluation. These contributors include, but are not limited to:

Municipal and Community Anchors:

City of Naperville | City of Naperville Information Technology Department | City of Naperville T.E.D. Department | Naperville Area Chamber of Commerce | City of Naperville Dark Fiber Team | City of Naperville Legal Department | City of Naperville Department of Public Utilities - Electric | City of Naperville Department of Public Utilities - Water | City of Naperville Public Works Department | City of Aurora | DuPage County | Naperville Park District | Naperville Public Library | City of Naperville Fire Department | City of Naperville Police Department | Naperville Development Partnership, and the Downtown Naperville Alliance

Business Community Focus Groups and Business Participants: |

Advanced Data Technologies | Bill Jacobs BMW | Comcast | | Ecolab | Gerald Auto Group | NACC |
Naperville Community Unit School District #203 | Sound Incorporated | Esser Hayes Insurance Group, Inc. | North Central College | Northern Illinois University | Indian Prairie School District #204 | Verizon

City of Naperville Ordinance Review:

AT&T | Comcast | Insight – Inc on behalf of Verizon | WOW | City of Naperville Legal Department | City of Naperville Dark Fiber Team

All participants in the City's Broadband Business Survey

TABLE OF CONTENTS

TABLE OF FIGURES

1. EXECUTIVE SUMMARY

Progressive communities are relying upon municipal fiber-optic networks to thrive in the new digital world. As municipalities continue to adopt and adapt technology platforms, more emphasis is being placed on meeting the growing technological demands of their internal departments and constituents through advanced communications systems. Municipalities that have invested in fiber infrastructure realize the importance of these assets to their governmental operations and are beginning to leverage them to streamline city services, deploy Smart City infrastructure and to support next-generation broadband for their communities. The City of Naperville (the "City") is pursuing identification of opportunities to enhance connectivity and expand city fiber through public and private partnerships, smart policy and direct investments.

In 2017, the City contracted with Magellan Advisors for a Broadband Evaluation and Plan ("Plan") to identify opportunities within the community that could utilize existing broadband assets (fiber/conduit/poles), how the City could address growing interest in the City's public rights-of-way and other assets by wireless carriers for 5G small cell expansion[1], address the opportunity to leverage the City's broadband assets to include opportunities to deploy Smart City technology, guide the City's fiber and broadband expansion through a range of partnership opportunities and updates to city policy and ordinances and strategic planning. This Plan outlines these expansion opportunities, while providing a clear framework to support the needs of the Naperville community. This Plan will enable the City to leverage its current assets to make Naperville a smart connected city, enhance the quality of life for its citizens and provide its business and community anchor institutions[2] with the tools to succeed in the digital world.

The City of Naperville is the fifth largest city in the State of Illinois, located just 30 miles west of Chicago. Naperville is an award-winning community that prides itself on quality of life for citizens of all ages. The City maintains a vibrant downtown district, great schools, exceptional public safety and has been rated one of the nation's top communities by various outlets over the past decade. City leadership understands that to maintain the City's prestige and continue to

---

[1] "5G" wireless technology is distinguished from the present "4G" based wireless service by use of low power transmitters with coverage radius of approximately 400 feet – 5G thus requires close spacing of antennas and more of them than use for "4G" wireless service.

[2] "Community Anchor Institutions" or "CAIs" are defined as "Schools, libraries, medical and healthcare providers, public safety entities, community colleges and other institutions of higher education, and other community support organizations and agencies that provide outreach, access, equipment and support services to facilitate greater use of broadband service by vulnerable populations, including low-income, the unemployed and the aged."
https://www.ntia.doc.gov/legacy/broadbandgrants/guidance/Glossary_01-29-10_v6.pdf

maintain its community centered environment it must continue to adapt to the rapidly evolving broadband communications needs of its constituents.

Naperville currently maintains and operates a fiber-optic network through its Department of Public Utilities - Electric which has been placed, operated and expanded for operational needs of its electric, water and municipal departments. The City's advanced investments in conduit and fiber-optic infrastructure position Naperville to develop and implement smart technologies for the benefits of its community. The Broadband Evaluation and Plan will promote long-term internal cost savings and efficiencies by supporting connections for the City's municipal departments and public facilities, streamlining the city's traffic and parking and supporting realization of benefits through Smart City and innovations in the Internet of Things ("IoT") as they continue to develop in the marketplace.

City leadership considers fiber-optic infrastructure as critical infrastructure to support the City of Naperville community, a "4th utility" equivalent to roads, gas/electric, and water and sewer services. Continued investment in the City's-owned fiber network is an endeavor that will support City operations and community needs for the next 30 to 50 years. While most City facilities are connected to the network today, the City understands that its communications needs will continue to grow from where they are today to embrace the future needs of the community. Educational and health care applications, expanded wireless services, surveillance cameras, sensor networks, traffic cabinets, smart light poles, extended Wi-Fi and other connectable devices will all dictate further communications needs that the City will have to consider.

This Broadband Evaluation Plan provides the City of Naperville the ability to:

1. Leverage City broadband assets in and above the ground;
2. Implement Wi-Fi throughout the City;
3. Identify where Smart City assets can provide needed Smart City services and functions;
4. Leverage broadband assets for revenue; and,
5. Provide broadband for customers such as schools, health care facilities, community anchor institutions and business customers, where appropriate.

In particular, the Broadband Evaluation supports dig once policies and practices for expanding community fiber assets and leveraging of the City's pole assets and fiber network for the ongoing evolution from "3G/4G" to "5G" wireless services. Ultimately, the Broadband Evaluation supports the City of Naperville's implementation of smart-city initiatives for health, education, public safety, mobility, livability and economic growth on an affordable basis.

1.1 City of Naperville's Telecommunications Goals

The City of Naperville understands the demand for broadband access and bandwidth will only continue to increase as the influx of IoT devices, cloud computing, wireless technology innovation and evolution, and innovations in transportation, healthcare and education continue to transform our communities. The City's leaders have taken the steps to identify goals for the City to prepare itself for the coming technologies that will impact the community now, and into the future as the community continues to grow in look and feel. Naperville will utilize the forward thinking of its leading investments in fiber-optic infrastructure and conduit to prepare a roadmap for future telecommunication projects and policy.

Through this Plan, the City of Naperville will look to strategically address telecommunication issues impacting the City's rights-of-way, land use, streetscapes, data needs, businesses and anchor institutions. The City has been approached by several private providers looking to gain access to the City's streetlights, utility poles and rights-of-ways (ROW) in preparation for the influx of 5G technology. This plan outlines the City's opportunities to address these inquiries and create policies that will streamline Naperville's abilities to respond to requests, while continuing the City's ability to define the look and feel of their landscape and streetscape.

Through interviews with the City departments, dark fiber team and city leadership the Plan will identify how Naperville can address its goals including:

- Preparing a strategic roadmap to expand Wi-Fi in the City;
- Shape policy including Dig Once and ROW wireless ordinance to prepare for 5G;
- Capitalize on opportunities to expand the current fiber infrastructure into a resilient community network;
- Develop opportunities for partnerships and dark fiber leasing; and,
- Consider priority "Smart City" applications through formation of a "Smart City" Steering Committee (as described beginning on page 75, and in Recommendation 1).

1.2 Summary of Recommendations

Magellan Advisors makes a number of recommendations throughout this Report which are summarized here:

1. Magellan Advisors strongly recommends that the City continue its assignment of 6 fiber strands of the existing DPU-E fiber-optic assets to the Information Technology Department, to be managed and administered for City and regional networking purposes. [Page 87]
2. The City should leverage the work that has been done in this project by the Dark Fiber Committee with a "**Phase II**" to design "**City Net**". [Page 90] To look forward to necessary expansion of the "City Net" Magellan Advisors recommends that the Dark

Fiber team (with direction from City leadership as required) design a resilient broadband backbone through a Phase II Fiber Master Plan that includes design engineering and RFP development for construction. The network design and strand count for this resilient network will take into account use of DWDM (dense wavelength division multiplexing), lit and managed network technology to design the network to accommodate current city, smart city, public safety and small cell deployment needs. [Page 88]

3. Fiber for traffic signal systems is separate from DPU-E fiber as traffic fiber is funded by state and federal transportation funding. Consideration should be given to some sort of partnership, so these assets may be jointly used to the benefit of the City, to the extent practical. [Page 25]
4. The fiber deployed in Naperville's network is primarily single mode, but in the downtown corridor it is multi-mode. The City should pull out the multi-mode fiber and replace it with single mode fiber. The City should then connect any cameras that are within distance of the existing multi-mode fiber and empty ducts for improved resolution, bandwidth and to increase the number of cameras that can be connected.
5. The City should formalize broadband-friendly public policies, as described at page 90.
6. The City should employ conditions for development that include placement of telecommunications assets as a part of the necessary development infrastructure. [Page 99] The City should renew its previous approach to coordination of projects in the rights-of-way among city departments and utilities to promote expansion of broadband infrastructure, reduce disruptive repeated excavations which cause traffic disruption, road deterioration, service disruptions and wasted resources. [Page 61]
7. The City should evaluate and encourage partnerships in utilization of fiber optic network assets:
    a. The City of Naperville should take specific steps to work with OnLight Aurora on regional networking. There is an interest and a clear benefit in connecting the cities' two networks for regional public safety purposes, economic development as well as siting for wired and wireless telecommunication providers. [Page 80] The City of Naperville's IT Department should work with OnLight Aurora on a regional basis to work on efficient ways to interconnect "City Net," to meet the cities' public safety needs and requirements, to support further efficiencies with the counties and parks departments, and in serving community anchor institutions such as schools and universities. [Page 92]
    b. The City should seek to include the DuPage County IT representatives in collaborative planning for creation of "City Net" and interconnection with OnLight Aurora so that DuPage County can also have the opportunity to benefit from this regional networking effort. [Page 81]
    c. The City should reach out and open and/or continue discussions with Comcast, Verizon, WOW, AT&T, VinaKom, Crown Castle, MCIMetro, and Level 3. Each of

these companies has expressed an interest in Naperville for permission to lay fiber in the public right-of-way for the oncoming deployment of 5G small cells. While investigating these partnership opportunities, the City of Naperville should focus on continuing to meet the needs and demands of City operations, while bringing value to the greater community, and monetizing any assets that are available. [Page 93]

d. School districts (#203 and #204) need high capacity broadband connections which can be supported by the City's infrastructure. The school district has interest in working with the City to connect schools, which seem to align well with the City's current conduit and fiber network. The City and school district should continue conversations to see how a partnership could be created, and if the City could service the schools at a better capacity and rate then their current connections. [Page 86] Partnering with OnLight Aurora or another ISP provider could provide additional economies. [Page 93]

e. Hospitals and medical institutions will continue to have enhanced bandwidth requirements and infrastructure needs. The City of Naperville should reach out to area hospitals and medical offices to determine if there is an opportunity to partner with the medical community and provide a reliable high-speed connection at a more favorable cost. [Page 82]

8. "Wi-Fi in our downtown would be a great advantage for our City and downtown." As the City looks to upgrade the Wi-Fi system, it should consider the vast number of users that would like to connect, including downtown visitors and businesses. [Page 67] The City should consider options to achieve the City's Wi-Fi objectives, including:

   a. Utilize the existing Wi-Fi system and upgrade/expand as necessary to provide an open Wi-Fi for the downtown area, and other areas as determined.

   b. As a standalone option (or in addition) use City electric poles and the new smart street lighting system to launch a pilot Wi-Fi network and then adopt a phased approach based on experience to turn up public Wi-Fi in the downtown and other areas.

   c. In any case, Wi-Fi deployment can be considered for special event corridors and in City parks, in the City's commercial districts, and ultimately at some point evolving to ubiquitous Wi-Fi throughout the City. [Page 37]

   d. There is a desire for broader free Wi-Fi availability in the downtown and other areas throughout Naperville. Free Wi-Fi should be included in master planning for usage downtown, and for schools and colleges in the area. [Page 65]

9. The City should immediately formalize its Smart City considerations via the formation of a **Smart Cities Steering Committee**. [Page 78]
    a. This Committee should include senior leadership from all relevant departments -- the Dark Fiber team would be a natural fit to hit the ground running.
    b. First review and investigate Smart City applications that have been under informal consideration by the various City departments.
10. The City should consider a full market analysis to analyze the specific areas of the City that are challenged by lack of advanced or affordable infrastructure. Concern exists that as one proceeds south in town broadband options begin to dwindle. The extent of this would be shown in a further detailed market analysis to ensure there is competitive choice and pricing for all businesses across the City. [Page 39]
11. The City should consider working with providers and the business community to hold education sessions that would help connect providers to businesses that need further services, to ISP's who can provide the services at a price point that is favorable for small and medium sized businesses in the City. [Page 48]
12. The City should reevaluate business and anchor institution satisfaction with their internet service periodically to determine whether City fiber and broadband assets could meet future business needs for internet connectivity. [Page 48]

2. BROADBAND OVERVIEW & NAPERVILLE'S FIBER OPTIC NETWORK

2.1 Overview of Broadband Network Technology

Broadband refers to high-speed internet services, which provide online content—websites, television shows, videoconferencing, cloud services, or voice conversations—to be accessed and shared via computers, smartphones, and other devices. The Federal Communications Commission defines broadband to be at least 25 Mbps downstream to the device, and 3 Mbps upstream,[3] though consumer demands are increasing. There are multiple broadband delivery systems, though mainly cable, DSL, fiber and wireless that connect devices to the internet.

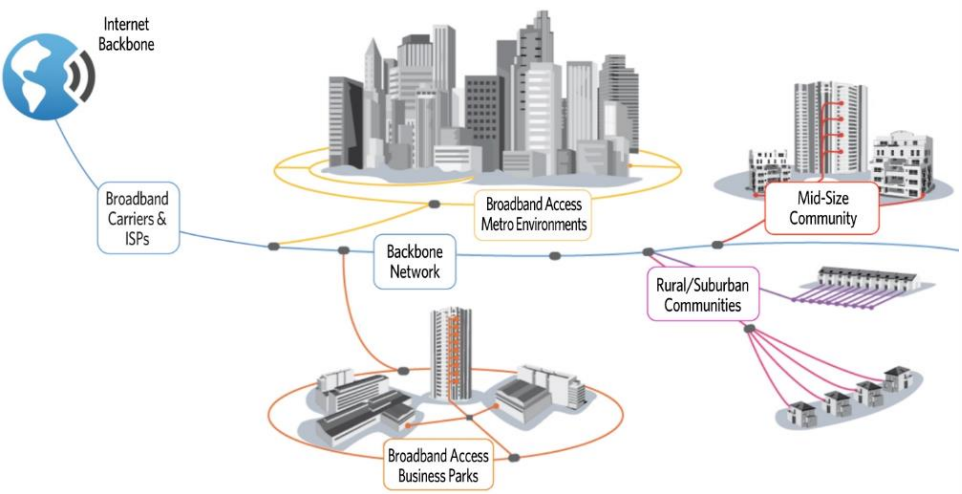
Fiber is considered the gold standard for supporting broadband, essential for fast, reliable connections. Fiber-optic cables — or just "fiber" — is a strand of glass the diameter of a human hair that carries waves of light. Using photons across glass, as opposed to traditional electrons across copper wire, fiber has the capacity to carry nearly unlimited amounts of data across long distances, literally at the speed of light. The term, "broadband" refers to the high-speed service, which enables devices to access online services.

Broadband is generally divided into business and consumer services, and those services have multiple tiers of performance and cost. Broadband is just one of many services, which include other types of telecommunications services. The variety of services and technologies are increasing—exemplified by the explosion in smartphone apps[4]—but the networks themselves are converging, so that anything can potentially connect with anything else.

[3] See www.fcc.gov/reports-research/reports/broadband-progress-reports/2016-broadband-progress-report.

[4] "App" is an abbreviation for "application" and refers to software packages that give devices certain functions.

Figure 1: How fiber-optic networks connect our communities



Broadband is supported by transmission media deployed throughout communities that carry digital signals to and from businesses and consumers. The content comes into the local community from around the world via global, national and regional networks. The local wireline infrastructure is built, connected and operated by internet and telecommunications companies that own the transmission media to each household. This started with telephone companies, which deployed twisted-pair copper telephone lines. The second wire came from cable television companies in the form of coaxial cable. Later satellite and wireless phone companies provided video and voice, with more locational flexibility to mobile and remote devices using radio waves. Passage of the Telecommunications Act of 1996 prompted broad-scale modification of telephone networks designed for voice transmission to accommodate digital data and the forerunners of internet services, as well as modification of CATV networks to accommodate voice and data services.

Local distribution facilities (copper and coax loops) that have not been substantially upgraded since that time result in slower, less reliable access to data and other content. Due to throughput capacity and reliability limits of this infrastructure, companies can't reliably provide high speeds on that infrastructure, which limits the amount of data consumers can use. Fiber does not suffer from these limitations and provides the robust infrastructure that provides true broadband internet access. Utilization of fiber-optic cable originally occurred in the core backbone network, to connect telco major switching centers, and over time fiber has been deployed closer and closer to the customer – now including Fiber to the Home deployments. Today, fiber-optic networks serve homes and businesses throughout the world providing telephone and television as well as internet access services. The next section describes internet access technologies in more detail.

2.1.1 Dial-Up Access

Though not defined as a broadband technology due to speed and bandwidth[5] limitations, dial-up access still exists (although it is rare to non-existent in Naperville). Dial-up internet access uses the public switched telephone network (PSTN) to establish an analog connection from a computer to an internet service provider (ISP). The computer connects via a modem by dialing a telephone number on a conventional telephone line and translating digital data into an analog signal.

2.1.2 Digital Subscriber Line (DSL)

DSL is a wireline technology uses high frequencies, which are not used by analog voice calls, to transmit digital data over traditional copper telephone lines faster than modems. DSL-based broadband provides transmission speeds ranging from several thousand bits per second (Kbps) to millions of bits per second (Mbps), generally ranging from 1.5 Kbps to 10 Mbps. DSL operates over the phone line—in parallel with voice traffic so calls are not affected—which plugs directly into a computer or router at the customer's site. The other end of the phone line connects to a DSL line card in the telephone company's central office or remote cabinet. Each user's data is multiplexed with their neighbors' over high-capacity fiber, transported to internet interconnection points, then routed over internet backbones to their online destinations.

There are different types of DSL:

- Asymmetrical Digital Subscriber Line (ADSL/ADSL2/ADSL2+) provides faster speed in the downstream direction than the upstream direction. This is fine for most customers who receive a lot of data but do not send much.
- Symmetrical Digital Subscriber Line (SDSL) – SDSL has the same speeds as ADSL and is used typically by businesses that generate online content or for services such as video conferencing, which need significant bandwidth both to and from the internet.
- Very-high-bit-rate Digital Subscriber Line (VDSL) – is a new generation of technology that provides up to 52/16 Mbps. It is more sensitive to line quality and requires a more expensive line card.

The availability and speed of DSL service depends on the distance from the customer to the closest telephone facility known as a central office. Telephone lines were optimized for voice

[5] "Bandwidth" is technically the range of electromagnetic frequencies that a piece of broadband infrastructure accommodates. In general use, "bandwidth" relates to how much information capacity is available for connections on a portion of a network.

communications and conditioned to eliminate high frequency noise. Consequently, some telephone lines cannot handle DSL, and others must be modified to support the service. Multiple DSL lines can be bonded to provide higher speeds, but the cost multiplies, too.

2.1.3 Digital Carrier Systems

Most commonly known as T-1s, this is the digital telephone standard in the US and has been the mainstay of corporate telecom for years. This service uses a four-wire interface to deliver 1.5 Mbps, which can be subdivided into 24 channels when bonded together. While not falling within today's federal definition of broadband, this is the way many companies get internet access and connect their various facilities. T-1s are almost universally available from local service providers, although they may charge for mileage and other things that make the service rather expensive. The digital services hierarchy extends to multi-megabit services and fits with the even higher bandwidth optical carrier services.

2.1.4 Cable Modem

Cable operators provide broadband to subscribers using the same coaxial cable that has historically delivered content to televisions through a cable modem across the same "tree and branch" network used to distribute channelized broadcast television. Technically termed DOCSIS (Data Over Cable Service Interface Specification), cable broadband literally allocates channels for carrying data to and from customers instead of television. Most cable modems are external devices that have two connections: one to the cable wall outlet via coaxial cable that goes out to the internet, the other to a computer or router via Ethernet cable.

On the cable network, where the coaxial physically ends, a DOCSIS interface strips out the data and routes them all to their destinations via fiber-optic cable. DOCSIS uses a "multiple access" approach to network in which every user's data is intermingled with others on the wire from the house to the router. Transmission speeds vary depending on the type of cable modem, cable network and traffic load.

In response to growing consumer demand for bandwidth, DSL and cable network operators upgrade outdated or underperforming equipment following their revenue models and capital budget limitations to attempt to make the infrastructure faster and more reliable. However, several fundamental issues exist that pose long-term challenges to meeting the growing bandwidth demand through copper infrastructure:

- Broadband signals degrade significantly over copper as distances increase.
- Broadband signals over copper are susceptible to electrical interference and signal degradation, particularly as they age.

- The amount of bandwidth available on portions of broadband networks is often shared among multiple users, which can result in an uneven distribution of speed to users, and slower speeds to all as facilities become congested.

2.1.5 Fiber-Optics

Fiber-optic network technology converts electrical signals carrying data into light and sends the light through transparent glass fibers about the diameter of a human hair. Fiber transmits data at speeds far exceeding copper, typically by hundreds of megabits per second. With fiber-optic broadband networks, speeds in the billions of bits per second range are possible. The fiber-optic network today operates at nearly 300 Terabits per second, which is so fast that a single fiber could carry all the traffic on the internet.

More commonly, fiber-optic networks provide between 100 Mbps and 10 Gbps to users. Fiber-optic networks can be designed to be highly reliable as well as fast. Fiber-optics are used extensively by major corporations and institutions and are at the core of every telecom company's network. There are numerous standards for fiber-optic networks. The two most common for broadband applications are Active Ethernet (AE) and Gigabit Passive Optical Network (GPON).

The actual speed the customer experiences will vary depending on a variety of factors, such as how the network is structured, the hardware attached to the fiber-optics, and how the service provider configures the service. The same fiber that provides broadband internet can also simultaneously deliver voice (VoIP) and video services, including video on demand. Fiber operates synchronously, meaning the service is just as fast to download as to upload, which is increasingly important for households and businesses.

Dark fiber is a fiber-optic strand with no hardware attached to generate laser light signals across the fibers. From the business perspective, dark fibers are facilities—real estate—that are leased to customers. As with any real estate, the value of dark fiber depends on location, location, location: its end points and route. Dark fiber customers are large enterprises, including internet service providers, that need to interconnect local area networks or "last mile" access network infrastructure.

The fiber must be "lit" to carry data between network nodes and provide network services. That equipment must be powered and connected to other network infrastructure and must be housed in a building or cabinet. And, of course, all this infrastructure must be secured and maintained. Dark fiber lessors and lessees need to be thorough, clear, and in agreement about who is responsible for each portion of the infrastructure.

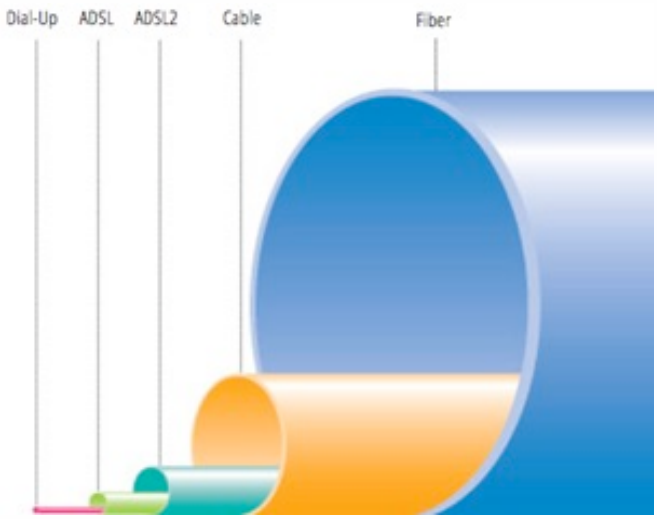
- Fiber to the Node (FTTN) brings high-capacity fiber-optic cables to communities and then connects to existing DSL and coaxial equipment. This is not an "all fiber" approach. Rather than bringing fiber-optic cables to every home or business, the fiber is connected

to the existing copper network to increase its capacity. The copper-based "last mile" network that connects homes and businesses to the local nodes is still a bottleneck and results in subscribers not accessing the true speeds of fiber-optic connections.

- Fiber to the Premise (FTTP) provides internet access by running fiber-optic cable directly from an internet Service Provider (ISP) to a customer's home or business. This approach is "all fiber" all the way to the customer. Fiber facilitates much faster speeds than copper wire, generally needs to be serviced less, and is "future proof" because technology can increase the bandwidth of fiber-optic cables. AE and GPON are both FTTP technologies.

Figure 2 illustrates the relative difference between common internet connection methods, comparing access technologies from basic dial-up service through DSL, cable and fiber. Whereas traditional broadband technologies have an upper limit of 300 Mbps, next-generation broadband that utilizes fiber-optic connections surpasses these limitations and can provide data throughputs of 1 Gbps and greater.

Figure 2: Physical bandwidth capacity comparisons



Dial-Up – 56Kbps
- *Legacy Technology*
- *Shared Technology*

ADSL – 10Mbps
- *First Generation of DSL*
- *Shared Technology*

ADSL2 – 24Mbps
- *Second Generation DSL*
- *Shared Technology*

Cable – 150Mbps
- *Data Over Cable (DOCSIS 3.0)*
- *Shared Technology*

Next Generation Fiber – 1Gbps
- *Passive Optical, Active Ethernet*
- *Shared and Dedicated*

2.1.6 Wireless

Wireless broadband can operate as mobile, hotspot, or fixed. Wireless can also be used as "backhaul" to connect remote locations or sparsely populated areas, where DSL or cable service would not be economically feasible, via long-range directional antenna. Fixed wireless services allow consumers to access the internet from a fixed point while stationary, and often require an

external antenna with direct line-of-sight between the wireless transmitter and receiver. Speeds are generally comparable to DSL and cable modem. These services have been offered using both licensed spectrum and unlicensed devices.

Hotspot wireless uses the Wi-Fi standard to provide connectivity for digital devices in an area via physical access points and a router, which interconnects wireless devices to the internet. Hotspots typically operate at 54 Mbps, but the actual bandwidth depends on the quality of the wireless signal and speed of backhaul to the internet. Wi-Fi is a multiple access technology, so bandwidth is shared with other users. While users can move around in the hotspot, they can't drive away: Wi-Fi does not provide a mobile connection. Wi-Fi is fast and robust, if limited in distance and susceptible to interference because it operates in open, unlicensed spectrum. Wi-Fi hotspots are common at hotels, restaurants and public buildings for public access. It is used in many homes and businesses for private access. Many WISPs use Wi-Fi, and it is increasingly available from traditional telecoms (AT&T and Comcast have many branded hotspots). Wi-Fi complements cellular data via mobile wireless (users often use it to avoid cellular data caps and slow speeds) and is used in conjunction with wired broadband services—most hotspots connect to the internet via broadband.

Wireless cellular data services, which borders on broadband speeds, are widely available from mobile phone companies. Typically referred to as either 3G or 4G (G for "generation"), mobile connections operate within cells that hand off signals from antenna to antenna as the device moves. 4G can move data at 12/5 Mbps, but speeds in the Kbps range are more common. Cellular data connections are most commonly used with smartphones, or with computers via cellular network interface card. Many smartphones can act as Wi-Fi hotspots or tether to computers via Bluetooth.

The next generation of wireless networks, 5G, are being designed and developed, with forecasted commercial availability in 2020 and an increased maturity of the network in approximately 2035[6]. 5G networks operate multiple frequencies (i.e., 5-GHz, 60-GHz, 0.47-0.71 GHz) and will utilize millimeter wavelengths. 5G networks will operate on the IEEE 802.11ac, 802.11ad, and 802.11af standards[7], also known as Gigabit Wi-Fi[8] and are expected to provide download/upload speeds up to 1 Gbps, which depends on the number of connections.[9] The networks are designed to provide increased efficiencies while decreasing latency and are

---

[6] Kinney, Sean. *Qualcomm SVP: New spectrum 'crucial' to 5G success,* RCR Wireless News, July 24, 2017. https://www.rcrwireless.com/20170724/5g/qualcomm-new-spectrum-5g-success-tag17, accessed December 5, 2017.

[7] http://ieeexplore.ieee.org/document/7169508/?part=1, accessed December 5, 2017.

[8] "802.11ac (Gigabit Wi-Fi). http://whatis.techtarget.com/definition/80211ac

[9] Rouse, Margaret. *5G.* What Is, March 2015. http://whatis.techtarget.com/definition/5G, accessed December 5, 2017.

designed for improving the performance of connected devices, or the Internet of Things (IoT). In particular, this means network architectures with an emphasis on massive multiple input multiple output technologies (MIMO) and device-to-device (D2D) communications. For example, autonomous vehicles, healthcare technologies (such as blood glucose monitoring), ultra-high-definition video, virtual reality with many more network designs architectures and other applications. With 5G networks being heterogeneous, they must include macrocells, microcells, small cells and relays.

2.1.7 Satellite

Satellite internet uses licensed radio spectrum to send data from and to anywhere on Earth. The signals go on a 46,000-mile roundtrip from earth-bound devices through the atmosphere via the satellite and back to earth to another computing device. These radio signals have limited capacity and thus the connections tend to be slow. Because of the distance the signal must travel, satellite transmissions are susceptible to weather. Satellite should be considered a last resort for all but the most rural and remote areas. Areas with a high adoption of satellite generally indicates a need for better service. Today, the federal government finds that no satellite broadband service meets the 25/3 Mbps threshold of broadband.

2.1.8 Municipal Fiber Networks

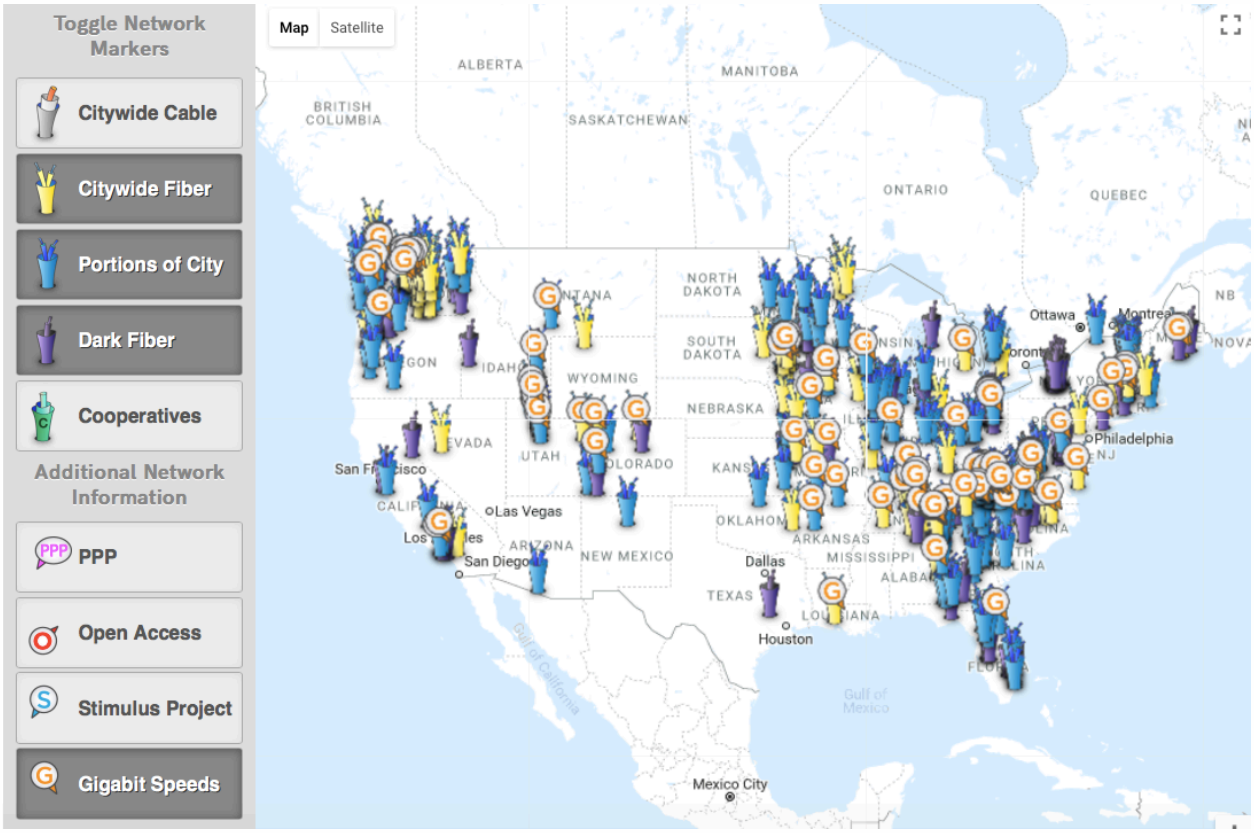
Fiber networks are the gold standard for municipal communications, broadband services and Internet access. Fiber is used to transmit large amounts of data securely over long distances with high reliability. It is flexible enough to support a wide range of applications and scalable enough to support nearly unlimited capacity and speed. It is considered a capital infrastructure asset like water, road and electric infrastructure and has a lifespan of up to 50 years or more with the proper installation and maintenance.

Over 1,000 cities in the U.S. own some form of municipal fiber networks and have used them for decades to support their operations. These networks are becoming increasingly important to cope with the rapid growth in connected devices. These devices run the gamut from utility assets and street lights, to traffic signals and surveillance cameras. Cities that maintain and manage these networks can accommodate these "smart city" technologies, which allow them to be more efficient, reduce costs, and increase the value they deliver to their constituents.

Within the past 15 years, some cities have expanded the use of these networks to enhance local broadband services in their communities. Broadband has become a key aspect to support economic development, education, healthcare, and other community functions, and cities have leveraged their networks to foster fiber-based broadband services, either directly, between and in cooperation with other government entities or more often, through wholesale agreements with commercial providers for leasing of dark fiber, conduit, or lit transport services. Figure 3

shows a recently updated map[10] of the more than 750 communities across the US with some form of publicly owned fiber networks, with more than 120 communities with a dark fiber network available similar to Naperville.

Figure 3: Community owned fiber networks



[10] https://muninetworks.org/communitymap

2.2 The City's Current Fiber-Optic Network

The City of Naperville maintains a fiber-optic backbone that consists of approximately 100 miles of fiber throughout the City and approximately 157 miles of available "duct banks" that could support future growth and expansion. The City covers just under 50 square miles. The City's base fiber network is comprised of a 24-strand fiber cable with 12 strands reserved for the Electric Utility, six strands reserved for the Water Utility and six strands reserved for general Municipal Government.

The City's current fiber Wide Area Network (WAN) was built and is operated by the City's Electric Utility. It connects most of the city owned properties and provides telecommunications, voice, video and data services. Most of the city network is already configured in rings supporting redundancy for critical use applications and programs, enhancing network reliability. The City has positioned itself to remain current with today's technology as well as positioned itself to be ready for future cloud technologies.

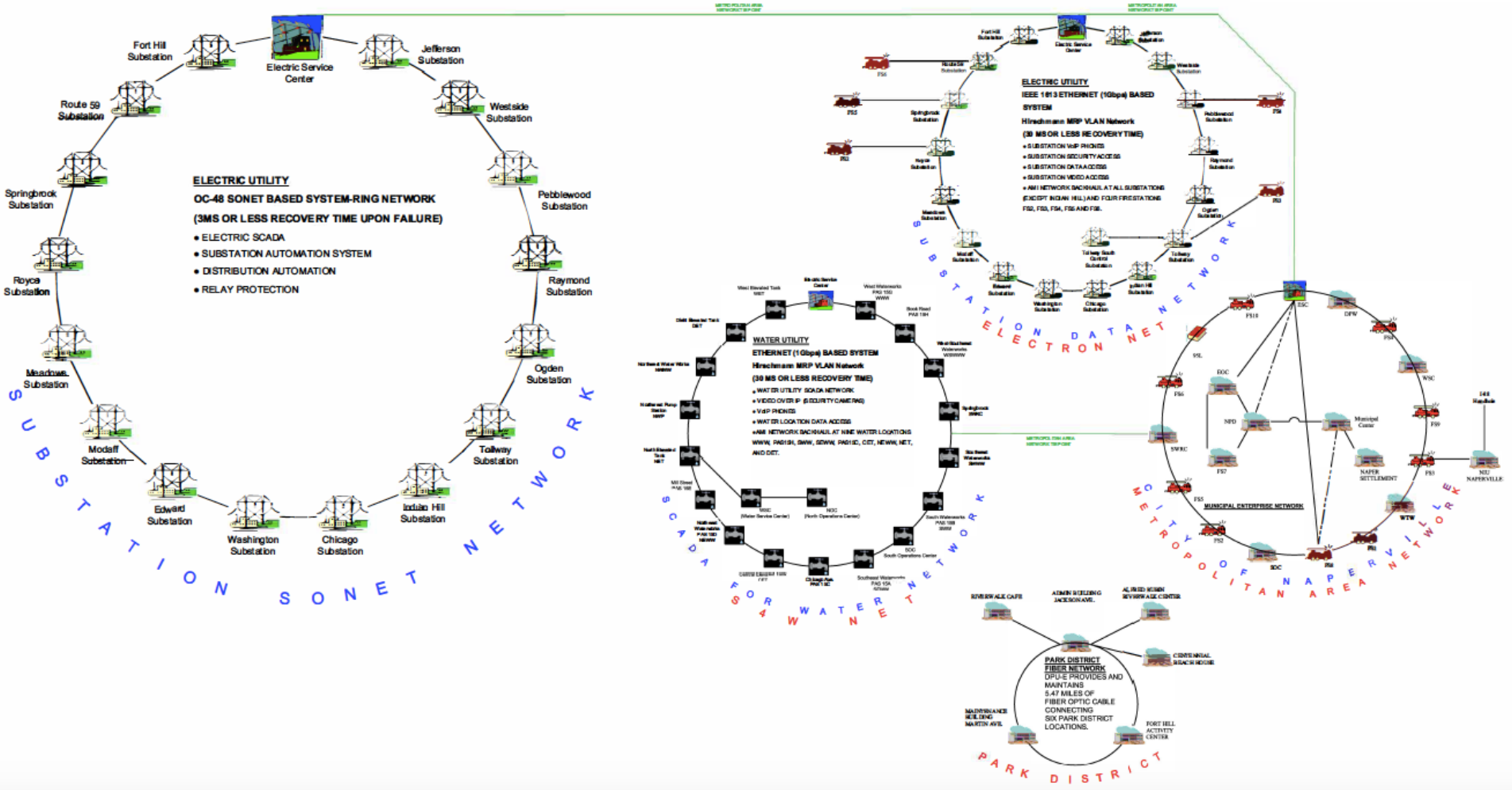
The City currently has 2,208 strands of fiber available which is distributed strategically throughout the City. This fiber infrastructure contains 528,555 foot-strands which is the result of a very proactive approach to the City's fiber infrastructure over the past several years. The utilization of these strands of fiber depends on the end points, some of which have available presently-unassigned fiber. In addition to the current WAN the City has 157 miles of underground ducts that can be used for future fiber expansion and growth. The City's backbone of 24 fiber strands is utilized to support Electric utility SCADA, Smart Grid, Water/Wastewater SCADA, Metropolitan Area network, Park District and more. Due to the nature of fiber optic technology and infrastructure (i.e., Dense Wave Division Multiplexing or DWDM), the City of Naperville thus is in a very positive position to embrace the future.

Figure 4: Network assets and utilization

Totals	**528,555**	**2,208**	**493**	**1,379**	**204**
100 Miles of Fiber	Foot-Strands	Total Strands	Used Strands	Un-used Strands	Unused, Coiled and Spliced

The network serves a total of 58 locations via fiber (52 City locations, and 6 Park District locations) and 950 City employees, including other functions and services such as VoIP telephone services, ISP services for DPU –E's Smart-Grid network, the Naperville Park District (via Municipal Center to Park District office on Jackson) and the Aurora/Naperville Teleconference System.

Figure 5: Graphic representation of the Naperville network



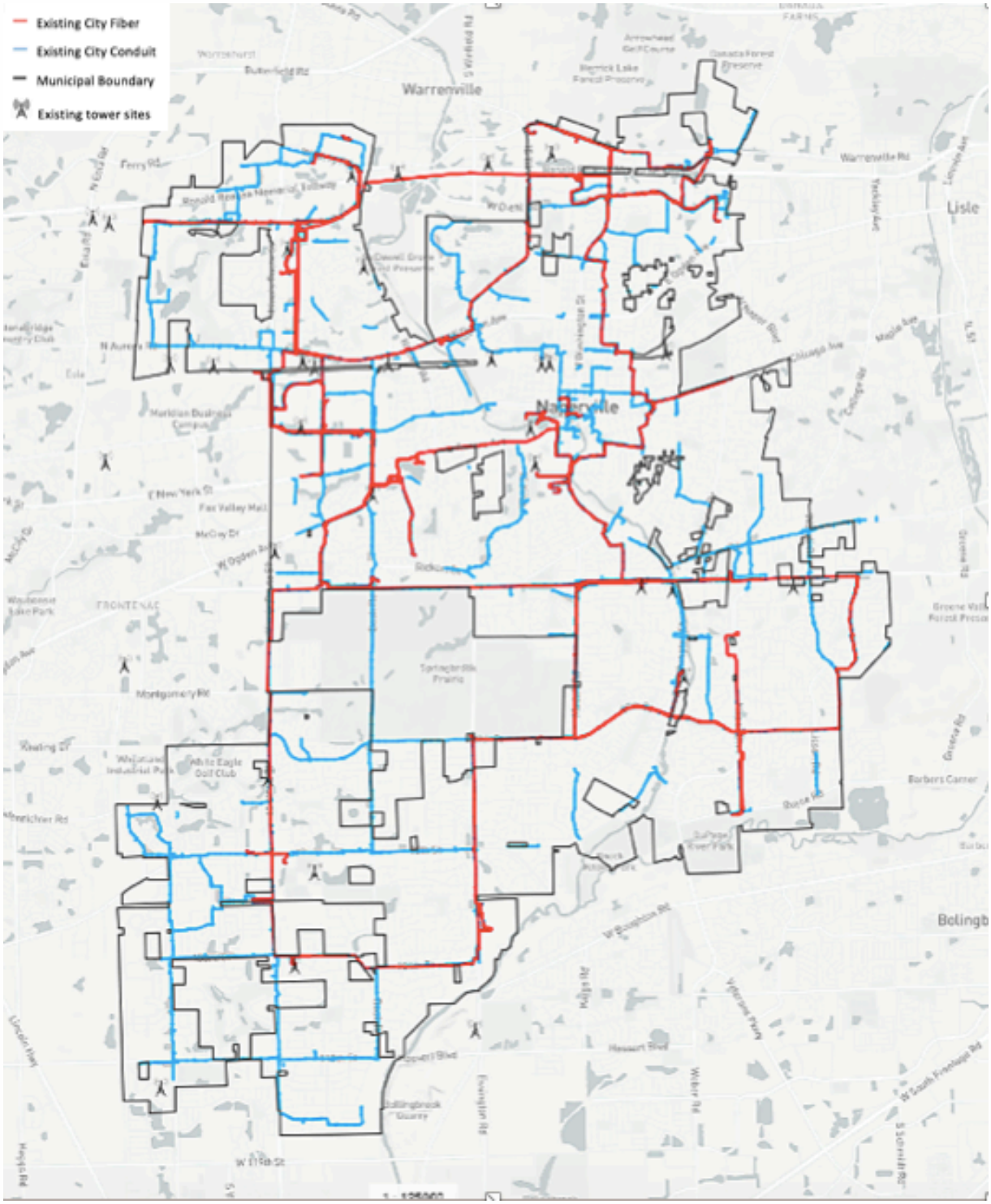
2.1.1 Electric Utility

Naperville's Electric Utility is locally owned and managed through its Department of Public Utilities – Electric ("DPU-E"), providing rates that are stable and competitive. Other benefits of local management include greater reliability and efficiency and quicker responsiveness to customer concerns. The DPU-E operates a SCADA system for control which was originally on a radio system but was migrated to a fiber-optic based system in 1998. The ring consists of 24 strands, with 12 strands for electric use, six for water, and six for the City's IT department networking. All fiber is placed in ducts with three to four 1.25 inch innerduct. The fiber network is also used for SmartGrid and AMI purposes, as well as to support Wi-Fi in strategic locations. There is also growing demand for cameras and video feeds for public safety as well as additional public internet access through Wi-Fi.

The DPU-E and Department of Public Works manages all street lighting and has undertaken conversion to LED. The City and DPU-E is poised to use pole assets for Smart City applications, with fiber backhaul supporting these applications.

The foresight of the DPU-E to create this fiber-optic ring provided the infrastructure to connect city facilities (e.g., Police and Fire Departments), to connect data centers, and to support water and wastewater facilities including pumping stations and water towers. The DPU-E has its own technicians and vehicles to accomplish fiber splicing with internal resources. Fiber for traffic signal systems is separate from DPU-E fiber as traffic fiber is funded by state and federal transportation funding. Traffic fiber is managed by Transportation, Engineering and Development Department ("T.E.D."). To the extent that DPU-E presently does not have access to the State's (IDOT) and counties' traffic signal cabinets, consideration should be given to some sort of partnership, so these assets may be jointly used to the benefit of the City, to the extent practical, i.e., for demarc purposes for support of smart city applications. City fiber is depicted by the red lines on the map on the following page.

Figure 6: City's Current Network Infrastructure



Naperville's Water and Wastewater Utility is one of the state's largest combined utility systems, operating both water distribution and sanitary district with wastewater treatment. The Department of Public Utilities - Water ("DPU-W") is known as a leader and innovator in asset renewal, sanitary sewer rehabilitation and maintenance activities. The DPU-W operates 30 pump stations, 19 of which are currently connected with fiber, with the remaining stations connected via cellular or radio connections. The DPU-W would like all stations connected with fiber for SCADA and other purposes. There is also interest in moving to AMI for meter reading. The DPU-W currently has leases for antennas on water tanks but would like to end this practice as soon as feasible, due to notice and safety concerns.

The DPU-W has used coordination meetings in the past for construction coordination and is therefore open to further consideration of "Dig Once" and conflict management practices. Also, the DPU-W would consider use of abandoned water mains to carry conduit or ductwork for fiber-optic cable.

2.1.2 Data Centers

The City of Naperville operates three primary data centers. The Municipal Data Center is located at Municipal Center at 400 Eagle Street. This data center is primarily for all City technology services and serves as the back-up for the Electric Service Center.

The City's second data center is the primary Electrical Data Center located at 1392 Aurora Avenue. This data center is the Electric Service Center (Smart-Grid) primary. It also serves as the backup for the Municipal Data Service Center and the Public Safety Service Center. The City's third data center is at the Police Departments Primary Data Center located at 1350 Aurora Avenue and is the Primary Public Safety Data Center providing Computer Aided Dispatch (CAD), Records Management System (RMS), Firehouse software services, etc.

The Naperville Data Service Centers provide services to the following;

- Electric Service Center – 1392 West Aurora Avenue
- Fire Station # 1 - 964 East Chicago Avenue
- Fire Station # 2 - 601 East Bailey Road
- Fire Station # 3 - 1803 North Washington Street
- Fire Station # 4 - 1971 Brookdale Road
- Fire Station # 5 - 2191 Plainfield - Naperville Road
- Fire Station # 6 - 2808 103rd Street
- Fire Administration/Fire Station #7 – 1380 West Aurora Avenue
- Fire Station # 8 - 1320 Modaff Road
- Fire Station # 9 – 1144 West Ogden Avenue
- Fire Station # 10 – 3201 95th Street

- Municipal Center – 400 South Eagle Street
    - Naper Settlement Campus – 523 South Webster Street
    - Water Street Parking Garage
- Police Administration – 1350 West Aurora Avenue
- Public Works Service Center – 180 Fort Hill Drive
- South Operations Center – 1800 South Washington Street
- Springbrook Water Reclamation Center – 3712 Plainfield - Naperville Road
- Civil Engineering (CEEC) – 3612 Plainfield - Naperville Road
- Water Service Center – 1200 W. Ogden Avenue
- Water Field Operations – 1200 W. Ogden Avenue

2.1.3 Market Supply/Service Providers

An assessment of private-sector telecommunications infrastructure and services in the greater Naperville area provides context for the more targeted assessment of the City of Naperville's assets. It also informs the City's strategies, since these companies are prospective partners and competitors. Companies that nominally sell wireline/fiber network services in the Naperville area are listed below:

- **AT&T** is the incumbent local exchange (LEC) provider in the City of Naperville. As the incumbent LEC, AT&T provides both retail services to consumers, businesses and wholesale services to other telecommunications providers. AT&T provides voice, Internet, and video services. AT&T maintains DSL services and has deployed U-verse selectively throughout the community. AT&T recently completed the acquisition of DirecTV, a cable TV provider using terrestrial satellite technology. AT&T provides OTT (over the top) cable TV service capitalizing on the DirecTV brand and entertainment. Infrastructure.
- **Comcast** is the nation's largest cable and broadband internet service provider, offering voice, television and broadband internet to consumers across the US, as well as wholesale services to other telecommunications providers. Comcast is the leading cable provider in the City of Naperville, offering triple play services to businesses and residents. Comcast provides the majority of its services to the Naperville community via its expansive coax infrastructure. Access to fiber-optics is available to some business and enterprise organizations with higher connection costs and build out pricing passed on to the consumer.
- **Crown Castle** owns and operates fiber infrastructure nationwide which it provides to wireless service providers (e.g., Verizon and AT&T) to connect cell towers and small cells, supporting the demand growth for data and other applications. The fiber infrastructure is also provided to businesses, technology companies and governments.

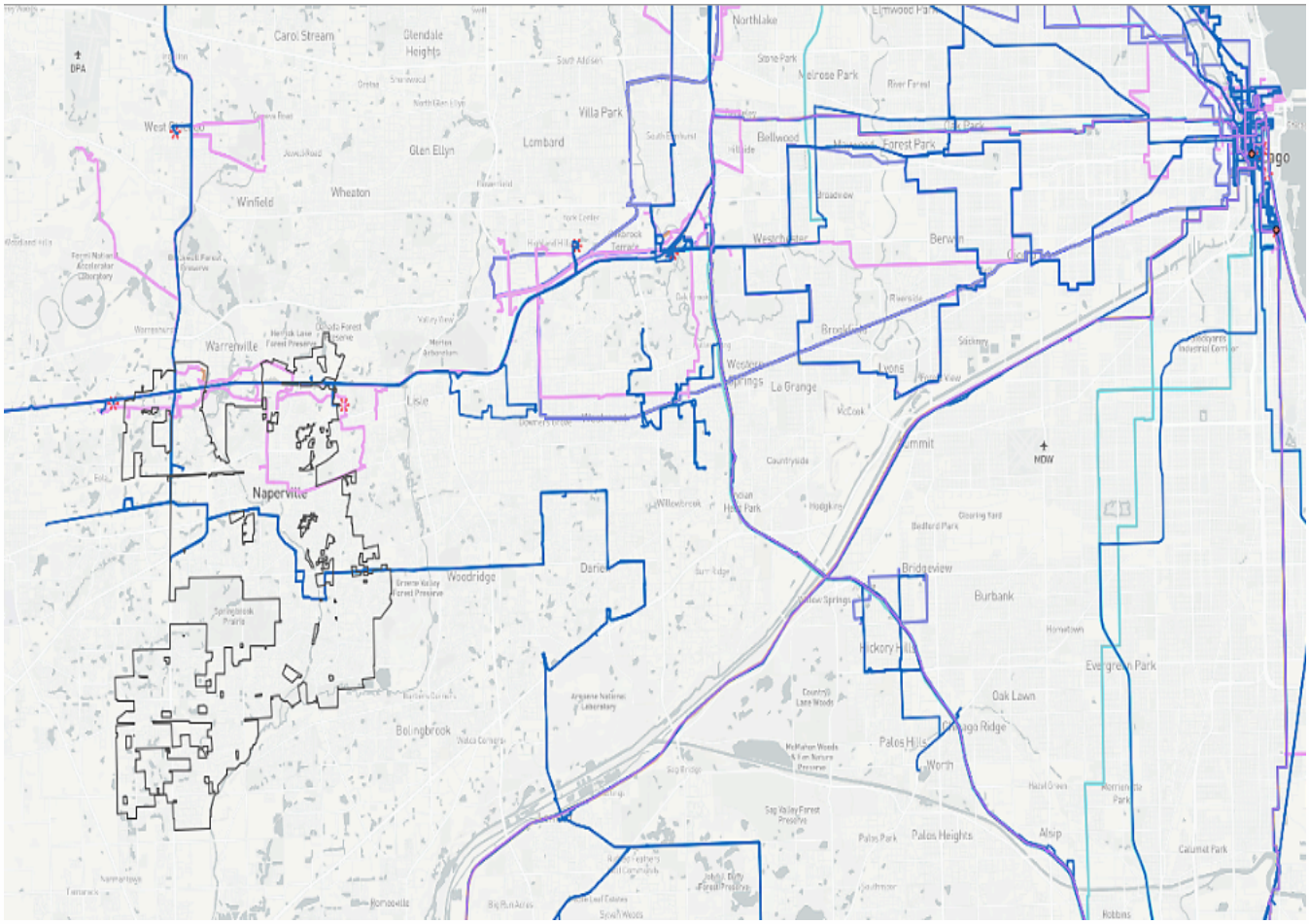
- **Level 3 Communications** (www.level3.com) is a global communications provider headquartered in Broomfield, CO that provides communications services to enterprise, government and carrier customers in over 60 countries. CenturyLink recently announced its intention to purchase Level 3. Level 3's Enterprise Solutions provides voice and video, data and security, and managed network services. A map of Level 3's network is online at http://www.level3.com/-/media/files/maps/en-network-services-level-3-network-map.pdf
- **Mobilitie** builds and operates wireless infrastructure for customers including wireless service providers, to provide a neutral host for outdoor and indoor DAS networks, Small Cells, Wi-Fi networks and communication towers.
- **OnLight Aurora** is a non-profit organization formed to manage and promote access to the City's fiber-optic network, which supports a "robust, highly available metro Ethernet network." OnLight Aurora's goal is to support business retention and economic development in Aurora through its high-speed fiber-optic network, which is designed to serve all areas of the City with economical service options. The OnLight network is used to provide high capacity fiber links to community anchor institutions such as hospitals, schools and government offices as well as other entities including data centers and Aurora businesses.
- **Verizon** provides both retail services to consumers and wholesale services to other telecommunications providers. Verizon provides voice, Internet, and video services. Verizon maintains DSL offerings in Naperville and have deployed fiber infrastructure selectively in the region.
- **VinaKom Communications** owns and operates a fiber network in the greater Chicago area which it is expanding to provide capacity, managed data center services, and MPLS networking for larger businesses.
- **Wide-Open-West (WOW!) (**www.wowway.com) WOW! is the sixth largest cable operator in the United States, providing cable, voice, cloud and broadband internet services to residents and businesses in ten states. WOW! also provides wholesale services to other telecommunication carriers including in the city of Naperville. WOW! operates a network that is constructed of coax and fiber-optic infrastructure. WOW! struck an agreement with Verizon in August 2017 to sell a portion of its fiber-optic network in the Chicago area, which includes assets in Naperville.[11] This sale of assets was consummated between the parties at the end of 2017. It is possible that this

[11] WOW! Press Release, August 1, 2017.

acquisition of WOW! Assets by Verizon in Naperville will support Verizon's deployment of 5G small cell wireless technology.

- **Zayo** (www.zayo.com) owns and operates a 112,600-mile network in North America with connectivity to thousands of data centers, carrier exchange points, wireless towers, media centers, entertainment venues, financial exchanges and cloud providers. Zayo offerings encompass a range of managed bandwidth, dark and lit fiber solutions, including wavelength, Ethernet, IP and video transport. Zayo's network map is at http://www.zayo.com/solutions/global-network.

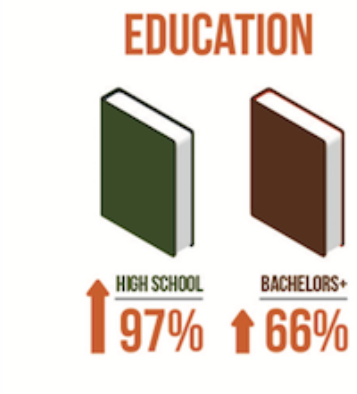
Figure 7: ISP long haul fiber routes through Naperville



3. NEEDS AND OPPORTUNITIES

3.1 Demographic Data

The key socioeconomic indicators in Naperville show high rankings versus national indices for housing prices and per capita and household incomes – which are almost double the national average ($56,000). These indicators stand out as favorable for empowering a strong innovative economy.



With its prime location as a suburb of the nation's third largest city – Chicago – Naperville attracts professionals and families who prefer to live outside of the City of Chicago. This is illustrated by Naperville's above average education demographics. National average for bachelor's degrees is around 40%, Naperville is a national leader in educated citizens.[12] According to Pew Research Center, Internet adoption rates jump by almost 20% when a person attains a college degree compared with a high school diploma. This shows Naperville has a citizenry of connected individuals with a desire and need for high bandwidth and state of the art broadband.

3.2 Stakeholder Outreach

A stakeholder is any individual or organization that might be affected positively or negatively by the outcomes or process of an action, event, initiative, policy, program, etc. Needs are a lack of an item or resource that impede progress or drives action, etc. Opportunities are situations that facilitate success of, hold promise for, or might benefit stakeholders. Any investment decision should be informed by understanding of needs and opportunities. Given the dynamic nature and range of potential benefits and costs of digital technologies, it is especially important to get stakeholders' input before undertaking investments in fiber-optics and similar assets.

---

[12] Internet Adoption Rates By Education
http://www.pewinternet.org/fact-sheet/internet-broadband/

Magellan Advisors conducted multiple interviews with internal stakeholders for the City, and with external City stakeholders. Most of these interviews were focused on network bandwidth and connectivity issues, but also touched on larger issues.

3.2.1 Internal Departments

The discussions held with internal departments in the City of Naperville included representatives from:

- Information Technology
- City Manager's Office
- Public Works
- DPU - E
- DPU - W
- Transportation, Engineering and Development (T.E.D.)
- Emergency Management and EMT
- Legal
- Finance
- Human Resources
- Public Safety (Police, Fire)

3.2.1.1 Public Safety

The City of Naperville's police and fire departments are utilizing technology at an increasing rate and have embraced a forward-thinking mentality when it comes to approaching the safety of the citizen in Naperville. The Fire Department recently received the "Heart Safe" community award, which directly results from the Fire Department's use of an app that links AED's (Automated External Defibrillators) and CPR administrators to proactively assist in a cardiac emergency. The City's Police Department is actively using License Plate Readers, and engaging citizens with the use of crime maps to track crime in their neighborhoods. The Police Department would like to use emerging facial recognition technologies at occasions like festivals, but there are questions about storage, and fiber connectivity to festival locations would be required. To demo this type of technology the Police Department needs more reliability with its camera systems, a fiber connection to the site, and fiber connections to their radio system to have a secure, and reliable connection so that officers can communicate in real time to identify threats. During on-site interviews the Departments stated they were interconnected with fiber connections, but there were concerns with wireless connectivity and connectivity in the field.

The Police Department is connected to neighboring Aurora with a Point-to-Point 1 gigabit microwave system that backhauls to a fiber ring serving Aurora locations. The network architecture is such that when one location is down, all go down, so there is a clear need for additional redundancy. The Police Department would like to see fiber to the radio sites, and to support Wi-Fi capability. Also, while the City has a fully redundant backup emergency communications center, it is too close to the main Public Safety Answering Point. Greater redundancy is important here and needs to be supported by fiber connectivity.

The Fire Department also is concerned with the availability of wireless connectivity in stations, which is generally obtained using Comcast residential service connections – paid for out of pocket by the fire fighters. During building inspections in the field, the field inspectors cannot send any information to businesses unless they access the business' open wireless connection or come back to the station to send. The use of wireless in the field is also desired for future technology including tracking firefighter's location within a building during an emergency and tracking vehicles during large festivals as well as day to day operations. Wireless capacity would also be very important for any mass casualty situations, including to support tagging of patients who need the most critical attention.

The Fire Department has a drone with infrared and 4k video, which is used for fire and search/rescue. The video feed can be very problematic, and there is a need for live feed applications.

The Fire Department uses video conferencing for daily briefing of crews. This application is shared with Aurora, and there is need to expand use of this capability for such things as access at the scene of a fire call, allowing incident commander and command post to get on video, and for other face-to-face applications such as national and state calls, and Chicago terrorism and alert situations.

Sensor technology has evolved in recent years which causes increased public safety needs for greater bandwidth and reliability. This is a trend in public safety agencies around the country. Naperville's police department is not currently using sensor technology, but as noted above is interested in deploying facial recognition for large scale events, as well as to assist in a mass casualty incident.

3.2.1.2 Cameras

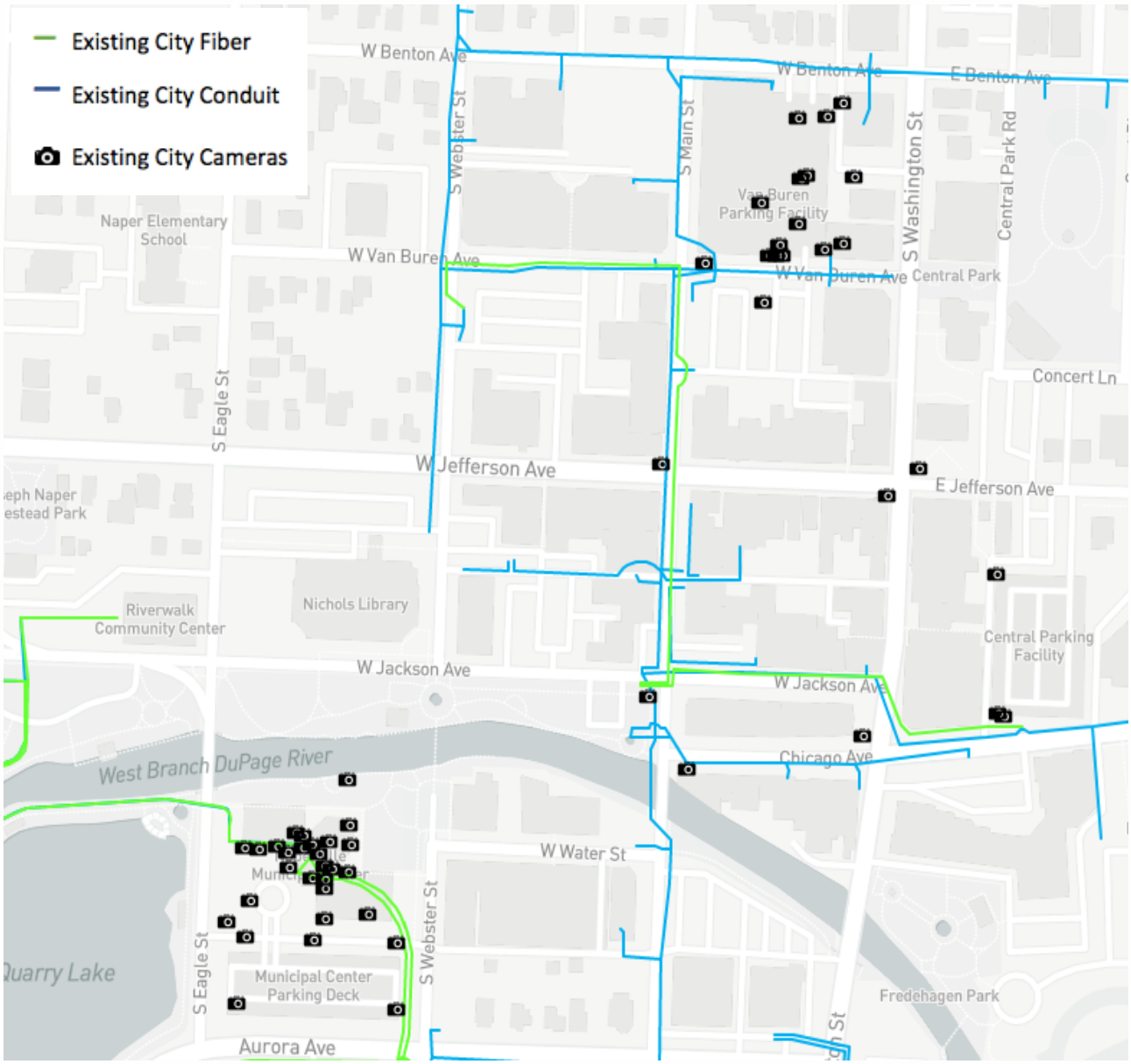
Over the course of the discussions Magellan captured many sentiments that connections and lack of availability of cameras was a source of frustration for several departments in the City. In interviews with the public works department they noted that the cameras are still connected to DSL, and they "would like to see more opportunities for cameras and street lights to be tied in to fiber." The reliability around the current cameras was a concern for public safety departments especially around larger events and festivals. The Naperville PD requested to "enhance reliability around video cameras, and the ability to download and stream video from cameras."

The public safety and emergency management departments expressed interest in connecting with cameras inside and outside of the city. Emergency management is currently lacking access to the City's cameras, in addition they would like access to the hospital and school cameras. Naperville PD expressed concern on gaining access to schools, hospitals and other municipalities cameras for investigation and emergency control situations.

The original MetroFi network proved over time to not be stable enough to support the network needed for the City's camera network, the City has since built a separate network for its camera systems. This is a closed network and was not intended to have the capacity to support public Wi-Fi. The traffic signal network has capacity in some locations to house other connections including Wi-Fi and motion detection cameras. The City should consider ways to partner with anchors to gain connection to cameras outside the city's jurisdiction, as well as working with emergency management to allow access to the City's current cameras, allowing for more efficiency.

Figure 8 on the following page illustrates the City's current camera system in relation to Naperville's fiber and duct assets. The cameras shown below are currently connected thru DSL, point to point wireless, and limited distance multimode fiber. The fiber deployed in Naperville's network is primarily single mode, but in the downtown corridor it is multimode, which is limited in its ability to transmit data over a distance, and therefore is a poor solution for the City's cameras and future needs. It is our recommendation that Naperville pull out the multimode fiber and replace it with single mode fiber. The City should then connect any cameras that are within distance of the existing multimode fiber and empty ducts for improved resolution, bandwidth and to increase the number of cameras as requested by public safety, emergency management and other city departments. Doing so would efficiently handle existing demand and provide the capacity to add more cameras as needed.

Figure 8: Camera locations, fiber (Green), ducts (Blue)



3.2.1.3 Wireless/Wi-Fi

Consistently over the course of the interviews City employees and leadership discussed the current state of wireless and Wi-Fi in the City and within the City departments. Wireless coverage was noted as lacking in the City and for internal departments. It was clear that leadership believes that the City needs to address the availability of Wi-Fi in Naperville, as well as departments' internal needs for advanced wireless connectivity.

Public Safety voiced the desire for "expansion of the Wi-Fi coverage and speed as well as improved connectivity for public safety agencies, improved coverage for the Parks District, and Wi-Fi for festivals and other special events in the City." They noted that the connections at the police department were "spotty,"[13] and that the reliability was important for everyday operations. The Utility department is currently using wireless connectivity for its SCADA operations, and noted the wireless connections are slow. Poor connections also affect the City when large crowds gather during festivals and impede public safety and festival attendees' connections to their wireless devices, as well as video streaming for law enforcement purposes.

Naperville's leadership discussed opportunities with Magellan Advisors to provide and enhance current Wi-Fi in the City. City leaders proposed an "Internet Park" in the grassy area outside of the Municipal Center, where an open wireless connection would be provided using the City's infrastructure. The City is also interested in enhancing its current downtown Wi-Fi "Napernet," that provides a limited 1 Mbps connection to citizens and visitors in the downtown corridor. Napernet is not sufficient to connect all desired users through the downtown area. The City would need to upgrade the current Richochet system to provide a ubiquitous coverage of the City's downtown district with current wireless technology.

Magellan worked with the City and local stakeholders to understand their current and future needs for connectivity to support internal and community operations. This included functions that can be enhanced through additional wireless capacity such as fire, police, public works, community development, traffic management and parking enforcement operations. Our assessment focused on current and future programs that the City will deploy and that rely on wireless infrastructure, and likely a City owned fiber backhaul. There is a clear need and desire to expand and enhance Wi-Fi networking in the City, which is also crucial to support Smart City options and functions, as described more fully below in both the Wi-Fi and Smart City sections.

[13] This issue has since been addressed.

3.2.1.4 Internal Bandwidth and Communication Needs

During discussions, Magellan Advisors found that the current internal City connection is meeting the basic needs of most internal departments for day-to-day operations, however there were several internal departments that noted increased bandwidth needs may be putting a strain on current connections. The City Clerk's office noted that its biggest hurdle is electronic payments and that they "Can take credit cards over the phone but have to walk over to another system to input it." They also noted that while operating internal computers they see "A lot of spinning blue circles." The legal department noted that computers and systems are currently being upgraded, but that there is some lag time. They noted that they were not certain if it was a result of the infrastructure or the Wi-Fi.

As the City of Naperville upgrades systems, they like many others have begun moving to a virtualized environment, storing more and more data, and operating more systems through the cloud. The City is working to move to a new Enterprise Resource Management (ERP) System that is expected to go live in the fall of 2018. With the new system, the City will be operating its business management on 24/7 online systems. Stable and secure connections are essential to keep these systems streamlined and constantly communicating. The City Clerk noted that council meetings will soon be streaming on demand, and that demand will only continue to increase, and she is not certain the current system will be able to support the increase. The City should consider if current bandwidth and infrastructure will be sufficient to support this and other needs of virtualized systems.

3.2.2 Naperville External Stakeholders

The City of Naperville scheduled two focus group discussions that engaged area anchors, businesses and regional municipal partners. The focus groups were well attended and echoed the sentiments of the online business surveys that most businesses and anchors in the City of Naperville felt that they were receiving quality broadband services with a fair amount of competition. The discussions did highlight a few areas where the City should consider opportunities to enhance citizen's connectivity, and partnerships with anchors and other municipalities.

3.2.2.1 Business Needs

Through our discussions, it appears that many businesses in Naperville are satisfied with their current connections, including access to fiber-optics, and feel that they have a fair amount of competition to choose from when selecting a provider. One business stated that they recently went out to bid for new services and received three competitive responses, and they were happy with the amount of choices. Businesses noted that on the north side of town there are a lot of providers servicing larger companies and running through because it is a major route. It was stated that there are "Plenty of options and multiple service providers at a distance that's

not too far, and you can also get it for not too much for a small business." "The north side of town is also near the CME data center and has a plethora of providers located in the data center, so anyone in that area has great infrastructure and options." There was however concern that once you get further south in to town the options may begin to dwindle. The City should consider a further detailed market analysis to ensure there is competitive choice and pricing for all businesses across the City.

A common theme emerged about increased bandwidth and options for backup/disaster recovery services. Businesses noted that if they could afford or convince ownership to add a connection at a reasonable price they would add an additional service. A representative from the auto industry noted that for the first-time Nissan is requiring its dealerships to have Wi-Fi connections for customers. He believed they were the first auto maker he is aware of that is implementing this requirement in its dealerships but assumes that others will not be far behind.

Representatives that were in the downtown area reiterated the need for increased capacity in the downtown's Wi-Fi.[14] The current Napernet is insufficient and customers "ask to connect to Napernet and get mad that it doesn't work." There is high demand from customers and businesses in the downtown area to expand and enhance the capacity of Napernet. "Wi-Fi in our downtown would be a great advantage for our City and downtown." As the City looks to upgrade this system, it should consider the vast number of users that would like to connect, including downtown visitors and businesses.

3.2.2.2 Education & Library

Representatives from K-12 and higher education were present in both focus groups. Both K-12 and higher education noted that increases in bandwidth needs are constant for education, and that they see no end in sight. Representatives from North Central College noted that one student arrived on campus with 13 devices that connect to the internet. The Superintendent of the Naperville Community Unit School District #203 discussed the district's current move to "1 to 1," meaning one internet enabled device for every student. The district recently handed out over 15,000 chrome books and iPads to students. Educational institutions should expect bandwidth needs to continue to increase as current trends would suggest and need to be prepared for yearly increases in bandwidth and ensuring they have appropriate infrastructure to support this.

Naperville Community School District #203 noted that it does still have some connectivity needs, and that they are very interested in the City's available duct work and fiber that was

[14] The development and evolution of the Naperville's Wi-Fi network, from its beginnings as "MetroFi" is described at 5.3 Wi-Fi in Naperville.

shown in the presentation from Magellan. They had reached out to the City in the past for a connection, but at the time the pricing model did not work. It was noted that although the schools all have a fiber connection, the schools are not connected to each other. The two high schools are, however, connected back to the central office. The school district has interest in working with the City to connect schools 202 and 204, which seem to align well with the City's current conduit and fiber network. The City and school district should continue conversations to see how a partnership could be created, and if the City could service the schools at a better capacity and rate then their current connections.

North Central College noted that the drive for bandwidth from student living and classroom technology keeps them constantly looking to update their infrastructure. He noted that the college is "looking for a disaster recovery connection, a fail over service." They currently have three providers including NGP to aggregate bandwidth. They are now considering changes that include: looking for another POP into campus with a different telco, covering the stadium in Wi-Fi, creating a smart campus, updating buildings to be able to collect big data through sensors for student analysis, and looking for a connection to Internet 2. The college's demand at the user level is "crazy" and they believe they will never be satisfied with the current bandwidth offers. "Bandwidth is doubled, but pricing goes up 75%." The college noted that they would be open to a partnership with the City, and Naperville should continue conversations to see if they can assist the North Central College with their current connectivity initiatives at a lower price.

The Naperville Library is following national trends of increased bandwidth needs, as libraries around the country have become a digital staple in communities attracting after school students, gamers, and tele-workers. In Naperville, the library is being used "almost like a co-working space, but they aren't paying for it." The demand for connectivity is so high that even in a City with relatively high income and broadband take rates the library still sees an increasing demand in connectivity including "people outside in the parking lot when we are closed." The City does supply a fiber connection to the library, and they are also using AT&T FTTP and ICN for internet. They expressed interest in furthering their partnership with the City for increased access to more bandwidth.

3.2.2.3 Municipalities

Naperville maintains positive relationships with DuPage and Will counties and neighboring communities such as Aurora. Representatives from DuPage County and the City of Aurora were present at the focus group presentations. DuPage County stressed that with continued trends to virtualize and move everything to the cloud, there "is never enough bandwidth" and that they are currently pushing 2 Gig.

The City of Aurora has established a successful fiber-optic broadband utility "OnLight Aurora,"[15] focusing on reaching its anchors and commercial sectors. The City is currently looking at issues of how to bridge the digital divide, and opportunities for Public Private Partnerships to assist in doing so. They have also been approached by providers for use of their infrastructure, which the City is cautiously discussing how that can positively impact their residents and achieve their goals of increased access for all citizens.

Naperville and Aurora have opportunities to connect and create a regional network that would assist in connecting public safety networks, bridging the digital divide, increase connectivity throughout the region, and create competition in the market place. Both City CIO's have had discussions that center around areas that make the most sense for the City's networks to connect.

Opportunities present themselves for interconnections at the Route 59 train stations – the Aurora and Naperville stops are the busiest commuter rail stations in Metra. The fact that these stops are the busiest on Metra presents both the need and opportunity for high-speed fiber connectivity to support Wi-Fi and other applications.

The current Public Safety Radio System connection to the Harris System is compatible with the Aurora Open-Sky system and a fiber connection presents an opportunity for the neighboring communities to have a more open line of communication on health and safety matters between the two communities.

3.3 Overview of Industry Trends in Naperville

3.3.1 Business Community Survey

To gather a better understanding of the broadband service, availability, speed, reliability and issues of broadband services to Naperville businesses, an online survey was conducted that included questions related to broadband access and its use in the operation of area businesses. In total, 213 businesses in the City of Naperville responded to the survey.

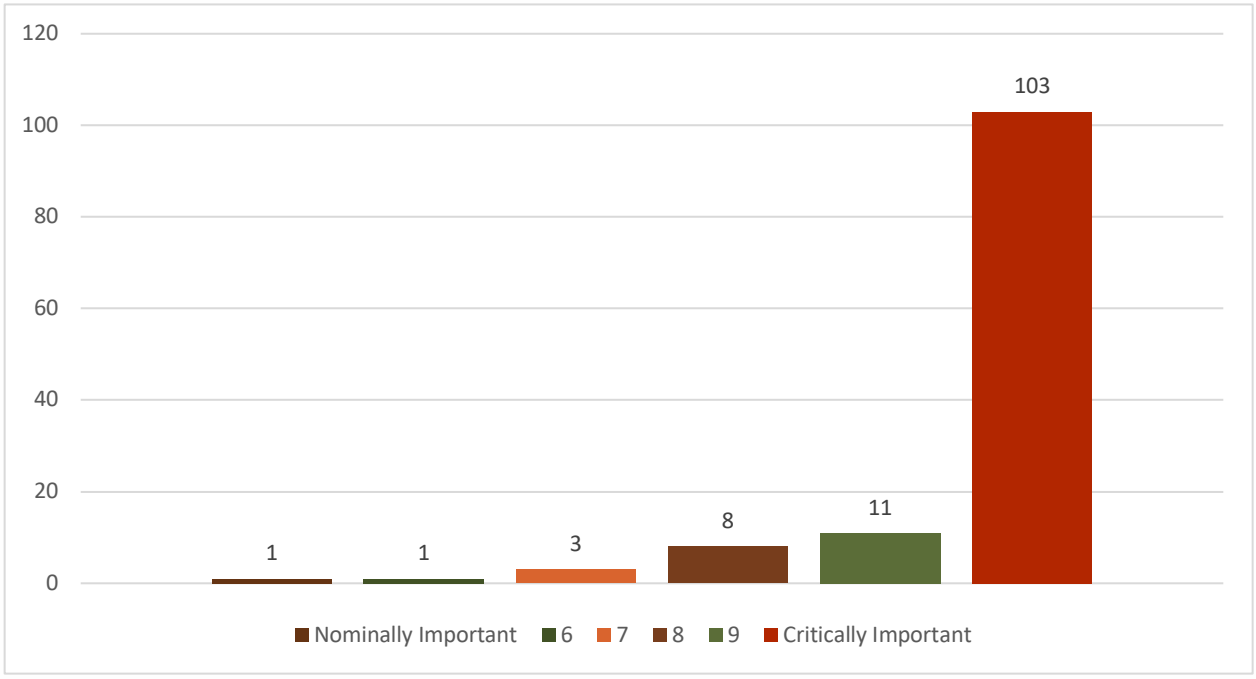
Details of the survey results follow, but in summary, the data shows that broadband access is widely available throughout the City, and adoption of internet and use of internet-enabled applications and devices is very strong. Of the 213 businesses that completed the survey, most businesses, an impressive 97.7% subscribe to internet services at their businesses.

[15] http://www.onlightaurora.com/

3.3.1.1 Naperville Business Connectivity Profile

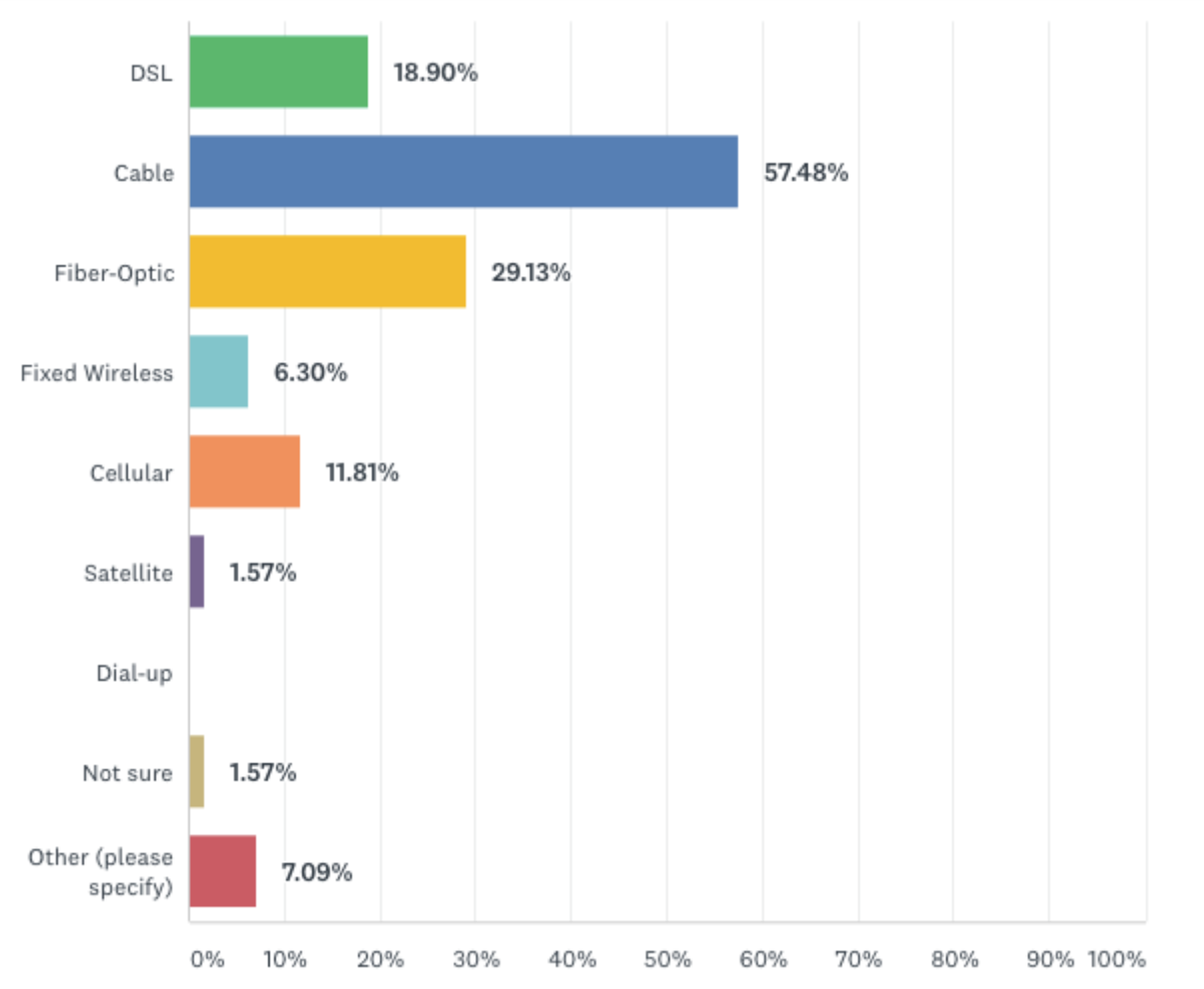
The business market in the City of Naperville is predominately made up of small to medium-sized businesses within the professional, scientific, and technical services sector. Most survey respondents were small businesses (62.8%) with 10 or fewer employees, while 14.1% of responses were from businesses with over 100 employees. These Naperville area businesses, regardless of size, reported the need for and use of advanced, high-speed broadband infrastructure as imperative for the success and future of their business.

Figure 9: On a scale from 1 to 10, how important is the Internet for your business?



Like many cities across the US, the majority of businesses in Naperville are still connected by legacy cable and DSL infrastructure. However, Naperville's businesses did display availability to fiber-optic infrastructure, and in the survey, it was the second most utilized infrastructure for businesses at 29.13%. This representation of advanced infrastructure for businesses may explain the overall feelings of satisfaction throughout the City with broadband connections.

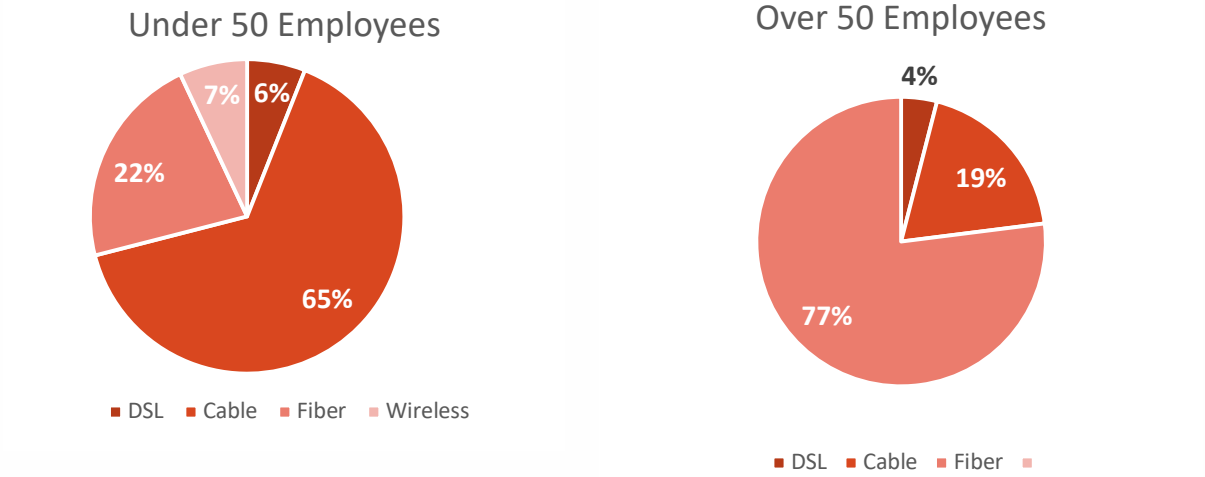
Figure 10: How Naperville area businesses connect to the Internet



As seen in Figure 10 most businesses in the Naperville area subscribe to internet services via cable (57.48%), with DSL coming in third at 18.9%. Approximately 29.13% of Naperville businesses connect to the internet via fiber. Making up the remaining connections are mobile wireless representing a strong market at 11%, while fixed wireless and others such as T1 represent the remaining 15% of Naperville businesses, with satellite claiming 1.5% of local business connectivity. Many businesses use multiple connections, for example a business may have a cable connection as its primary connection, and DSL as its secondary.

What is interesting is the comparison of broadband services subscribed to by small businesses and large businesses in Naperville. In Figure 11, survey responses from businesses that employ less than 50 people are represented by the chart on the left, while the chart on the right represents business with over 50 employees. The item that stands out here most is that only 22% of surveyed small businesses subscribe to fiber, while fiber is the choice of 80% of larger employers in Naperville.

Figure 11: Naperville business internet connections, based on employment size



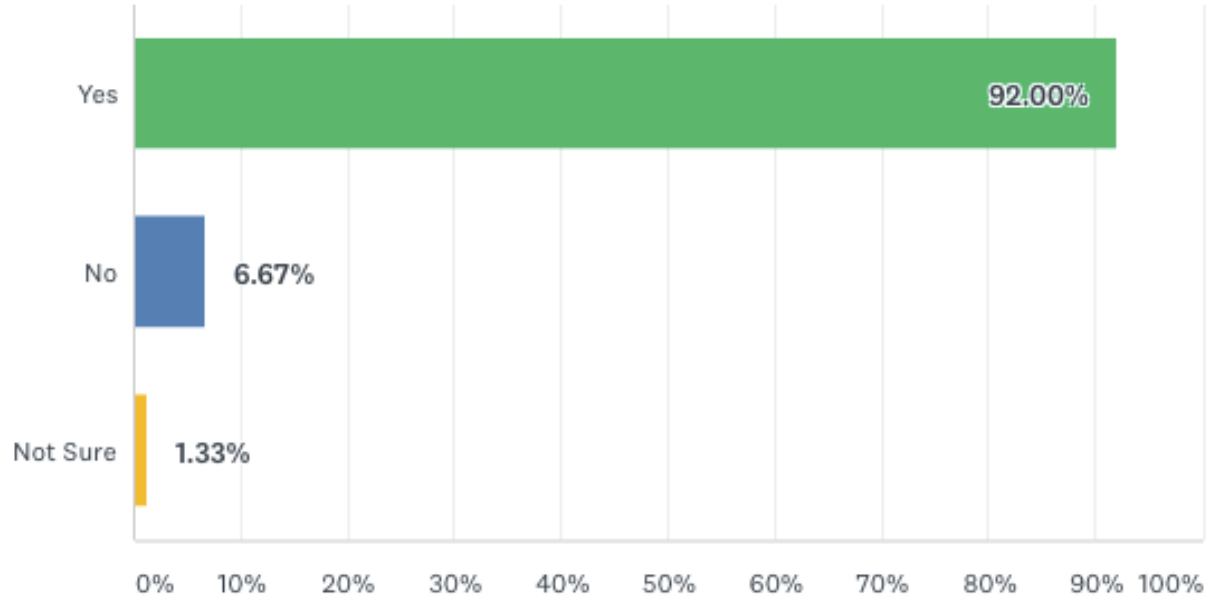
Certainly, bandwidth requirements for larger business are driven by the fact that larger employers have more computers and equipment, and thus have a stronger dependency on the advanced capacity that fiber offers. Yet whether out of necessity or a lack of having fiber as a viable choice, cable and DSL remain the options for most small businesses in Naperville.

While some small businesses noted that they were unaware if better services were available in their area, in cases where fiber is available, the cost is often challenging for smaller businesses. A lack of viable fiber-optic service options and pricing severely limits smaller start-up companies from having access to bandwidth at a cost that would allow them to be innovative and to grow.

Another point illustrated in Figure 11 speaks to the quality and reliability of wired versus wireless broadband. No businesses in Naperville with over 50 employees relies on any wireless form of connectivity, while a small portion of small businesses still rely on satellite, fixed wireless or mobile wireless. Availability and affordability are at play here, but the data suggests that larger businesses in Naperville choose wired network technologies over wireless for reliable bandwidth capacities. This is a standard throughout the country.

To gauge the perception of the importance of broadband connectivity to Naperville businesses, the question was asked if broadband is considered a utility. Businesses overwhelmingly (92%) consider broadband to be the "fourth utility," on par with electricity, water and sewer as something that should be universally available and affordable.

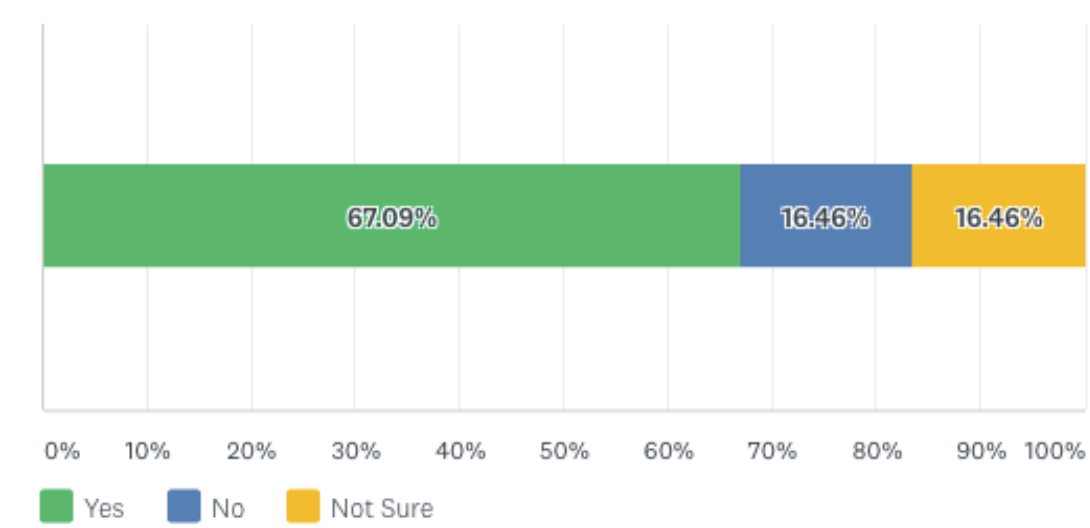
Figure 12: Is broadband considered a utility?



Having access to reliable broadband and subscribing to services is one thing, but to realize benefits from broadband, meaningful utilization must first occur. As such, accessible, affordable and reliable broadband is a key economic development tool to attract, sustain, and grow businesses in the Naperville.

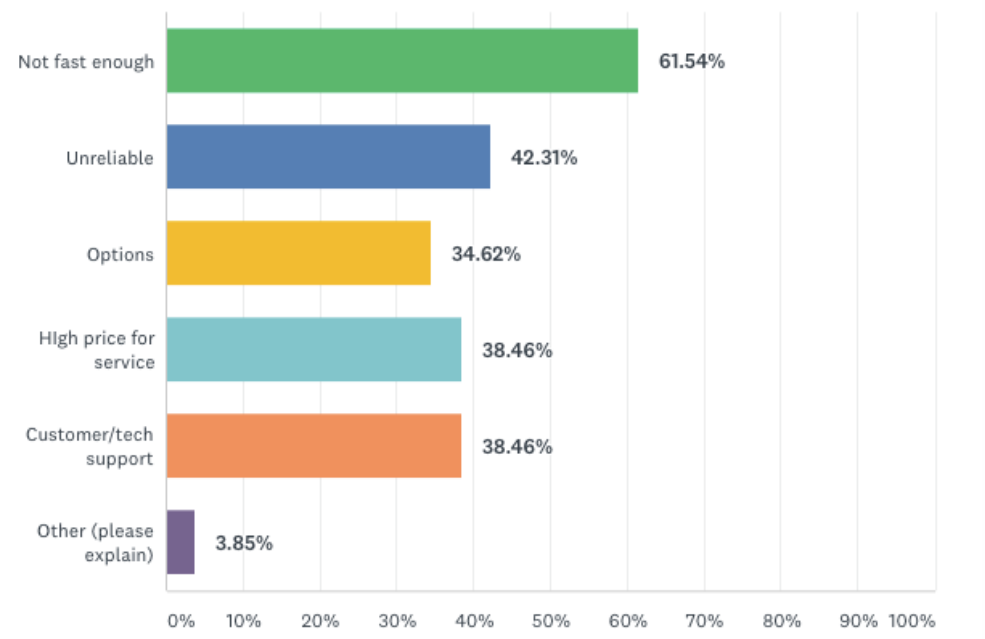
Businesses were asked their levels of satisfaction with their current internet service provider. In thinking of internet services that can support local business, shows that 67% of all businesses in Naperville are satisfied with their current services and believe that their internet is meeting their needs.

Figure 13: Internet services meeting business needs



Of the 16.5% of businesses in Figure 13 were asked how their internet provider is not fulfilling their business needs, the top response from 61.54% of that group was that their "service is not fast enough," while 42.3% said that "service is unreliable" with 38.4% felt that "price is too high for the level of service received," and "responsiveness of customer support was inadequate."

Figure 14: In what ways is your internet provider not meeting the needs of your business?



When asked why their business hasn't upgraded internet services to greater speeds and service levels, 46.15% said that "better services are not available in my area." The second and third most responses were that "the price is too high for services received" (42.3%), and "unsure of other service providers in my area" (26.1%).

Though the survey respondents were asked "If the City of Naperville were to offer Internet access, how likely would you be to subscribe if comparable services were offered at a competitive price compared to other local Internet providers?" The majority of respondents (32%) said they would "maybe" consider taking services from the City, while only 20% said they would definitely consider it. Sixteen percent of respondents said it was not likely that they would take services from the City if they were to consider serving businesses. Businesses who would consider the services emphasized that, "Assuming it were fiber or the fastest option available."

Other comments reflecting concerns and thoughts revolving around the question of the City's role in improving broadband include:

- "It's likely that the nature of the internet – constant change and upgrades – will always create some sense of unreliability. As a pro-business community, here's hoping private and free enterprise will find ways to meet this city's needs."
- "I do not believe that the City should be entertaining the idea of competing with private enterprises. Stick to basic government services and leave communications and internet services to communications providers."
- "I would wait a year if the City offered it, to see how reliable it was. There would be no reason for me to switch unless it was less expensive."
- "We have two Naperville locations and would be open to discounted bundling of services."
- "The City won't - or rather shouldn't have the resources available to service this properly. This is not something the City should be providing - private sector is already handling this well."
- "The City of Naperville will also have to be able to demonstrate the ability to stay current in this ever-changing technology. I think to penetrate the current market an improvement in speed and a cost incentive would be required to have people switch. Given the exorbitant costs cable companies are placing on TV service today, and as internet TV is coming into play, the city has a real opportunity to leverage its fiber infrastructure to the benefit of its residences and businesses."

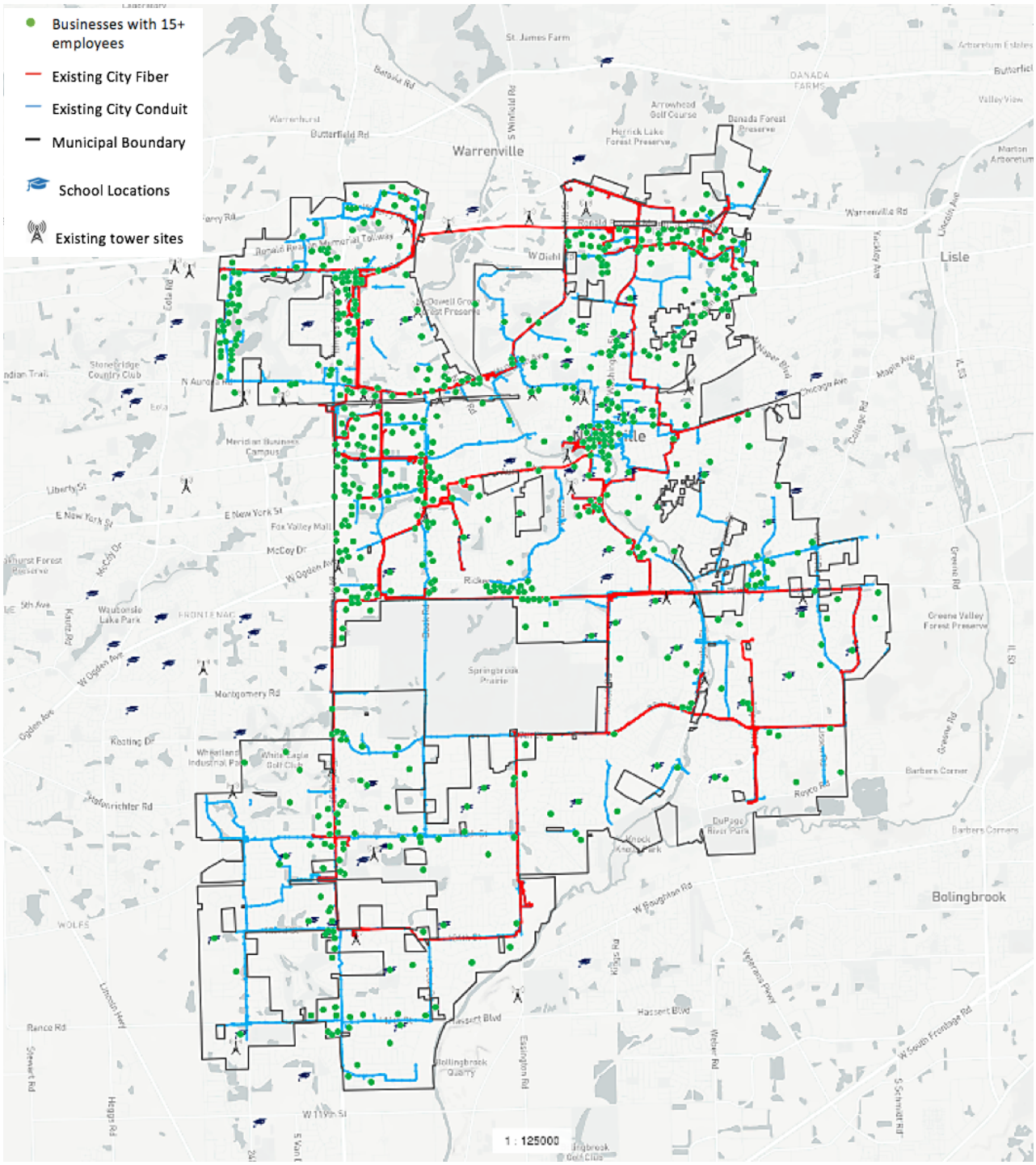
Businesses were asked to submit general comments and concerns about the state of business internet in Naperville. Some of these are included below.

- "Gigabyte service should be available at a reasonable cost, so we can compete globally."
- "WOW is our 3rd provider in 5-years. Comcast was pricy and not reliable, and AT&T only offered DSL and kept raising price to get you to switch to a service that was not available at our location."
- "Currently on coaxial, and moving to fiber this month."

The results of the survey show a snapshot of the internet availability and concerns of the Naperville business community and are reflective of comments from the City's business focus groups. We can make some assumptions that most businesses in the City are served and satisfied by current providers. The City shouldn't ignore that some businesses are still facing challenges with outdated infrastructure and are unsure if other services are available. The City should consider a full market analysis to analyze the specific areas of the City that are challenged by lack of advanced or affordable infrastructure. The City should also consider working with providers and the business community to hold education sessions that would help connect providers to businesses that need further services, to ISP's who can provide the services at a price point that is favorable for small and medium sized businesses in the City.

The map on the following page shows the close alignment of the City's fiber-optic routes with school and business locations. Although the focus groups and business survey data show that at present businesses are largely satisfied with their internet service, the City should reevaluate this conclusion periodically to determine whether City fiber and broadband assets could meet future business needs for internet connectivity. This is particularly important given the recommendation to work with OnLight Aurora to expand regional networking as OnLight Aurora serves business customers with its network. Also, serving businesses can support network infrastructure to serve Naperville's schools more cost effectively, as recommended in this Report.

Figure 15: Naperville businesses & schools in location to City fiber



4. STRATEGIC BROADBAND POLICIES

This document provides information to guide the creation and implementation of local policies to enhance, improve, and increase the availability and performance of broadband. Broadband originally referred to means of transmitting information in multiple channels over a single medium or wire. It has come to be an umbrella term for high-speed internet access. The internet is basically the system for interconnecting any and all digital devices—computers, routers, sensors, smartphones, etc.—that use the Internet Protocol.

The lower-case term "internet" refers to all the information available on and through these devices, as well as the system that interconnects them, which has become an essential and integral part of life in the 21st Century. Broadband is now a service that certain companies provide for a fee rather than just a means of transmitting signals. There are a range of internet service options but the Federal Communications Commission (FCC), which regulates telecommunications services including broadband, has defined broadband as a minimum of 25 Mbps downstream and 3 Mbps upstream. That baseline will undoubtedly increase over time. Those communities and places with the infrastructure and services for broadband beyond the baseline will have a competitive advantage.

4.1 Broadband Policies

4.1.1 Wireless Policy

4.1.1.1 Introduction

Wireless providers are looking forward to the deployment of "5G," which is distinguished from the present "4G" based wireless service by use of low power transmitters with coverage radius of approximately 400 feet – 5G thus requires close spacing of antennas and more of them. This has obvious implications for city authorities with applications for location of antennas by service providers before city and municipal authorities. These providers – Verizon, AT&T, Sprint and T-Mobile – are making a concerted push for new rules and legislation before state, local and federal authorities with jurisdiction and responsibilities for siting of wireless facilities. As stated by the FCC,

> The wireless industry is currently deploying and planning for additional construction of a large number of small cells, and the number of these facilities is expected to grow rapidly over the next decade. S&P Global Market Intelligence estimates that between 100,000 and 150,000 small cells will be constructed by the end of 2018, and that small cell deployments are expected to reach 455,000 by 2020 and nearly 800,000 by 2026. AT&T has reported that the substantial majority of its infrastructure deployments over the next five years will be small cell sites. In addition, Verizon is deploying small cells in several

> urban areas, including New York, Chicago, Atlanta, and San Francisco. Sprint announced last year a goal of deploying 70,000 small cells within two years.[16]

The placement of wireless facilities is governed by an interrelated legal framework including shared jurisdiction of state and federal authorities. The Federal Communications Commission has preempted the authority of state and local jurisdictions in other cases and may be poised to take preemptive steps again regarding siting of wireless facilities, in two current proceedings. The FCC states the "dilemma" – as well as its perspective regarding jurisdiction – as follows:

> We recognize, as did Congress in enacting Sections 253 and 332 of the Communications Act, that localities play an important role in preserving local interests such as aesthetics and safety. At the same time, the Commission has a statutory mandate to facilitate the deployment of network facilities needed to deliver more robust wireless services to consumers throughout the United States. It is our responsibility to ensure that this deployment of network facilities does not become subject to delay caused by unnecessarily time-consuming and costly siting review processes that may be in conflict with the Communications Act.[17]

The emergence of 5G technology is causing significant current rulemaking and legislative activity in both the federal and state jurisdictions. In fact, the Illinois General Assembly passed SB 1451 in November 2017, and the bill awaits action by the Governor.

It should be noted that the recent purchase of WOW! Fiber by Verizon is indicative of their interest in owning fiber assets for deployment of 5G small cell networks in the region. This is an area of discussion that we encourage Naperville to take seriously and attempt to understand Verizon's intent and how it relates to Naperville's new Wireless and Dig Once Ordinances for permitting, joint trench and in-kind negotiations.

---

[16] *Streamlining Deployment of Small Cell Infrastructure by Improving Wireless Facilities Siting Policies; Mobilitie, LLC Petition for Declaratory Ruling*, WT Docket No. 16-421, Public Notice, 31 FCC Rcd 13360, December 22, 2016, at page 3-4 (citations omitted). ("Improving Wireless Facilities Siting Policies Public Notice"*).*

[17] *Id.*, at page 2.

4.1.1.2 Federal Communications Commission (FCC)

The FCC has implemented "Shot Clock" requirements that place a maximum time for local authorities to review applications to place wireless facilities. Current FCC shot clock requirements arise in two contexts. First the 60-day clock for "Wireless Facility Modifications"[18] arises from § 6409(a) of the Spectrum Act.[19] The Spectrum Act applies to applications which do not "substantially change" an existing tower or base station, and thus are eligible requests to modify existing towers or base stations which do not substantially change the physical dimensions. Eligible requests include colocation of new transmission equipment, removal of transmission equipment or replacement of transmission equipment. All terms are defined in the rule, including "substantial change." The time-period for review is "within 60 days of the date on which an applicant submits a request seeking approval." The 60-day clock may be tolled only by mutual agreement, or when the agency determines the application is incomplete. Clear and specific written notice is required within 30 days. Requests for approval gain "deemed granted" status if the request is not acted on within the 60-day timeframe, and the applicant notifies the local authority in writing.

The second context for "shot clock" requirements is under § 332(7) of the Communications Act[20], regarding "Preservation of local zoning authority." In its Declaratory Ruling[21] in 2009 the FCC set "presumptively reasonable period of time" deadlines of 90 days for collocation applications, and 150 days for all other applications, including new siting applications. An application is defined as a request for collocation "if it does not involve a 'substantial increase in the size of the tower' as defined in the Nationwide Programmatic Agreement for the Collocation of Wireless Antennas."[22] Applications are not "deemed granted" if the local authority fails to act on a completed application within the shot clock time period for review, instead the provider must pursue any relief in court.

---

[18] 47 CFR § 1.40001.

[19] *See* Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, 126 Stat. 156, § 6409(a) (2012) (Spectrum Act), *codified at* 47 U.S.C. § 1455(a).

[20] 47 U.S.C. § 332(7).

[21] *Petition for Declaratory Ruling to Clarify Provisions of Section 332(c)(7) to Ensure Timely Siting Review*, Declaratory Ruling, Federal Communications Commission, 24 FCC Rcd 13994 (2009), at paragraph 45.

[22] *Id.*, at paragraph 46.

The statutory provisions of the Communications Act and the Spectrum Act overlap to a certain extent, but the FCC up to now has specifically preserved the distinct standards above under the two provisions.

4.1.1.3 Wireless Infrastructure NPRM

On April 21, 2017, the FCC opened an inquiry into "accelerating wireless broadband deployment by removing barriers to infrastructure investment."[23] The FCC's Notice of Proposed Rulemaking (NPRM) identifies estimated benefits from deployment of "next-generation wireless broadband," i.e., 5G, and seeks to define an "updated regulatory framework that promotes and facilitates next generation network infrastructure facility deployment" to realize those potential benefits.[24] The NPRM states "an urgent need to remove any necessary barriers" to deployment of "large numbers of wireless cell sites to meet the country's wireless broadband needs and implement next generation technologies."[25]

A large portion of the NPRM focuses on the "process for reviewing and deciding on wireless facility deployment applications conducted by State and local regulatory agencies," and examining new rules or clarifications intended "to expedite such review."[26] The NPRM appears to place the onus on State and local authorities, with only passing mention of the actions or inactions of wireless service providers – although comment is sought on that subject as well.

The FCC is seeking comments in the Wireless Infrastructure NPRM on the extent to which the above shot-clock framework should be modified, including whether the "deemed granted" remedy should now also apply for § 332 applications, changing the "rebuttable presumption" to "irrebuttable presumption" that the time frame for review is adequate. The NPRM is also examining whether the shot clocks should be aligned and shortened, i.e., the collocation shot clock under § 332 reduced to 60 days from 90 days under the Spectrum Act, and whether there should be new categories for applications, with different shot clocks. Importantly for Naperville, the NPRM also seeks comments "on the proper role of aesthetic considerations in

---

[23] Notice of Proposed Rulemaking and Notice of Inquiry; *In the Matter of Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment*; WT Docket No. 17-79, FCC 17-38; released April 21, 2017. ("Wireless Infrastructure NPRM" or "NPRM") The FCC has a parallel investigation into accelerating wireline broadband deployment.

[24] *Id.*, at paragraph 1.

[25] *Id.*

[26] *Id.*, at paragraph 4.

the local approval process,"[27] opening the door that aesthetic considerations may be diminished as a factor by the FCC. Finally, the NPRM seeks comment "on the extent to which localities may be seeking to restrict the deployment of utility or communications facilities above ground and attempt to relocate electric, wireline telephone, and other utility lines in that area to underground conduits."[28]

The outcome and timing of FCC action on these "shot clock" matters is not known, and the proceeding bears tracking because it interrelates with the efforts of wireless providers to limit municipal wireless facility siting oversight through state legislation. The wireless providers likely would be satisfied with the passage of more restrictive rules by either state legislation or the FCC, whichever comes first.

4.1.1.4 The Mobilitie Petition

Notably, the FCC has another proceeding open on wireless siting – the Public Notice on "Improving Wireless Facilities Siting Policies," based on Mobilitie's Petition for a Declaratory Ruling. The FCC has sought comments in this matter as well, noting that:

> Many wireless providers are deploying small cells and distributed antenna systems (DAS) to meet localized needs for coverage and increased capacity in outdoor and indoor environments. Although the facilities used in these networks are smaller and less obtrusive than traditional cell towers and antennas, they must be deployed more densely – i.e., in many more locations – to function effectively.[29]

The FCC suggests it may use provisions of the Communications Act and the Spectrum Act to "remove barriers to deployment of wireless network facilities by hastening the review and approval of siting applications by local land-use authorities."[30] The FCC has called for comments on the Mobilitie Petition to develop a "factual record" regarding whether and to what extent "the process of local land-use authorities' review of siting applications is hindering, or is likely to hinder, the deployment of wireless infrastructure."[31] The Public Notice requesting comments lists a number of complaints by wireless providers about fees, cost and time period for review of applications, and opines in other areas. It also notes instances where cities have

---

[27] *Id.*, at paragraph 92.
[28] *Id.*, at paragraph 98.
[29] Improving Wireless Facilities Siting Policies Public Notice, at page 1.
[30] Improving Wireless Facilities Siting Policies Public Notice, at page 2.
[31] *Id.*

modified processes, citing New York City, Boston, and Baltimore. The Public Notice seeks current information – systematic data, not anecdotal evidence – on a broad array of subjects:

- How have matters changed since FCC actions in 2009 and 2014 regarding the "shot clock"? Better, worse or the same? What local actions or inactions, if any, have the effect of hindering deployment?
- How much time currently elapses for small cell applications?
- Are processes the same for microcell applications as for macrocell?
- Should the "shot clock" vary depending on whether the request is for a single cell deployment, versus consolidated applications for multiple cells?
- How often are applications denied, and for what reasons?
- How often is litigation pursued, and how long does it take?
- What legislation, ordinances, and regulations are viewed as most problematic?
- Are application fees and charges for use of Rights-of-Way reasonable and non-discriminatory?

From comments on these questions the FCC is seeking to determine whether it should issue a declaratory ruling to clarify or expand its previous rulings in 2009 and 2014. But Naperville's experience indicates there are no substantial issues in the topics the FCC is seeking to evaluate. The City and its staff have worked well with the service providers to support provision of desired services to the City's residents and visitors. In particular there have been no "shot clock" issues of any significance. However, it has been observed that better definition of requirements in City ordinances could be beneficial for avoidance of doubt regarding the basis for specific requirements. The City does maintain a focus on aesthetic standards which is very appropriate.

4.1.1.5 State and Local Authorities

Along with pushing for reexamination of FCC rules, the wireless providers – Verizon, AT&T, Sprint and T-Mobile – have embarked on a nationwide push for state legislation to limit what local authorities can do regarding placement of "small wireless facilities." The state legislative push is strategic on the part of the wireless providers looking forward to the deployment of "5G," given the vastly increased number of antennas that will be required. The state legislative framework advanced by the wireless providers generally truncates timelines, limits review, limits payments, and removes this subject from home rule authority. Such legislation has passed in some states (approximately 14, e.g., Florida) and has been introduced but not passed in other states.

The **"Small Wireless Facilities Deployment Act"** was introduced last session in Illinois as **Senate Bill 1451**, and at the behest of the wireless providers. SB 1451 passed in the Senate but encountered significant opposition in the House. The City of Naperville and other municipalities opposed passage of the Bill, and the Illinois Municipal League (IML) originally opposed the Bill as well but obtained amendments to the Bill sufficient to change the IML position to "neutral." Ultimately SB 1451 did pass the General Assembly in November 2017 and awaits action by the Governor.

SB 1451 "specifies how local authorities may regulate the collocation of small wireless facilities." The Act does not apply to municipalities with a population of 1 million or more, i.e., Chicago. The Act's provisions and related potential impacts on Naperville include:

- Limitation of Home Rule: "a home rule unit may not regulate small wireless facilities in a manner inconsistent with this Act." *Elimination of Home Rule Authority is a major negative impact of SB 1451 on the City of Naperville.*

- 30-day deadline for local authority to determine if application is complete, or notify of incomplete/missing information, deemed complete if no notification provided. *This deadline is similar to FCC "shot clock" deadlines but engraving it in statute with "deemed complete" consequence at 30 days is a negative impact on the City of Naperville's flexibility and administration.*

- Deemed approved after 90 days, if authority does not approve or deny application. *This deadline is shorter than FCC "shot clock" deadlines in some instances and engraving it in statute with "deemed approved" consequence is a substantial negative impact on the City of Naperville's flexibility and administration.*

- Application may include up to 25 small cell wireless facilities, if facilities and structures are substantially the same. *"Stacking" of locations in one application may complicate review and processing and create negative impact on the City of Naperville's flexibility and administration. The City does not limit the number of sites that may be included in a single application, but it has moved to a practice of requiring unique lease agreements for every site. The City permits and leases each site independently and individually and does not give out bundles of permits. SB 1451 does not appear to address right-of-way leasing.*

- Permit duration shall be for period of not less than five years. *Stated minimum term in statute has negative impact on the City of Naperville's flexibility and administration.*

- Application fees shall not exceed the lesser of "the amount charged … for a building permit for any similar commercial construction" or $350 for each small wireless facility. *This shifts the burden of proof regarding fees and setting low caps on permitted fees and is clearly a usurpation of authority currently held by cities.*

- "Small wireless facilities shall be classified as permitted uses and not subject to zoning review or approval."

- A "utility pole" is defined as any pole or similar structure used by a communications service provider, or for electric distribution, lighting, traffic control, signage, or similar function." *The effect of this provision along with other provisions of SB 1451 is to mandate the City allow collocation of small wireless facilities on all such poles for a maximum of $200 per year. Additionally, the City has determined it does not want to have antennas installed on traffic signal poles and standards, and this decision is precluded by SB 1451.*

- The wireless provider may not be required to perform services such as in-kind contributions, including reserving fiber, conduit or pole space." *This clearly impairs the flexibility of the City to meet the needs of its departments and citizens by prohibiting a reasonable practice that has traditionally been used by cities.*

- Defining the types of information that can be required and limiting it to what is required of a communications service provider who is not a wireless provider but allowing for additional information to be required for collocation on the City's "utility poles."

- Precluding required placement on "any specific utility pole, or category of poles, or require multiple antenna systems on a single utility pole."

- Precluding limitation of placement based on minimum horizontal separation distances.

- Various limitations on setting maximum heights.

- Limits on collocation terms including fee limit of $200 per pole per year unless costs are greater with burden of proof on the local authority, existing fees must be reformed, terms for make-ready estimates. *Shifting the burden of proof regarding fees and setting low caps on permitted fees is clearly a usurpation of authority currently held by cities.*

- Dispute resolution at the circuit court, with collocation allowed in the interim at no more than $200 per year per pole.

- Indemnity and Insurance provisions, including allowing the local authority to require it to be named as an additional insured.

- Special provisions for "any new telecommunications facilities in Lake County that are not AM telecommunications towers or facilities." *Lake County is the only one that has special provisions carved out of SB 1451.*

4.1.2 City Ordinances

4.1.2.1 Naperville

Naperville's primary ordinances bearing on siting of telecommunications/wireless facilities are contained in Chapter 13 of Title 6 which contains zoning regulations applicable to telecommunications facilities, antennas, towers and dishes for wireless services. Regulations applicable to use of public rights-of-way for telecommunications facilities are addressed in Title 9, Chapter 1.

Title 6 zoning regulations tie into the City's Official Comprehensive Plan. The zoning ordinance sets the purpose of the regulations as "improving and protecting the public health, safety, comfort, convenience and general welfare of the people."[32] The specific purposes[33] of Chapter 13 pertaining to wireless facilities are:

1. Provide for the appropriate location and development of communication towers and antennas to serve the residents and businesses of the City;
2. Minimize adverse visual effects of towers and antennas through careful design, siting, landscape screening and innovative camouflaging techniques;
3. Prevent harm to the health and welfare of Naperville and its citizens through engineering and location restrictions;
4. Avoid situations where towers and antennas can adversely impact municipal utility security, operation and maintenance efforts;
5. Maximize use of any new and existing telecommunications facilities to minimize the need to construct new telecommunications facilities and minimize the total number of such facilities throughout the City;
6. Maximize and encourage use of alternative tower structures (e.g., camouflaged and concealed antennas) as a primary option and discourage the construction of additional single use towers; and
7. Encourage and promote the location of new telecommunications facilities in areas which are not zoned for residential use.

TED also handles the application and permitting process for wireless facilities under Chapter 13, which typically require a right-of-way permit and building permit.

---

[32] 6-1, Naperville Municipal Code. Note that "telecommunications services" could reasonably be added to the fifth objective for achieving the general purposes of the zoning regulations.
[33] 6-13, Naperville Municipal Code.

In addition, Title 9 of the Municipal Code of Naperville addresses use of "Public Ways and Property" with "the purpose of improving and protecting the public health, safety, comfort, convenience and general welfare of the people." This purpose is to be fulfilled by seeking the following objectives:

1. Permit and manage reasonable access to the public ways of the City for private purposes on a competitively neutral basis.
2. Conserve the limited physical capacity of the public ways held in public trust by the City.
3. Assure that the City's current and ongoing costs of granting and regulating private access to and use of the public ways are fully paid by the persons seeking such access and causing such costs.
4. Secure fair and reasonable compensation to the City and the residents of the City for permitting private use of the public ways.
5. Assure that all persons providing facilities or services within the City comply with the ordinances, rules and regulations of the City.
6. Assure that the City can continue to fairly and responsibly protect the public health, safety and welfare.

The ordinance requires that written determinations be issued by the City within 90 days of receiving a complete application.

Current fees are:

- Right-of-way Use:
  - Application fee: $1,500
  - Construction permit fee: Greater of $1,500 or 2% of the estimated cost of construction
  - Annual fee: $1.50 per linear foot for newly constructed facilities, and $0.50 per linear foot for facilities being located in existing facilities

- Wireless facilities:
  - Building permit fees: $16 clerical fee plus $44 per page for plan review
  - Right-of-way permit fees: $45 - $80

All of Naperville's zoning ordinances reasonably express desired community standards regarding aesthetics, appearance, avoidance of nuisance, and provision for adequate public services, comfort and convenience, but require significant review and updating given the continued march of technology and applications, including 5G wireless service.

4.1.2.2 City of Aurora/Illinois Municipal League "Model Ordinance"

The Illinois Municipal League has developed a "model ordinance" for use by Illinois municipalities to use for Small Cell Antenna Siting in public right-of-way.[34] The City of Aurora has recently (December 13, 2016) passed two telecommunications ordinances using IML "model ordinance" as a point of beginning. The Telecommunications Facilities and Services Ordinance addresses "facilities and equipment involved in all modes of communication," for a variety of purposes including to minimize adverse impacts from placement of such facilities, enhance the ability to provide services to the community quickly, to encourage attachment of antennas to existing structures and encourage shared use/collocation, and to provide for public safety. Among other things, the ordinance amends an existing ordinance and is applicable to new towers, antennas or poles with antennas, and:

- Addresses emerging use of utility and light poles, as well as decorative poles, including prohibition of antennas on decorative poles, and height limitations for antennas;
- Addresses emerging backhaul connection of antennas – not just towers/cell sites;
- Recognizes the I-88 Technology Corridor;
- Eliminates fees for communications facilities in the public right-of-way for those entities paying the Simplified Municipal Telecommunications Tax;
- Sets design requirements in light of aesthetics, including landscaping with buffer of plant materials, fencing, and preservation of mature tree growth and natural land forms;
- Prohibits installation of signs on antennas;
- For proposed installation of new towers or poles with antennas, requires demonstration that no suitable existing structures, or alternative technology exists with reasonable economics or meeting engineering requirements;
- Requires a notarized statement for installation of new tower or pole with antenna, whether the facility will accommodate collocation of additional antennas by future users;
- Administrative review provisions, including "deemed approval" of the application for failure to respond within 60 days, for applications outside historic districts and shorter structures, and, for modification or reconstruction of existing towers for collocation;
- Requires special use permits in certain instances, including within the I-88 Technology Corridor;
- Provides for additional requirements related to communications support facilities;

[34] http://legal.iml.org/page.cfm?key=2191

- Provides various specific application information requirements; and,
- Provides various other measurements, separation and setback requirements.

At the same time, Aurora passed an amended ordinance regarding Construction of Facilities in the Public Rights-of-Way. Among other things including elimination of obsolete language, the amended ordinance now specifically addresses placement of fiber-optic cable.

4.1.2.3 Modification of Naperville Ordinances

There is a strategic decision to be made whether to make necessary modifications to the ordinances by amending existing ordinances and text, or by passage of a new ordinance. The City of Aurora has updated its ordinances via amendment based on Illinois Municipal League model ordinances, and that is clearly a reasonable direction for the City of Naperville to consider. The City has chosen to draft new ordinances pertaining to wireless communications facilities, based on the City of Aurora and other neighboring jurisdictions, which was in turn based on a Model Ordinance developed under the auspices of the Illinois Municipal League. City staff in conjunction with Magellan Advisors has accomplished a full revision of the Title 9 Chapter 1 and Title 6 Chapter 13 ordinances, which will be presented to the City Council for review.

4.1.3 Dig Once Policy

"Dig Once" can be defined as policies and/or practices that foster cooperation among entities that occupy public rights-of-way, to minimize the number and scale of excavations when installing telecommunications infrastructure in rights-of-way. Dig Once has a number of substantial benefits, including promoting and supporting the placement of broadband infrastructure (e.g., fiber-optic cable and conduit); reducing the consequences and disruptions of repeated excavations (traffic disruption, road deterioration, service outages, and wasted resources), and enhancing service reliability and aesthetics. Dig Once accomplished the goal of minimizing costs of constructing separate trenches and facilities – via shared costs of construction. The cost savings are significant. The Federal Highway Administration estimates it is ten times more expensive to dig up and then repair an existing road to lay fiber, than to dig a channel for it when the road is being fixed or built. According to a study by the Government Accountability Office, "dig once" policies can save from 25-33% in construction costs in urban areas and approximately 16% in rural areas.[35] In addition, development of Dig Once standards and guidelines for deployment of conduit and fiber will facilitate economic development and

[35] https://eshoo.house.gov/issues/economy/eshoo-walden-introduce-dig-once-broadband-deployment-bill

growth, as it enables cost-effective staged or gradual deployment of broadband infrastructure. The City of Naperville has therefore expressed interest in exploring and adopting Dig Once policies.

Dig Once policy discussions generally address the planning and coordination process for construction projects in the public rights-of-way. But the concept can also extend to required placement of conduit for fiber-optic conduits, as expressed in recent Congressional legislation. The Broadband Conduit Deployment Act of 2015 required the inclusion of broadband conduit during construction of any road receiving federal funding.[36]

Policy approaches also differ between detailing specific Dig Once processes in ordinances (e.g., San Francisco) or stating the policy direction to require coordination of projects in the roads and rights-of-way, leaving specific implementation and management to designated city officials (e.g., Director of Public Works).[37] The latter approach may work best for Naperville, given that several departments have responsibilities in or regarding the public rights-of-way, such as T.E.D, DPU-E and DPU-W, and the Public Works Department. Also, the City has used this type of coordination of projects in the past. Magellan Advisors recommends that the City renew this approach to coordination of projects in the rights-of-way to promote expansion of broadband infrastructure, reduce disruptive repeated excavations which cause traffic disruption, road deterioration, service disruptions and wasted resources.

[36] *Id.*

[37] The City of Aurora has a Dig Once policy rather than an ordinance, which has supported development of OnLight Aurora.

5. CITYWIDE WI-FI

5.1 Background

Wi-Fi is a technology that uses radio spectrum for wireless local area networking among devices based on the IEEE 802.11 standards. Wi-Fi most commonly uses the 2.4 and 5 gigahertz (gHz) radio bands. However, connectivity provided through the emerging Wi-Fi frequencies below 1 gHz is being developed to extend the range and reach of signals through more materials. Devices that can use Wi-Fi technology include personal computers, smartphones, digital cameras, tablet computers, utility meters, public safety, equipment, security cameras, printers as well as various sensors. Wi-Fi compatible devices can connect to the internet via a Wireless Local Area Network (WLAN) network and a wireless access point. Such an access point (or hotspot) typically has a range of about 66 feet indoors and a greater range outdoors. Hotspot coverage can be as small as a single room with walls that block radio waves, or as large area covered by using multiple overlapping access points.

Opportunities exist for the municipal deployment of Wi-Fi/wireless broadband networks strategically within the City of Naperville. The cost of wireless network equipment has dropped significantly while the performance has improved dramatically. Determining where and how to build, deploy, and operate a fixed wireless broadband network is significantly less expensive and easier to manage than it was just a few years ago – and for a substantially better-performing network. Experience and technology/vendor improvements have smoothed out or otherwise addressed what were larger problem areas in early implementations, including practices to deal with frequency interference, balancing CPE[38] deployment on the network, and software systems development to support network and operations administration.

5.2 LinkNYC

LinkNYC is an infrastructure program in New York City which is using old phone booth locations to create 7,500 "Links" which provide a 9-1-1 Emergency Call button, "superfast" gigabit free public Wi-Fi, phone calls and charging stations.[39] The Link kiosks also provide a tablet for access to city services, maps and directions, and two large high definition screens for public service announcements. Based on experience and feedback, the browser function has been removed from the tablet. The project is funded by advertisers and partners based on a franchise agreement with the City to ensure the Links are well maintained, and so there will be no cost to use the Links. The advertising is "digital Out-of-home" to reach people that are on the go outside on city streets. Expected benefits are to address availability gaps and the digital

[38] Customer Premise Equipment
[39] https://www.link.nyc/

divide, as well as to create jobs. In addition, the Link system provides substantial funds to New York City (estimated at half a billion dollars). The Links have two security cameras for which the footage is stored for seven days. The Links will be installed over the next few years in all five of New York's boroughs. This citywide retrofit is intended to set the stage for a new brand of future smart city that will be powered by a universally accessible Wi-Fi network.

Appendix B. provides further detailed information on wireless strategies recently implemented by cities across the U.S. which the City of Naperville may consider as it decides what strategy to pursue for its own Wi-Fi network expansion.

5.3 Wi-Fi in Naperville

5.3.1 Wi-Fi History and Status

Wi-Fi in the City of Naperville has evolved over time. MetroFi constructed networks for the City of Naperville, the City of Aurora, as well as other cities. Following an earlier failed implementation by another company, the City of Aurora permitted MetroFi of Mountainview, CA to construct a pilot network in 2007. The pilot network implementation consisted of the downtown area, and other discrete areas near Orchard Valley Golf Course, Stonebridge Country Club, and south of Ogden Avenue.[40] The MetroFi network was ultimately intended to cover the entire city. The business model was to provide advertising-supported Wi-Fi service for free, or an ad-free version for $19.95 per month.[41] While the launch of service was apparently well received, MetroFi management changed hands, and the new company unsuccessfully attempted to change terms of the contract with the City to include build-out for public safety purposes at additional cost to the City. MetroFi ultimately abandoned the installed equipment in Naperville.

The equipment has subsequently been reused and managed by WOW Access since 2009 to provide NaperNet. However there does not appear to be any plan to improve or continue to support this service. Service has deteriorated over time, and the signal strength today is questionable. The City has since built a separate network for its camera systems, but this is a closed network and it is not clear whether it has adequate capacity to support public Wi-Fi.

The DPU-E currently uses Wi-Fi connected via City fiber for Advanced Metering Infrastructure (AMI), to permit two-way communications between meters and other electric infrastructure. Wi-Fi reliability is important for both the Fire and Police departments, and both need better

---

[40] "Naperville is building Free Wireless Internet Network"; the Chicago Tribune, August 24, 2007. http://articles.chicagotribune.com/2007-08-24/news/0708231059_1_metrofi-wireless-internet-network-internet-access

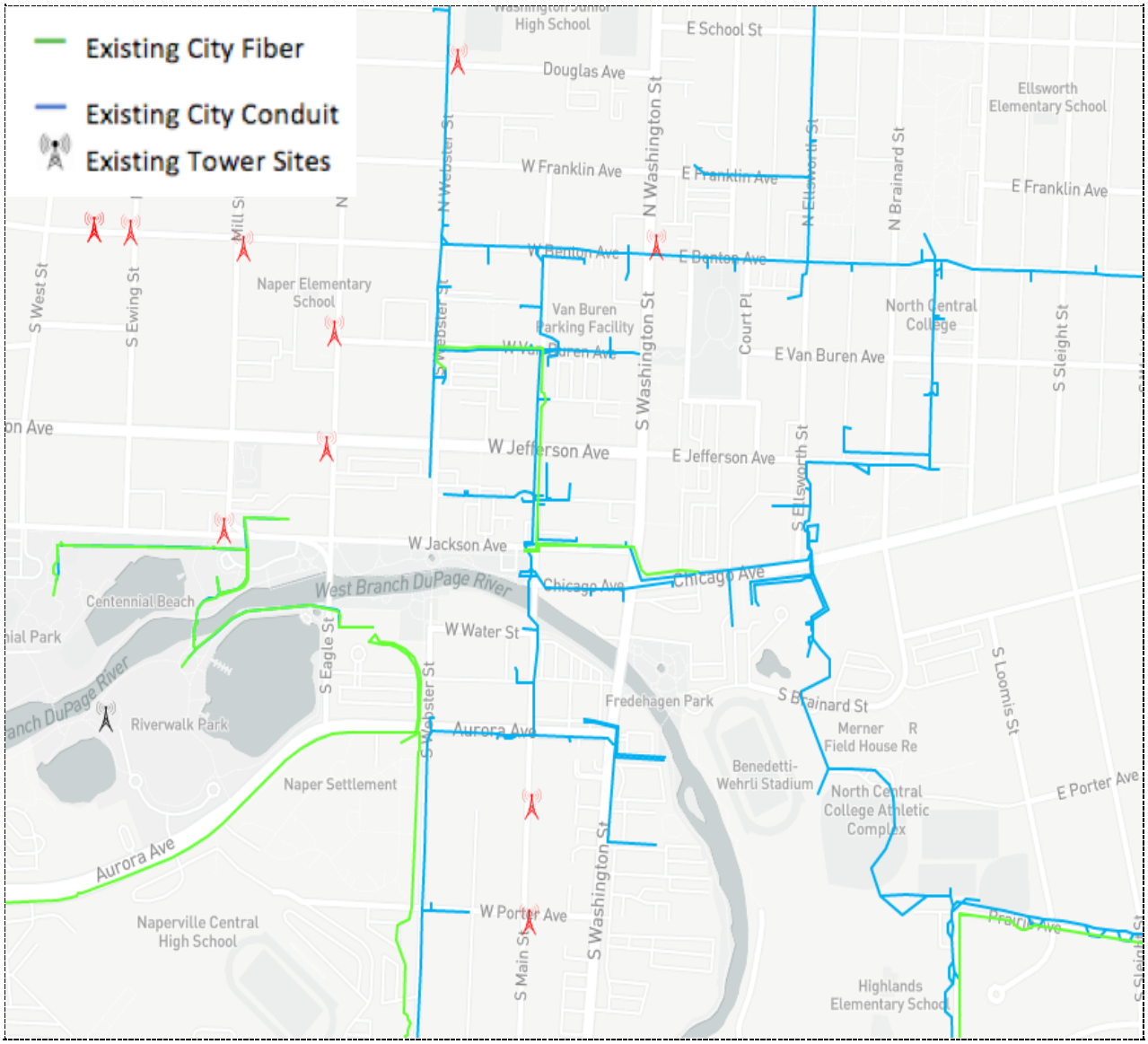
[41] *Id*.

coverage in the field. For example, fire inspection is iPad based, rather than mobile wireless, so transmission from business locations being inspected cannot occur without a Wi-Fi connection there. This requires inefficient return to the fire station or commute to another location with Wi-Fi. A similar issue exists with ambulance reporting. The traffic signal network has capacity in some locations to house other connections including Wi-Fi and motion detection cameras.

There is a desire for broader free Wi-Fi availability in the downtown and other areas throughout Naperville. Free Wi-Fi should be included in master planning for usage downtown, and for schools and colleges in the area. At present, the City does not have an issue with 24/7 Wi-Fi access in area parks including a planned activity center, but that is administered by a separate parks district.

City leadership has shown interest in expanding wireless capabilities across the City, and the figure on the following page shows the assets and proximity to fiber that could be used for future Wi-Fi expansion plans.

Figure 16: Assets and proximity to fiber for future Wi-Fi expansion plans



5.4 Wi-Fi Recommendations

The City's fiber assets (DPU-E and traffic signals) can support significant Wi-Fi implementation. The City has Wi-Fi needs beyond Smart City applications. The City desires to provision Wi-Fi broadband connectivity for the general public and businesses to promote economic development, increased access to broadband, and digital inclusion for all members of the community. The City also desires to improve wireless broadband connectivity to support public safety, Smart City initiatives, and delivery of municipal services by field-based staff using a wide variety of mobile government applications over tablets, laptops, and smartphones. The City of Naperville can clearly install Wi-Fi capability to achieve these objectives in different areas of the City including downtown – it is well poised to do so with the capabilities of its fiber networking and emerging Smart Light Pole technology. However, the existing Wi-Fi installations may not provide much platform leverage, and it is likely that Wi-Fi networking will need to be built "from the ground up."

Fortunately, Naperville does have significant fiber networking assets which can be utilized. Options for consideration to achieve the City's objectives are:

1. Utilize the existing Wi-Fi system and upgrade/expand as necessary to provide an open Wi-Fi for the downtown area, and other areas as determined.
2. As a standalone option (or in addition) use City electric poles and the new smart street lighting system to launch a pilot Wi-Fi network and then adopt a phased approach based on experience to turn up public Wi-Fi in the downtown and other areas.
3. In any case, Wi-Fi deployment can be considered for special event corridors and in City parks, in the City's commercial districts, and ultimately at some point evolving to ubiquitous Wi-Fi throughout the City.

Naperville has worked with the City of Aurora on other initiatives and has the potential partnership opportunity with Aurora to share its ISP connection, which would benefit the Wi-Fi deployment under either option by leveraging that existing ISP connection.

6. SMART CITY INITIATIVES

6.1 Overview

Cities are on the cusp of rapid change precipitated by technology – technology is being integrated into municipal operations for a variety of functions and applications. A "Smart City" is one which "has developed some technological infrastructure that enables it to collect, aggregate, and analyze real-time data and has made a concerted effort to use that data to improve the lives of its residents."[42] Advancing technologies place cities at the center of innovation: autonomous vehicles revising the concept of traffic and traffic signals; Wi-Fi transforming the way information is used and accessed; facial recognition technology transforming building security; shared vehicles allowing a move away from parking costs and land use; integration of renewable energy sources and smart metering technology for water, electric and gas; smart street lighting poles providing a vertical asset for wireless data via 4G/5G and Wi-Fi, applications enabled via wireless data, smart lighting and embedded sensors enabling numerous applications including embedded sensors providing for faster responses for public safety; and integration of systems with customer feedback loops to enhance and improve customer service for residents and visitors.

Smart Cities are enabled generally by the "Internet of Things." The "Internet of Things" is being driven by the increased sophistication and reduced costs associated with wireless, Bluetooth and sensor technologies, coupled with the advent of cloud computing, which places storage and computing power in the cloud. "All" devices around us are undergoing technological re-imagination to incorporate technology to make them "smart." Increasingly simpler and cheaper devices can be employed by cities to connect municipal assets and functions to generate more and more data – enabling more efficient and effective management of services and programs.

However, Smart City initiatives require high bandwidth network connectivity for transmission of large and growing amounts of data. Where does a city obtain this fiber-optic cable-based high bandwidth connectivity? Area service providers will sell high bandwidth (broadband) to cities as a service on their own infrastructure, but this is priced as a retail service from relatively few providers and is unaffordable to cities in both the short and long run. The alternative is to use and expand city assets in public rights-of-way, on a planned and strategic basis, to provide Smart City connectivity. Municipal broadband networks provide affordable means for

---

[42] "Trends in Smart City Development: Case Studies and Recommendations", National League of Cities, 2016. http://www.nlc.org/sites/default/files/2017-01/Trends%20in%20Smart%20City%20Development.pdf ("NLC Smart City Report")

implementing Smart City initiatives for health, education, public safety, mobility, livability and economic growth. Therefore, as communities invest in fiber infrastructure, they are constructing foundational communications networking useful to support a multitude of technology-based initiatives that require connectivity.

It is important to note that Smart Cities are not exclusively technological. Organizational and human factors must be provided for to foster the necessary collaborations and investment in human capital. Ultimately Smart Cities initiatives are layered, involving network facilities infrastructure, with connected devices (cameras, sensors, Wi-Fi, etc.), and the data from these devices which allows capabilities to be embedded in daily practices based on collaboration among organizations and departments.

This Plan is intended to guide the City in leveraging the assets it has in and above the ground, in part to identify where the City can locate use/construct assets for Smart City applications. In particular, the City's pole assets can be leveraged as part of the transition/evolution from "4G" to "5G."

6.2 Array of Things

An advanced Smart City application was recently started nearby the City of Naperville. A partnership of Argonne National Laboratory, the City of Chicago, and the University of Chicago last year began an "urban sensing project" called the "Array of Things."[43] AT&T is the "communications partner" for the project and is contributing wireless network connectivity. The project places nodes containing sensors throughout the City of Chicago, which collect data on urban environment, infrastructure and activity. Up to 500 nodes are planned for installation on Chicago streets, by 2018. The nodes will collect data, to be made available on an open basis to researchers, City planners, and others to allow study of critical challenges including urban flooding, traffic safety, air quality and climate change. The ultimate goal is to provide real-time data to "help engineers, scientists, policymakers and residents work together to make the City of Chicago and other cities healthier, more livable and more efficient."[44]

---

[43] http://www.anl.gov/articles/chicago-becomes-first-city-launch-array-things-unprecedented-urban-sensing-project The Array of Things is funded by a grant from the National Science Foundation ($3.1 million) as well as investment by Argonne National Laboratories and the Chicago Innovation Exchange. There are also partnerships with scientists at many other academic institutions.

[44] http://arrayofthings.github.io/faq.html

The nodes are experimental and vary in cost depending on their scientific capabilities.[45] 50 nodes were installed last year on traffic light poles in The Loop, Pilsen, Logan Square and along Lake Michigan. "These nodes will contain sensors for measuring air and surface temperature, barometric pressure, light, vibration, carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone and ambient sound intensity. Two cameras will collect data on vehicle and foot traffic, standing water, sky color and cloud cover." The node locations and data collected were determined based on research and community input. Additional nodes are planned in cities across the US, as well as in other countries.[46]

- Pilsen nodes will track air quality in an effort to relate it to asthma and other diseases;
- Nodes in The Loop are for study of pedestrian and vehicle flow, and traffic safety;
- Nodes along Lake Michigan and in other areas will allow for measurements of urban weather and climate change; and,
- Nodes will support City of Chicago efforts to use predictive analytics and data-driven policy.

6.3 National League of Cities "Smart Cities" Report

There is a vast and growing body of studies, information, products and implementations on the "Smart City." The National League of Cities has produced a report on trends in Smart City development.[47] Smart City applications require three things working together for effectiveness: computing and telecommunications infrastructure to collect data, software applications and tools to analyze and interpret the data, and a collaborative environment in the organizations that innovate, create and use Smart City applications.

---

[45] *Id*.

[46] New York City, Seattle, Portland, Atlanta, Mexico City, Newcastle (UK), Glasgow (UK), and Amsterdam.

[47] NLC Smart Cities Report.

The Report contains many examples of interconnection of devices in a Smart City, while noting that:

"A reliable Internet ecosystem is the glue that holds the Internet of Things together":

- Transportation Congestion Sensors
- Water and Wastewater monitoring
- Parking apps and kiosks to coordinate with smart meters
- Bridge inspection systems
- Self-driving cars, shuttling people in and out of the city or making deliveries
- Waste management sensors
- Lighting
- Fire detection
- Energy monitoring
- Solar panels
- Smart logistics/freight
- Vehicle fleet communications
- Drones for public safety and infrastructure
- Monitoring cameras
- Body cameras
- Wearable detection

The Report also contains case studies for Chicago, Philadelphia, Charlotte, NC, San Francisco and New Delhi, India, along with comparisons and recommendations.

- Chicago has created an administrative structure including its Department of Innovation and Technology which provides for "an open data platform and mandated cross-functional collaboration." This structure positioned Chicago to partner with Argonne National Laboratory on the "Array of Things."

- Philadelphia created an Office of Innovation and Technology to support movement toward smart city concepts, including programs and measures designed to lower the crime rate.

- Charlotte, NC established a PPP to help the City support its accelerating population growth, including an initiative to reduce wasted energy consumption.

- San Francisco has focused on environmental and transportation improvement measures, including programs designed to reduce traffic congestion and improve reliability of municipal transportation services.

NLC Smart City recommendations are:

1. Cities should consider the outcomes that want to achieve. "Data collection is not an end in itself." Initiatives need to be clearly defined. Consider what the need is, not just what other cities are doing.

2. Cities should look for ways to partner with universities, non-profits and the private sector. Cities can even partner with other cities. There are many benefits to partnering and collaboration, including access to experience, shared risks of development, and providing project continuity. Downsides to collaboration also need to be considered in structuring any partnership.

3. Cities should continue to look for Smart City best practices. Technologies are new and at present there is significant variability and a lack of agreed standards. The National Institute of Standards and Technology is working on this matter.

6.3.1 Smart Cities Readiness Guide

The Smart Cities Council publishes a "Smart Cities Readiness Guide."[48] The guide has detailed information on smart city drivers and barriers, benefits, "beyond silos," and City responsibilities. City responsibilities and opportunities are outlined as follows:

- Built Environment: Leading and planning for "smart buildings" powered by ICT, using sensors, meters, systems and software to monitor and control a wide range of building functions including lighting, energy, water, HVAC, communications, video monitoring, intrusion detection, elevator monitoring, and fire safety.
- Digital City Services: Switching to digital delivery of city services to increase citizen engagement, increase employee productivity, increase competitiveness, increase citizen satisfaction, and reduce cost. Services are delivered via the web, smartphones and kiosks, which can require implementation of new technologies, and attitudes or approaches.
- Energy: Smart energy is a priority for Smart Cities, which start with smart energy systems.
- Health and Human Services: Smart Cities ride the transformation wave provided by advances in ICT to transform the delivery of essential health and education services since "an educated and healthy city is a wealthy and successful city."
- Ideas to Action: A "roadmap" linked to a City's vision document and comprehensive plan is necessary to turn ideas to action, and make technology serve the City's larger goals. The path to a smart city is not quick, and targets are needed for clear goals to motivate citizens and permit any required course corrections.
- Mobility and Logistics: Population growth and wasteful congestion make this a critical area for the Smart City. Traffic congestion is wasteful and costly to the economy – both directly and indirectly. There are a variety of action steps and targets that can provide for safer, more efficient transportation, including accommodating electric and autonomous vehicles and smart parking among others.

[48] http://rg.smartcitiescouncil.com/readiness-guide/article/drivers-whats-driving-smart-cities

- Public Safety: Public safety relies on a lengthy list of infrastructure, agencies and people to keep the public safe. ICT in the smart city fosters quicker and smarter responses without wasteful duplicated effort to save lives, property and resources.
- Smart Payments and Finance: Digitalizing both disbursements and collections generates significant savings and increases operational efficiency.
- Smart People: A new city hall mindset that is more open, transparent and inclusive to build two-way communications and create stronger initiatives.
- Telecommunications: An adequate telecommunications infrastructure is vital for business and community development and underlies the Smart City.
- Waste Management: Population growth and accelerating consumption have created a rising tide of waste, outpacing the rate of urbanization. Smart cities can collect and process waste more efficiently and recover materials which have value, with a beneficial impact on public health, the environment and sustainability/zero waste, and cost control.
- Water and Wastewater: Like energy, water is critical to everyday life. There is also an energy – water nexus, where it takes water to produce electricity, and electricity to pump water. The Smart City provides intelligence for both energy and water systems and provide the platform for economical and sustainable production of both energy and water.

6.4 Smart Lighting

Smart City initiatives allow for municipalities to take light poles in the rights-of-way and utilize them for many different functionalities from light monitoring and management to deployment of sensor technologies that can monitor environmental factors that many have never thought possible, including crime activity, trends in traffic congestion, pollution, among other factors. But community standards regarding aesthetics, design and style solutions require that high functionality be coupled with pleasing design characteristics.

Current trends in smart street lighting range from cost saving LED lighting to powerful engineered solutions including sensor placement, distributed antenna systems (DAS) and Wi-Fi deployment, and municipal communications functionality (i.e. security cameras, traffic monitoring). Municipalities vary in their implementation of these devices and technologies, however, determining an appropriate street pole can assist a city or town in scaling technology for the future, enabling additional technologies to be added as they come to market.

Crucially, evolution to 5G mobile phone technology depends on closely spaced antennas – for which street lights and other poles, and traffic signal standards can be very useful. Mobile service providers often prefer exclusive rights to poles, and the evolution to 5G will likely be no different. Service providers likely will state that they cannot co-locate with their competition on

the pole structures, therefore they are moving quickly to gain rights to this real estate before cities can organize and prepare for the 5G deployment coming within a few short years.

By planning strategically and installing smart street lighting with 4G wireless and possible 5G capabilities, a city or town could potentially develop a future-proof plan for advancing technology and ensure that additional structures do not enter their rights-of-way and add blight or clutter to the city. One of the of the most underutilized assets in municipalities and utility companies is the electric light pole. Their sheer numbers and locations deployed throughout municipalities makes them well suited for the delivery of 4G and 5G mobile services. Street light poles can be retrofitted with smart LED-based lighting, which leads to energy saving within a city and can be leased out to service providers for deployment of their DAS/small cell technology. Furthermore, addition of Intelligent Traffic Systems capability improves traffic efficiency and facilitates safer, coordinated, and more intelligent decisions around traffic management.

Smart Pole uses and applications include:

- LED lighting and lighting applications: Naperville is well along in the conversion to LED lighting. Studies show a municipality could save 50-60% in energy costs based on the type or brand of lighting. LED lighting saves in energy costs and the lights burn three to four times longer than the traditional bulb, saving not only energy but materials as well. Numerous products on the market also allow for lighting applications, which provide for monitoring and management of lighting throughout the area. Reduction in maintenance costs are also a benefit as software systems are connected to the lights alerting public works employees of bulb outages, breaks, or issues. Additionally, various products allow for lighting to be set on timers to dim during low traffic periods, shut off during daylight hours, or be connected to sensors to brighten when pedestrians or cars pass the pole.
- Solar Panels: Solar panels are now being deployed onto street lights, enabling cities to realize a net zero energy cost in relation to the energy consumed by the lamps. However, the majority of the products currently on the market require another "head" on the lamp with the solar equipment built into it. New technology is coming onto the market evolving and allowing for smaller, more efficient use of the light pole for solar powered energy. In these newer designs, the solar panels are on the physical poles.
- Sensors: Sensors are an area of many current and potential applications. The light pole is ideal for accommodating sensors, as the poles already have electricity, and provide sensors a great view of the landscape. Additionally, light poles are great for transmitting wireless signals due to their height. Sensors are used to monitor air quality, weather conditions, and motion. Law enforcement can use sensors for parking enforcement, contacting emergency services in the event of an accident, and security cameras. Motion sensors could be configured to dynamically light up a section of road

when vehicular or pedestrian movement is detected and switch off or reduce the illumination in the absence of any movement, aiding in public safety. Additionally, the sensors and networks can be sensitive to sunrise and sunset for LED operating hours, or the dimming of the lighting can be set to a schedule to accommodate city or town needs. Besides the cost savings, there are many other benefits from smart lights. The system can be used to control stop lights from a central location. One example of a public safety application enabled is for a fire truck to remotely activate the system to have street lights flash red ahead of the truck's route. Drivers are thus warned that an emergency vehicle is approaching, and it reduces travel times for the emergency vehicle.

- Wi-Fi: Smart cities connect everything – buildings, lights, meters, and streets – to the internet through the power of Wi-Fi. Connectivity provided through the emerging Wi-Fi frequencies below 1 gHz is being developed to extend the range and reach of signals through more materials and is particularly well-suited for applications with low data payloads – like sensors. This is ideal for smart devices that don't require a constant speed connection and are located in harder to reach places.
- Wireless Services/4G/5G: Currently, 4G transfer speeds top out at about one gigabit per second in perfect conditions. However, we rarely experience 4G's maximum download speed since the signal can be disrupted by buildings, microwaves, Wi-Fi signals, trees etc. 5G on the other hand, will have much higher speeds (up to 10 gigabits per second), capacity, and significantly lower latency. It will also support the thousands of internet-connected devices being introduced into our lives. The high reliability and low latency of 5G creates opportunities for city management, and public safety to control critical services and infrastructure. Cities can now connect to millions of networked devices, making real-time, intelligent, and autonomous decisions. This real-time data will reduce maintenance and create greater operational efficiency. 5G will bring broadband and media everywhere allowing users and devices to communicate in crowded or remote areas with lightning fast broadband speeds.

See Appendix C. for Smart Street Light Options.

6.5 Smart City in Naperville

Department interviews conducted during Magellan's site visit make clear that City of Naperville management and staff have significant interest in Smart City initiatives, particularly in transportation-related areas. Potential smart city applications include wireless on-street parking meters, directional signs, and parking structures accepting credit cards and displaying real-time parking availability on signs. The real-time parking system pushes space availability for on-street meters, structures and lots to the public via apps on IOS and Droid mobile devices. Pay-on-Foot devices allow the public to pay-by space using a credit card in lots without controlled entrance and exit lanes. These smart parking technologies reduce the time it takes to

find a space and in turn, reduce traffic congestion and lower the carbon footprint from vehicles looking for a place to park. Also, traffic signal controllers can provide for traffic signal synchronization and remote access for staff to perform ad hoc traffic signal timing changes based on real-time conditions, emergencies and events. Naperville's fiber also provides backhaul capacity for an enormous amount of HD digital video from cameras for managing traffic and public safety.

The City has three parking decks and may be adding a new one (although that is not yet in the Capital Plan). The City currently has the capacity to count vehicles going in and out of the parking decks, and the decks do have sensors, which were recently connected to radio systems in the downtown area. There is an interest in seeing this tied into apps such as the WAZE app to connect drivers with empty parking spots.

The City of Naperville has also noted the potential of tying in street lighting, and the potential for "smart poles." (Much of the City's lighting has been changed to LED.) Smart pole features can include weather and air quality monitoring (including rain intensity and lightning activity, wind and barometric measures, etc.); digital signage for directions, alerts and announcements; electric vehicle charging; car and pedestrian counting; cameras, Wi-Fi, and controls for light levels/lighting capabilities – in addition to wireless communications antennas.

The City has a planned next phase for installation of approximately 3,000 decorative street lights. For example, the Downtown District has 300 "shepherd hook" poles. These are very expensive poles, and not made to support additional weight from antennas, cameras, etc. The lighting is planned to be taken out in favor of LED. Also, there is a street scape plan over the next four to five years for the downtown area.

Street lights are viewed by many as ideal places for sensors for "Smart City" and other applications. The City of Naperville is acting on this potential and is upgrading 12,000 poles City-wide to new LED fixtures with the 7/10 Smart Switch. These will all be dimmable and include a 7pin receptacle to be used for the City's new Smart Grid Lighting System. Nine thousand upgrades have been completed, and the remaining 3,000 are in the upcoming year's budget for completion (most of which are in the downtown area). The City has also deployed a camera network using electric eyes on light poles to facilitate control, as connected by City fiber networking as well as Wi-Fi. There are approximately 160 cameras installed for the various departments, with an addition of a significant number of Pan/Tilt/Zoom cameras budgeted this year and next year.[49]

Upgrading the street light poles has complied with the City's policy and planning direction on aesthetics and clean appearance. The City plans on standard appearances and approaches on

[49] "Security Camera 5 Year Budget" workpapers.

poles, light standards, and antennas. In particular, the City wants a single standard for pole, antenna and light standard placements, and does not wish to permit different service providers to hang different things on poles and standards. The "Southwest standard" (as implemented by SRP and the City of Phoenix) has been noted as a better approach.

6.6 Smart City Recommendations

Broadband and Wi-Fi capacity can be used to transform and improve the Naperville community via Smart City applications in the areas of Advanced Metering Infrastructure (AMI), Smart Grid, Public Wi-Fi, Electric vehicle charging stations, traffic detection and forecasting, sanitation, wastewater/storm water data, and transportation including intelligent parking and traffic signal prioritization. In particular there are fleet management applications that could be very useful, such as using Automatic Vehicle Location (AVL) on snow plows to map and see which streets have been plowed/salted, and salt utilization could be monitored. Various fleet management functions such as monitoring of fuel consumption and costs can generally be addressed. The City of Naperville is also known for its large festivals that pull in 250-300,000 people along with smaller activities including triathlons, a marathon and holiday festivities in the winter. All these activities have traffic and traffic control requirements that can potentially be aided using Smart City applications, including greater use of fiber network capacity instead of radio, traffic operations, event related detours, and installation of temporary cameras.

In sum, there are potential applications too great to number for such things as camera systems for public safety, security, traffic, and parks/bike paths; speed sensors; Wi-Fi in support of public meeting rooms, downtown visitors and commerce, teen and senior centers, tech classes; parking management and enforcement, wireless parking meters, real-time parking guidance; support for inspectors and City officials and their tablets/laptops; smart waste pick up and bin sensors, smart manhole covers, and smart devices to mitigate residential traffic cut through.

The City has met with telecommunications vendors (i.e., Comcast and AT&T) regarding Smart City implementations and applications but purchasing these applications at retail prices is likely to be unaffordable for the City, and unnecessary when the City has the necessary telecommunications infrastructure.

Magellan recommends that the City immediately formalize its Smart City considerations via the formation of a **Smart Cities Steering Committee**. This Committee should include senior leadership from all relevant departments. The Dark Fiber team which supported this project would be a natural fit to hit the ground running as the Smart Cities Steering Committee. The Committee should first review and investigate Smart City applications that have been under informal consideration by the various City departments (such as tying in sensors in parking decks to WAZE app, and use of street light poles for various functions such as dimming) and

"vet" those applications with a view toward determining feasibility and requirements. Review and investigation of particular Smart City applications would include:

- Determining the organization(s) or department(s) that would "own" the application and its implementation;
- Organizational adaptations that must be made within the City;
- Department ranking of importance of implementing the application versus other potential Smart City applications;
- City management and council ranking of the priority of the application versus other potential Smart City applications;
- Community views on the importance and utility of the Smart City application;
- Legal or policy requirements that must be addressed (if any);
- Costs of the application and its associated equipment;
- Network implications of supporting the application, including network proximity;
- Use of existing OnLight Aurora ISP connections to support necessary internet connections for Smart City applications;
- Timeline for installation of the application, including activation of the application;
- Resources needed for installing and testing the application;
- Savings and benefits for the City generated by use of the application;
- Funding and budget sources (including potential grant funding) and what budget actions are necessary; and,
- Other relevant information.

The figure on the following page shows a graph of phases and locations that Naperville could deploy Smart City applications over the next several years.

Figure 17: Potential Smart City Application Deployments

Department	Agency or Location	Wi-Fi	CCTV	5G	Parking	EV Charging	Smart Lighting	Traffic Monitoring & Pedestrian Flow	Smart Grid	Sensors	Others
City of Naperville	Municipal Center	X									Internet Park
Police Department	Headquarters Building, city-wide	X				X				Speed	Fiber to Radio Sites
Fire Department	Headquarters and Fire Stations	X								Vehicle	Video Connections, Wi-Fi in the field
Public Works	Camera & Street Light Locations	X	X	X		X	X			Weather & Parking	Smart Poles connected to Fiber, Fleet Management Applications, Digital Signage
TED	Inspectors and staff in the field	X						X			
Naperville Parks District	City Parks, Festival Locations										
Downtown District	Downtown Business District	X	X	X		X				Parking	
Police	Headquarters Building	X	X	X							
Emergency Management		X									Access to City Cameras
City of Naperville	Downtown Garages (Water St and Central Parking Facility)		X		X	X					
Public Works	Electric/ Water Meters	X							X		AMR
Water Department	Pump Stations										Fiber for SCADA Connections, Use of abandoned water mains for Fiber and Cionduit

7. PARTNERSHIP OPPORTUNITIES

7.1 Local Governments

7.1.1 City of Aurora and Onlight Aurora

The City of Aurora is adjacent to Naperville, and the two cities have taken advantage of opportunities to coordinate and cooperate for many years. The cities are both among the top five cities in size in Illinois and share similar demographics and geography along transportation corridors (i.e., I-88). Naperville and Aurora have existing successful sharing and collaboration for public safety networking, including fire departments.

The City of Aurora has formed a fiber-optic network entity – OnLight Aurora – as the "fourth utility." OnLight Aurora started with a vision, which became a plan that resulted in a network. It began with a realization that different areas of the City had varying internet access availability and speeds – faster or slower. This affected not only residents but city buildings and facilities – the City had "fast" and "slow" buildings as an artifact of the network buildout of service providers in the City.

A non-profit organization – OnLight Aurora[50]-- was formed to manage and promote access the City's fiber-optic network, which supports a "robust, highly available metro Ethernet network." Service providers can use the fiber-optic network connectivity to upgrade broadband links to their customers, including community anchor institutions such as hospitals, schools and government offices as well as other entities including data centers and Aurora businesses. OnLight Aurora is intended to support business retention and economic development in Aurora through its high-speed fiber-optic network, which is designed to serve all areas of the City with economical service options. OnLight Aurora's network architecture is 10 Gigabit Metro Ethernet and supports DWDM options as well as wireless point to point. The development of the network was supported by the City's "Dig Once" policies, such that every time the road is opened conduit is placed to support fiber-optic networking.

OnLight Aurora has a structured board that includes the Mayor, the city's CIO, an alderman, and six appointed members. The Board can be expanded as warranted to include additional representation of the range of core subscriber and supporters, industries and community organizations. This presents an open path for Naperville to collaborate and cooperate in the mutual interest of the two cities and the OnLight organization. Naperville can leverage its existing and future fiber-optic networks by interconnecting with the adjacent City of Aurora

[50] http://www.onlightaurora.com/

network. Extensive conversations have occurred on this subject between the staffs of the two cities, and it is clear there is both opportunity and interest, with anticipation of cost savings/sharing and expanded functionality. Magellan Advisors recommends (in Section 8.3.1) that the City of Naperville take specific steps to work with OnLight Aurora on regional networking. There is an interest and a clear benefit in connecting the two networks for regional public safety purposes, economic development as well as siting for wired and wireless telecommunication providers.

7.1.2 DuPage County

Representatives from DuPage County attended the focus group meetings in November 2017, where the Broadband Evaluation project was discussed with members of the business and community anchor communities. Input was sought and provided from the focus groups regarding broadband experiences and needs in the Naperville community and surrounding areas. DuPage County representatives saw much the same needs and benefits from a collaborative approach to meeting broadband needs as did Naperville and Aurora representatives. Naperville should seek to include the DuPage County IT representatives in collaborative planning for creation of "City Net" and interconnection with OnLight Aurora so that DuPage County can also have the opportunity to benefit from this regional networking effort.

7.2 Community Anchor Institutions

Fiber-optic networks provide an infrastructure that can be used for an assortment of public benefits, including enhanced utilities and improved collaboration and infrastructure sharing programs, as well as improved public safety and first response. When local government and public service organizations use broadband, the fiber then provides a platform for long-term adoption and "smart community" innovation.

As we look to the future, local governments and public-sector organizations like schools, hospitals, libraries, first responders, civic organizations – all considered "community anchors" - must operate as a business and strive to work smarter through technology. Each department and its staff should be able to access information and have a process to do their jobs as efficiently as possible. Technology today can send and receive bandwidth-intensive information that can help all local departments share workflow documents, detailed maps and blueprints, high resolution photographs and other documents and forms of unified communications.

7.2.1 Healthcare

Broadband is expected to transform healthcare, simultaneously enabling better outcomes and lowering costs, both on the internal operations of the healthcare practice, and on the patient care side through telehealth. The National Broadband Plan says that Electronic Health Records and Remote Monitoring technology could alone save over $700 billion over 15-25 years.[51] Beyond the cost aspects, using telehealth is a viable way to revolutionize patient care. The American Medical Association (AMA) believes that the appropriate use of telehealth applications to deliver care to patients could greatly improve access and quality of care while maintaining patient safety. In 2014, the American Medical Association created guiding principles for ensuring the appropriate coverage of telehealth services that state:

- Telehealth provided over robust broadband networks can facilitate immediate diagnoses and care to prevent lasting damage to stroke victims, prevent premature births, and deliver psychiatric treatment for patients in underserved rural areas.
- Telehealth is viewed as a cost-effective alternative to the more traditional face-to-face consultations or examinations between provider and patient.
- Similar to regular small businesses, rural clinics and small physician offices have the same price sensitivity to broadband, which is often priced beyond their means or altogether insufficient to support their health IT needs.[52]

For patients, remote access to healthcare providers offers major advantages over traditional methods of delivery. Obviously, broadband connectivity to the patient's home is the enabler of all telehealth benefits. At the top of this list is making certain types of care more accessible for those who struggle to get to distant medical facilities, which are precisely the demographic that commercial service providers neglect – the elderly and the poor.

While not a substitute for in-person visits, telehealth can provide face-to-face care and improve a patient's understanding of his or her own health. Broadband is crucial for healthcare providers as they begin to leverage electronic medical records and other important capabilities of telehealth and the electronic exchange of health care information.

The Healthcare Information and Management Systems Society recently published a study[53] of the telemedicine industry and the use of the technology by healthcare organizations. The

[51] http://www.broadband.gov/issues/healthcare.html
[52] https://download.ama-assn.org/resources/doc/hod/x-pub/a14-cms-report-7.pdf
[53] http://www.bna.com/telemedicine-market-nearly-n57982063688

research found that 57.7% of healthcare organizations in the US have adopted some form of telehealth, and that most of those organizations use more than one type of technology.

Bandwidth needs of healthcare providers in Naperville are guaranteed to continue growing, and connected devices are incorporated all the time. The FCC's Connect2Health program considers ways to accelerate the adoption of healthcare technologies by leveraging broadband. The FCC envisions that future healthcare systems will use broadband-based tools to allow clinicians, pharmacies, and health and social service providers to collaboratively optimize health outcomes – all in an interconnected healthcare ecosystem.

As a guide, the FCC has released minimum recommended broadband speeds for healthcare organizations, as part of its Healthcare Connect program. These speeds identified by Healthcare Connect should be considered minimum requirements and any healthcare organization should have access to more bandwidth if needed.

Single Physician Practice – 4 Mbps

- Supports practice management functions, email, and web browsing
- Allows simultaneous use of electronic health records (EHR) and video consultations
- Enables non-real-time image downloads
- Enables remote monitoring

Small Physician Practice (2-4 physicians) – 10 Mbps

- Supports practice management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables non-real-time image downloads
- Enables remote monitoring, and use of HD video consultations

Nursing Home – 10 Mbps

- Supports facility management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables non-real-time image downloads
- Enables remote monitoring, and use of HD video consultations

Rural Health Clinic (approximately 5 physicians) – 10 Mbps

- Supports clinic management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables non-real-time image downloads
- Enables remote monitoring, and use of HD video consultations

Clinic/Large Physician Practice (5-25 physicians) – 25 Mbps

- Supports clinic management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables real-time image transfer
- Enables remote monitoring, and use of UHD video consultations

Hospital – 100 Mbps

- Supports hospital management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables real-time image transfer
- Enables remote monitoring, and use of UHD video consultations

Academic/Large Medical Center – 1,000 Mbps

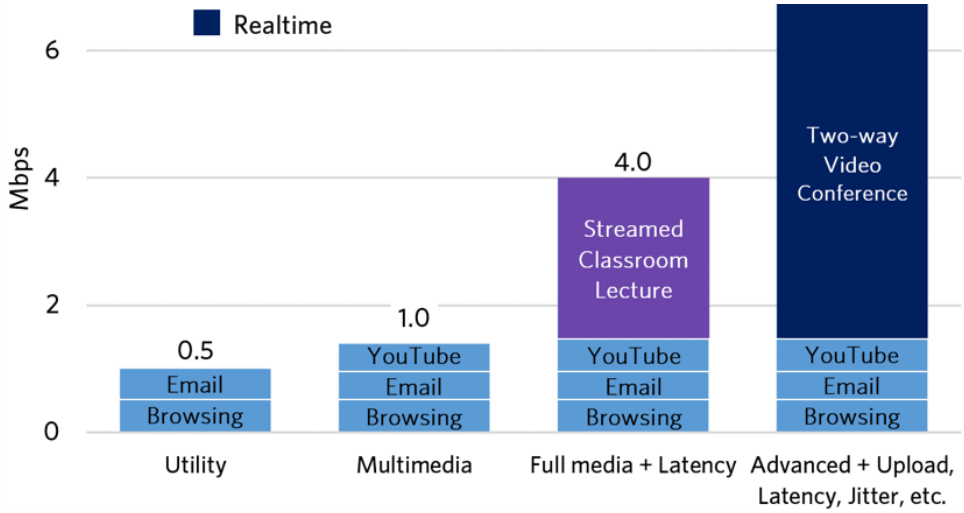
- Supports hospital management functions, email, and web browsing
- Allows simultaneous use of EHR and high-quality video consultations
- Enables real-time image transfer
- Enables remote monitoring, and use of UHD video consultations

Hospitals and medical institutions will continue to have enhanced bandwidth requirements and infrastructure needs. The City of Naperville should reach out to area hospitals and medical offices to determine if there is an opportunity to partner with the medical community and provide a reliable high-speed connection at a more favorable cost.

7.2.2 Education

To provide an idea of what bandwidth is needed in the typical classroom, Figure 18 illustrates the bandwidth requirements per student for common educational applications and the quality and performance requirements of these applications. Basic educational tools, such as web browsing, and video streaming consume up to about 1 Mbps per student. However, moving up to more advanced educational technologies such as streamed classroom lectures and 2-way video teleconferences, significantly more bandwidth is used per student, between 4 Mbps and 7 Mbps when combined with the basic educational tools.

Figure 18: Bandwidth download demands for concurrent applications



7.2.2.1 The FCC E-Rate Program

E-Rate is the commonly used name for the Universal Service Program for Schools and Libraries, which is administered by the Federal Communications Commission (FCC). The program provides federally-subsidized discounts to help schools and libraries obtain affordable telecommunications and internet access. It is the federal government's largest educational technology program.

The E-Rate program is one of four federal programs funded through the Universal Service Fund fees that are charged to telecommunications companies that provide interstate services, which is passed on to consumers on their telecommunications bills. Since all households that subscribe to services pay into the Universal Service Fund, it is important that communities maximize their participation in the E-Rate program to help recoup the investment made by their residents that pay into the fund.

The E-Rate subsidy for the Naperville Schools is 40%. This percent is attached to each school district's free and reduced lunch program. Therefore, if a school system has 40% of its students that receive free or reduced cost lunch, it also means that 40% of that school district's telecommunications and internet access costs are funded by the federal government. The school district must pay the remaining 60% through its own internal cost allocation.

The E-Rate program offers a significant amount of money, and it would benefit the success of any broadband initiative in Naperville to serve the E-Rate Schools and Libraries Program. This funding could help support the infrastructure to the schools and libraries in the city, which

would both keep money in the local economy and help sustain the network to benefit the larger community.

7.2.2.2 Naperville Community Unit School District 203

The Naperville Community Unit School District 203 operates 22 schools in the City of Naperville, with approximately 16,000 students. The school district receives internet access through AT&T and is subsidized 40% by the federal E-Rate program. In funding year 2017 over $146,000[54] was committed from the Universal Services Fund to aid the school districts Internet Access costs. In stakeholder outreach meetings, the district stated the need for fiber to connect additional schools and noted that the district was interested in partnering with the City to access the City's fiber-optic infrastructure. Conversations have since taken place to address a proposal that was created to build a connection to the schools and to connect back into the City's existing network. The proposal would connect school districts 203 and 204. Discussions are ongoing on the proper way to connect the schools, and the funding methods to do so. Connecting the districts to the City's network would be a significant opportunity for the City to expand its network to assist local stakeholders, and discussions should continue to see if a partnership can be formed.

7.2.2.3 Indian Prairie School District #204

The Indian Prairie School district 204 operates 31 schools in the communities of Naperville, Aurora, and Bolingbrook. The District operates 18 schools in the City of Naperville. Indian Prairie serves over 28,000 students throughout DuPage and Will Counties. Indian Prairie District 204 does not have any registered information with the Universal Services Fund for E-Rate services, which leads us to believe that they are not receiving any E-Rate subsidies for telecommunication services.

Indian Prairie did not attend or participate in any stakeholder outreach discussions with the City or Magellan, and therefore no formal information about the District's infrastructure or telecommunication and broadband needs can be reported. The City should continue to reach out to the District to ensure that all their telecommunication and broadband needs are being met. If not, the City should work to see if they could offer any solutions or costs savings to meet the District's needs.

[54] http://www.usac.org/sl/tools/commitments-search/default.aspx

8. ASSESSMENT AND RECOMMENDATIONS

The City of Naperville is well positioned to leverage technological advances to realize the benefits and stay abreast of broadband trends. The City, through its DPU- E, operates a well-planned and well-developed fiber-optic network which can be leveraged for additional uses including serving businesses and community anchor institution locations upon request. The City has experience with the operation of Wi-Fi and camera networks and is poised for "Smart City" applications. The City's fiber network and infrastructure can be leveraged for evolution and deployment of emerging 5G networks. Providing 5G, Wi-Fi and Smart City applications in the downtown district will promote economic development which would further enhance Naperville's already award-winning communities as one of the best places in America to live.

While the City through its foresight possesses certification from the Illinois Commerce Commission as a Competitive Local Exchange Carrier (CLEC), and thus has the legal basis to provide telecommunications/internet services to its businesses, community anchor institutions and citizens, there does not appear to be community demand for business services at the present time. The City is not considering Fiber-to-the Home deployment. There are identified needs for community anchor institutions however, thus development of network infrastructure to serve City and community anchor needs are the priority. These needs include schools and universities, Downtown/Washington Street/Chicago Avenue connectivity, Parks District, and connectivity for public safety.

The City needs a more reliable network for public safety uses and especially the fire department who utilizes a system owned by Aurora. In addition, redundancy through another connection to the north is necessary, which should be a high priority for public safety and quality of life in Naperville.

Magellan Advisors strongly recommends that the City continue its assignment of 6 fiber strands of the existing DPU-E fiber-optic assets to the Information Technology Department, to be managed and administered for City and regional networking purposes. This permits DPU-E and DPU-W to continue focusing on the needs of their utility customers, while the Information Technology Department can focus on the communications needs of the City and anchor institutions and schools. This creates the proper focus and alignment of a secure network for utility operations, and a separate fiber-optic "City Net" for Naperville city, anchor institutions, smart city applications and regional public safety and wireless carrier operations and partnership opportunities. This separation of responsibilities and assets creates an efficient platform for supporting an expanded implementation of "Smart City" applications, expanded Wi-Fi in the downtown and in other areas of the City, and 5G deployment by the wireless providers. There is a need to update and provide better Wi-Fi in the downtown to replace the old system that is place, as it is in poor condition/End-of-Life.

To look forward to necessary expansion of the "City Net" Magellan Advisors recommends that the Dark Fiber team (with direction from City leadership as required) design a resilient broadband backbone through a Phase II Fiber Master Plan that includes design engineering and RFP development for construction. The network design and strand count for this resilient network will take into account use of DWDM (dense wavelength division multiplexing), lit and managed network technology to design the network to accommodate current city, smart city, public safety and small cell deployment needs. This network design will also have the ability to be expanded for use by community anchors such as schools and universities, Park District, Library, Naper Settlement, and the Downtown. This network can then be further leveraged through lateral connections to connect businesses and commercial zones that are underserved.

8.1 Recommendation 1: Formalize a Smart City Steering Committee

As described fully in the recommendation contained in the Smart City section above, the City should leverage the work that has been done in departments to date on Smart City applications, and formalize a Smart City Steering Committee to evaluate and prioritize Smart City applications to implement and best practice in broadband governance.

8.2 Recommendation 2: Implement Broadband-Friendly Policies

Magellan believes that Naperville's most immediate strategy to encourage next-generation broadband infrastructure growth is to formalize broadband-friendly public policies. In meetings with the City of Naperville departments, it was discovered that many progressive considerations are already in place, and informal policies were being formalized that are generally accepted as best practice. The City of Naperville needs to ensure that it employs conditions for development that include telecommunications assets as a part of the necessary development infrastructure.

In support of this strategy, Naperville should continue to implement broadband-friendly public policy tools. These policy tools influence how broadband services develop throughout the City and show the community and prospective newcomers that Naperville is serious about promoting broadband growth and accessibility. In addition, it will allow the City to expand its underground conduit and fiber system with savings over more traditional fiber construction methods, allowing the City to take a master planning approach versus deploying in an ad-hoc, unplanned way.

What are Broadband-Friendly Public Policies?

Broadband-friendly public policies are tools that Naperville is formalizing that will encourage broadband infrastructure growth. These include many items that are already informally performed by the City now, such as practices that reduce the duplication of effort and minimize the cost associated with installing utility and broadband infrastructure within its jurisdiction. Below is a list of ways that the City can encourage broadband development through the adoption or continuation of broadband-friendly polices:

- Evaluate fees levied on broadband providers for constructing broadband infrastructure to ensure they do not discourage broadband investment.
- Develop methods to streamline the broadband permitting processes within public rights-of way to ensure broadband providers do not face unnecessary obstacles to building infrastructure.
- Develop a process so that municipal Planning, Engineering, and Public Works Departments coordinate with each other to identify projects that could install infrastructure at reduced costs.
- Identify opportunities to install broadband infrastructure in conjunction with public and private construction projects.
- Maintain broadband infrastructure specifications in a city-owned GIS-based fiber management system, requiring updates as built, and implement processes for accurate documentation.
- Adopt policies that incorporate broadband as a public utility and create a policy framework to promote its deployment in public and private projects as appropriate.
- Draft policies to Naperville's specific needs and adopt them into local policy, codes, and standards (including dig-once, joint trenching, engineering standards, etc.).
- Incorporate broadband concepts into Naperville's Capital Improvement Plans (CIP), as appropriate, and make a commitment to fund broadband infrastructure.
- The City should adopt a dig once ordinance and effectively manage its new wireless communications ordinance for placement and method of 5G small-cell deployments.
- The City should adopt in-kind negotiation strategies when licensing small cell pole attachment agreements.

What are Broadband-Friendly Public Policies? (con't)

Comprehensive Broadband Standards and Joint Trenching Policies that incorporate broadband infrastructure requirements into Naperville's land development statutes or General Plan will allow and encourage broadband construction in conjunction with other capital projects. For example, installation of fiber-optic conduit during all projects involving roads, sidewalks, trails, or lighting projects where the ground is to be opened for other purposes would be less costly than installing conduit through standalone broadband projects. Since the majority of costs to build broadband infrastructure is incurred through trenching, boring, and restoration, this strategy can alleviate significant costs by opening the ground once instead of multiple times. In many states and municipalities, this formalized policy is referred to as a "Dig Once" policy.

8.3 Recommendation 2: Gather Information to Design "City Net"

The City should leverage the work that has been done in this project by the Dark Fiber Committee with a "**Phase II**" to design "**City Net**" that would include and address:

- A specific inventory of existing fiber, fiber capacity and strand use and availability for "City Net", including the existing 6 strands assigned for IT Department use:
    - Identify available fiber and conduit, and availability for future use.
- Identify locations of abandoned water mains, and assess their suitability as supporting structure for placement of fiber duct and innerduct.
- Recognize the present assignment of specific strands between "City Net," DPU-E, and DPU-W.
- Design and plan for the implementation of Wave Division Multiplexing (WDM)[55] technologies for making best use of limited fiber counts in building of the fiber backbone.

---

[55] WDM, or wavelength-division multiplexing is a term used in fiber optic communications. WDM is a technology which multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths (i.e., colors) of laser light. This technique enables bidirectional communications over one strand of fiber, as well as multiplication of capacity.

- Review of all needs and opportunities (e.g., Smart City applications, school district, OnLight Aurora, park district, public safety) that have come to light during the course of this project, to inform network design and allow appropriate modifications to be considered for the network to accommodate these needs and opportunities:
    - Identify specific locations for which connections should be planned, including Route 59 stations, and additional public safety and camera connections (see Smart City Implementation Chart in Section 6.6); and,
    - Identify options and preferred solutions for railroad crossing to connect with OnLight Aurora for regional public safety communications.
- Use this information to create a phased expansion plan, and high-level network design of "City Net" which:
    - Accommodates plans for network expansion (fiber connections, Smart City and Wi-Fi);
    - Provides connectivity for upcoming City projects such as the Jefferson Street area; connectivity, and repair and rehabilitation of fiber on Washington Street;
    - Provides upgraded and replaced Wi-Fi connectivity in the downtown area and other designated areas of the City including parks and open spaces;
    - Considers the locations of businesses as indicated by the business address layer of GIS data (shown below); and,
    - Includes hub locations utilizing WDM, identifying laterals into a Smart City;
    - Optimizes construction of laterals to serve municipal buildings, schools and universities, and other community anchor institutions.

8.4 Recommendation 3: Pursue Partnership Opportunities

This project has illuminated several intriguing "win-win" partnership opportunities that should be explored with all due speed, in concert with design of "City Net." Among other benefits, these situations provide the opportunity for the City to "start small," and incrementally add on to the current network with the benefit of expanding scale and scope.

The term wavelength-division multiplexing is commonly applied to an optical carrier, which is typically described by its wavelength, whereas frequency-division multiplexing typically applies to a radio carrier which is more often described by frequency. This is purely convention because wavelength and frequency communicate the same information.

Based on our engagement with the City, the highest priorities the City is considering include:

1. Continuing to build and advance their fiber assets;
2. Completing a Dig Once Ordinance to provide opportunities for joint trench and savings in expanding broadband assets while protecting the public right-of-way;
3. Providing Wi-Fi in the downtown;
4. Enhancing Public Safety services through connections and partnerships with OnLight Aurora;
5. Working with the school district and other education anchor groups;
6. Connecting the remainder of the government buildings; and,
7. Focusing on economic development opportunities by connecting anchor institutions, development projects and commercial zones.

8.4.1 Partner with the City of Aurora

The City of Aurora and the City of Naperville have a history of sharing and collaborating for the benefit of businesses and residents in the region. The City should continue network development via "City Net" to meet needs in the City of Naperville, but with consideration of regional network opportunities and development in collaboration with OnLight Aurora. The City should continue to work with Aurora on regional issues such as public safety and deployment of 5G, as well as connections for schools, universities, and anchor institutions. County and City parks organizations should be included as well. Extending collaboration will have strong economic development benefits for the region.

Magellan Advisors recommends that next steps be pursued between the cities to accomplish interconnection of the networks and joint planning to realize efficiencies and expanded network reach and functionality for the benefit of local businesses, community anchor institutions including city government, and ultimately residents of the two cities. Naperville's "City Net" should be operated in a parallel fashion with OnLight Aurora as the first step. "City Net" should be interconnected with OnLight Aurora to share ISP connections for the benefit of both organizations. The City of Naperville's IT Department should work with OnLight Aurora on a regional basis to work on efficient ways to interconnect "City Net," to meet the cities' public safety needs and requirements, to support further efficiencies with the counties and parks departments, and in serving community anchor institutions such as schools and universities. Efficiencies can be gained in security and network operations, ISP connectivity, and other telecommunications and internet functions. Subsequently, OnLight Aurora and "City Net" will need to work together to reorganize internal governance roles and rules, and operational policy and procedures for the OnLight organization that includes Naperville. Magellan Advisors recommends that the City use this parallel course with OnLight Aurora with the ultimate goal of joining that entity.

Networking implications of joining networks to achieve regional objectives should be included in the "City Net" planning, including connections for the Route 59 Metra stations (Aurora), public safety radio connections to the Harris system, and connectivity supporting additional cameras.

8.3.2 Partner with the School District # 203 – Initiative

There is a desire to work with the City's educational system and more specifically in the very near future District 203 who has put an RFP on the street. Working with District 203, possibly considering e-Rate and running a second connection to the north to connect to the Aurora "OnLight" network might be a better or more viable solution. Naperville partnering with Aurora or another ISP provider could reduce some costs for District 203 and provide for a better solution by saving time. Although District 204 has not issued an RFP the same considerations and direction would also apply for District 204.

8.3.3 Partner with Service Provider(s)

The City should reach out and open and/or continue discussions with Comcast, Verizon, WOW, AT&T, VinaKom, Crown Castle, MCImetro, and Level 3. Each of these companies has expressed an interest in Naperville for permission to lay fiber in the public right-of-way for the oncoming deployment of 5G small cells. The City should also reach out to the wireless companies including Verizon, AT&T, Sprint and T-Mobile to determine and gauge their interest in use of the City's street light poles for deployment of 5G.

While investigating these partnership opportunities, the City of Naperville should focus on continuing to meet the needs and demands of City operations, while bringing value to the greater community, and monetizing any assets that are available. Cities across the United States are developing these types of infrastructure programs to drive new revenues to the city and to support the long-term sustainability of their communities. These revenues are being generated off conduit and dark fiber assets, lit network services, and through the lease of vertical assets such as street lights and towers. In many cases, municipal broadband networks provide residential Fiber-to-the-Home (FTTH) or business fiber-optic telecommunications services both in retail and wholesale offerings.

There are several tasks required in order for Naperville to formalize this effort, they include:

- Document and maintain an inventory of available assets;
- Implement a fiber management system;
- Develop and standardize agreements for fiber and conduit leasing;
- Develop pricing policies for fiber and conduit leasing;
- Publish rates and terms;

- Create a City enterprise fund to maintain proper budgets, cost accounting, and to track revenues of the program; and,
- Create a capital fund to cover costs of building infrastructure.

The City should plan to incrementally grow its program. This series of progression will allow Naperville to take measured steps to deploying broadband throughout the community, enabling the City to incrementally expand its network as partnership opportunities and community needs present themselves.

8.3.4 RFP & Outsource

The City of Naperville should identify how it will utilize the fiber-optic network to bring next-generation broadband services to the greater community. The City will also have to select the most appropriate business model that aligns with the vision of the community and its leadership, and one that fits organizationally into the City's municipal operation. While many communities strive to be a fully functioning provider of retail services, it comes with significant challenges. The most common approach is for the City to contract many of its municipal operations to third parties and this model should be considered when selecting a business model for broadband as it is likely this endeavor would follow suit. The City would be best served in contracting with a third party to deliver broadband services to anchor institutions, the downtown and to commercial zones. Naperville should construct, own, and maintain the physical broadband infrastructure, while the contractor markets and delivers retail service offerings. This arrangement would provide the greatest positive impact to the community and addresses the limited resources currently available at the City.

In conclusion Magellan Advisors expresses its gratitude for the great work and assistance provided by each member of the Dark Fiber Committee during this project. The City's fiber optic network is a critical element for how Naperville will maintain its position as one of the top places in the country to live, work, play and learn. The network is a foundational tool that to drive competitiveness in Illinois and beyond, and act as a platform to enable economic development, smart city technologies and empower local government innovation. The City of Naperville will benefit greatly in coming years from the Committee's work and foresight.

APPENDIX A. ORDINANCE EXAMPLES

City of Vallejo

- Purpose is non-discriminatory treatment of Telecommunications Facilities and Wireless Communications Facilities, to ensure that installations and modifications in Public ROW are completed consistent with all applicable laws, are safe, and avoid or mitigate visual, environmental and neighborhood impacts.
- The ordinance is very clearly oriented to concerns regarding aesthetics and City character.
- Key definitions
    - Accessory Equipment
    - Administrative Approval
    - Concealment Elements
    - Existing Height
    - Modifications
    - Small Cell Site
    - Substantial Change
- Application requirements include executed lease agreement for use of City property or placements on City assets
- New installations are subject to review by Community and Economic Development Director
- Like-for-like replacement at existing locations is considered Routine Maintenance. Changes to existing site are considered modifications, subject to discretionary review.

City of Santa Monica

- Purpose is to ensure reliable access to state of the art wireless services, and that installations modifications and maintenance in PROW are completed per applicable laws, safely, and mitigating visual, environmental and neighborhood impacts.
- Up-to-date definitions
- Rental amounts shall be not less than FMV and may take account of rents charged in other jurisdictions.
- Replacement projects use administrative review, other changes require discretionary approval.
- Prerequisites for discretionary approval are stated:
    - Proposed facility complies with all applicable laws
    - Proposed facility will not interfere with use of ROW
    - Proposed facility impacts will be mitigated via camouflage and concealment
    - Proposed facility complies with federal EMF standards

- Ten-year permit period with stated renewal requirements and procedures
- Inspection and report requirements, required maintenance.
- Design standards for all sites in PROW.
    - Any expert assistance required by the City shall be reimbursed by Applicant
    - Required compliance with noise ordinance, CPUC regs, etc.
    - No exposed slack or extra cable
    - No decorative/historic lights are available
    - No electric meters allowed, must be negotiated flat rate
- Specific and detailed Macrocell site requirements, by type of support structure
- Specific and detailed small cell site requirements, by type of support structure
- DAS applications—single application, single master license agreement
- Cell-on-wheels
- Placement requirements for city owned property.
- PROW findings of proliferation of competing uses, including water, sewer, storm drains, gas, electric, telephone, telecommunications, and cable crisscross PROW. Management of PROW is therefore necessary to preserve public health and welfare, with multiple stated purposes.
- Existing facilities to be brought into compliance at first reconstruction/modification/replacement.
- "Dig once" coordination, no excavation on streets that have been resurfaced or repaved in prior 3 years
- Each utility must submit annual network diagrams, not a public record
- Stated requirements for excavation, backfill, construction, etc.

City of Concord (in Process)

- Purpose is to establish "reasonable regulations" for wireless facilities that "protects and promotes public health, safety and welfare, and balances the benefits that flow from robust wireless services with the unique character, aesthetics and local values of the City"
- Applicability is to applications for new wireless facilities/collocations/modifications
- Required permits are categorized
- Application requirements are stated, including required licenses, site development plans, photo simulations, RF exposure compliance report, statement of purpose, alternative sites analysis, noise study and deposit
- Design and aesthetic standards are stated, including for building mounted and free standing wireless facilities, as well as facilities in public rights-of-way
- Costs of specialized, expert review of applications are to be paid by the applicant

City of Fountain Valley (in Process)

- Purpose is to "ensure that the installation of wireless communication facilities will not be detrimental to the city's public health, safety or welfare" and to establish standards and timelines that are consistent with federal and other requirements
- Key definitions:
    - Distributed Antenna System
    - Eligible facilities request/support structure/" existing"/" substantial change" all keyed to FCC definitions
    - Small cell
    - "Vertical infrastructure" is used for City poles etc., instead of "utility poles"
- States procedures, and burden of proof on applicant to show discrimination in denial, or creation of significant gap in service
- General provisions for ten-year review in light of "recent technology", zoning and code compliance, visual impact, facilities not in PROW shall be non-exclusive to encourage collocation/sharing, and "stealthing"
- Special provisions for ground mounted facilities include minimum proximity limits to other existing structures, and alternative site analysis
- Review and approval provisions including administrative permitting, conditional use permitting, master deployment plan permits, timeframes for review and shot clock, and required findings and required submissions for approval
- Policy and standards for wireless facilities in PROW, including small cell

California Cities – Wireless Implementations[56]

Richmond, California

Population (2014 Estimate): 108,565 *Area: 52.48 sq mi*

Population Density: 2,000/sq mi

The city joined a Community Partnership, "roof2roof", to support antenna-based internet access to the community. The venture is supported by Internet Archive, a non-profit entity with the main objective to address the digital divide. Internet Archive installed a 70-foot antenna on its building, which provides internet access to anyone with line-of-sight and who purchases a directional antenna. In addition, there are two repeating locations as well as booster antennas. City-owned fiber provides the backhaul. In addition, the city provides access to other infrastructure as well as city staff. Other non-profit partners support the project with custom software and provide refurbished computers to low-income families. Access is relatively high-speed (16 Mbps).

San Francisco, California

Population (2016 Estimate): 870,887 *Area: 46.87 sq mi*

Population Density: 18,581/sq mi

San Francisco's #SFWi-Fi was developed in stages, beginning with an abandoned EarthLink deployment. The focus then turned to deployments for low income communities, which created a strong but bare bones network. The city is working to upgrade the network through its current public Wi-Fi initiative that expands service along Market Street, in public parks, and in other areas throughout the city and county. The network uses city-owned fiber, traffic cabinets, and traffic poles to mount wireless access points. The city received significant contributions from Google, Cisco, and donated connections to the internet. Speeds average 10 Mbps down and 5 Mbps up. The network is managed by the city and county's

[56] Insert source document.

Department of Technology. A total of $1.4 million was invested to serve public areas, and operating expenses are approximately $120,000 funded from the city budget.

San Jose, California

Population (2014): 1,026,908 *Area: 179.97 sq mi*

Population Density: 5,700/sq mi

The City of San Jose deployed Wickedly Fast Wi-Fi in the downtown area as a free service. The network has been expanded on a targeted basis to the airport and convention center, as well as the new MLS stadium. The city manages and operates the network and has two partners cooperating for the deployment and operational support. A total amount of $94,000 was spent for deployment, and operating expenses are minimal. The city benefits from faster connections and improved parking due to faster transactions. Much of the network usage is from streaming online content. The network is intended to be supplemental or niche in nature, as there are numerous providers in the area including good coverage from wireless providers.

Santa Clara, California

Population (2014): 116,468 *Area: 18.407 sq mi*

Population Density: 6,300/sq. mi

The network originated in a desire of the city's municipal electric utility to support Advanced Metering Infrastructure (AMI). Santa Clara Free Wi-Fi is a joint venture between the city and the city-owned utility. While the AMI implementation totaled $11 million, the Wi-Fi implementation cost $2 million, which included $800,000 in fiber-optic extension with operating costs of approximately $200,000. The utility's fiber network provides the backhaul for approximately 600 access points placed on city light poles and facilities. The network is divided between utility/city use, and public use. Customer speeds are capped at 3 Mbps.

Santa Monica, California

Population (2010): 89,736 *Area: 8.415 sq mi*

Population Density: 11,000/sq. mi

The City Wi-Fi network was preceded by the implementation of the city-owned fiber network for business connections. Earnings from the fiber network provided funding for implementation of the wireless network. The fiber network is also used for backhauling data. The network currently consists of over 550 access points and is deployed to cover transit and commercial corridors as well as other popular areas including the beach, boardwalk, business improvement districts and parks. Most access points are linked directly to the fiber network which provides higher quality of service, and speeds of up to 8 Mbps symmetrical. The city's initial goals have been achieved in that there have been benefits for business districts, public safety, and city needs and functions. The network supports development and deployment of mobile apps which provide information relevant to citizens and visitors such as real-time parking availability, and a sense of place with a different internet launch page depending on where the person is on the network. Capital cost for network implementation was approximately $500,000, and annual operating costs are approximately $100,000.

Additional Cities – Wireless Implementations

Boston, Massachusetts

Population (2016 Estimate): 673,184 *Area: 89.63 sq. mi*

Population Density: 14,024/sq. mi

The "Wicked Free Wi-Fi" network implementation followed several years of discussion and planning to address the digital divide. Partial funding for the network came from a grant from the Department of Housing and Urban Development (HUD) in 2011, for redevelopment. The project began in 2014 with installation of 70 access points in a low-income neighborhood. The network relies upon the city's existing fiber network ("BoNet") for backhaul. Public Wi-Fi has also been installed in many of Boston's downtown locations and business districts for economic development purposes. The city carefully plans access point locations to be able to rely upon the city's fiber network in an economical fashion. The Wicked Free Wi-Fi network can be expanded as the city's fiber network expands to obtain economical backhaul capability. Beyond that, the network also uses and leverages other existing city infrastructure to the extent possible.

The network cost approximately $6 million to install, $300,000 of which was provided by the HUD grant. Annual operating costs are approximately $100,000. Near term plans include expansion to approximately 300 access points in total. It is an outdoor network, with bandwidth limitations, supporting speeds up to 1 Mbps. The network is managed and operated by the City's Department of Innovation and Technology, who contracts out some functions to private companies. The Wi-Fi service has been presented as an "as-is" service, in part to avoid creating user demands on administrative capacity.

Corpus Christi, Texas

Population (2016 Estimate): 305,215 *Area: 503.6 sq. mi*

Population Density: 610/sq. mi

The origin of the city-funded project was to enable Automated Meter Reading (AMR), in 2002, for the city's gas and water meters. The network spans the city through 1,700 access points, supporting speeds of up to 54 Mbps, although typical usage is 3 Mbps symmetrical. Costs at the time were $7.1 million, and specification and deployment of the system was supported with outside resources. City infrastructure (e.g., traffic signal poles) and 200-mile city fiber network is used to support the outdoor network. Annual maintenance costs are approximately $500,000, under management of the City's CIO. The network was purchased by EarthLink in 2007 for subscription-based use but abandoned by EarthLink and reclaimed by the city the following year.

The system has provided the expected efficiencies of AMR, including safety, convenience, precision, cost economies, and the ability to monitor and manage resource usage. Following implementation of AMR, it became clear that bandwidth was also available for public Wi-Fi use, which was enabled in 2005. Beyond use by the public, this has fostered efficiencies and collaborations among government departments and city workers.

Minneapolis, Minnesota

Population (2016 Estimate): 382,578 *Area: 58.4 sq. mi*

Population Density: 7,485/sq. mi

The city met with key stakeholders in the early days of wireless to explore options for the city. It was concluded that the best approach was through a Public-Private Partnership, using an RFP process for selection. The network was fully complete by 2009. Requirements and objectives included that the entire city must be covered, pricing must be reasonable to assist in addressing the digital divide, and city uses must be supported, such as enabling remote data collection by field staff, and more. In addition, the operator provides ongoing funding for efforts to increase digital literacy. Support for public safety applications is also viewed as crucial. The operator pays the city a fee for use of city assets including light poles and traffic signal standards. The city pays $1.25 million per year for use of the network as anchor tenant.

Network speeds range from 1 – 6 Mbps, and higher speeds (25 – 40 Mbps) are being tested in pilot projects, which would also require higher subscription prices. There are approximately 120 free public Wi-Fi areas in parks and business districts. 3,000 wireless devices support the network across the City of Minneapolis. Network costs are estimated at $20 million.

Oklahoma City, Oklahoma

Population (2015 Estimate): 638,367 *Area: 620.34 sq. mi*

Population Density: 930/sq. mi

The city-wide network was developed for public safety purposes, funded by a new sales tax. The network was expanded to support connectivity to city facilities, and for city field staff. Oklahoma City encompasses a very large geographic area. The initial cost of the network was $5.2 million, and annual operating costs are $245,000 from the city's budget, as managed by the city's IT Department.

Some consideration has been given to enabling public access, but so far that has not happened. The network supports average speeds of 4 Mbps and consists of approximately 1,500 nodes. The network has improved city services and enhanced efficiencies. The network incorporates extensive security, given the public safety use of the network.

Ponca City, Oklahoma

Population (2010): 25,389 *Area: 19.3 sq. mi*

Population Density: 1,382/sq. mi

Originally installed and tested for field communications among city personnel, the network was later opened for public access. The network uses city-owned fiber. City funds provided the initial $3.2 million to build the network, and subscription revenues for business fiber connections and residential modems support annual operating costs. The network currently consists of approximately 500 nodes. User speeds are 3 – 12 Mbps, with potential for up to 25 Mbps.

The network is viewed as successful since it provides efficiencies for city operations and services and provides economical access to the public thereby

expanding internet utilization. The network also supports educational technology. Public use has exceeded expectations from the beginning.

Port Angeles, Washington

Population (2015): 19,448 *Area: 14.52 sq. mi*

Population Density: 1,779/sq. mi

The primary purposes of the network are to support public safety, including security cameras, and to provide public access in a city with a high percentage of the population below the poverty line. Original capital investment was $3.7 million, current operating expenses are approximately $90,000, and the network now is managed and operated by an ISP with a revenue share to the city. Speeds range up to 6 Mbps down and 1.2 Mbps up. While the public subscription is lower than anticipated, the network provides the anticipated public safety benefits for the city.

Comparative Wireless Strategies Summary

Each network was implemented for specific original purposes, supported by a specific business model. The table below provides a comparison of the purpose, business model, funding mechanisms, and resultant network speeds of the cities' wireless implementations.

Table 1. Comparison of City Wireless Implementation Strategies

City	Purpose		Business Model			Funding			Speed	
	Address Digital Divide & Public	Support City Functions	Public**	Public-Private	Public Partnership	City Budget	Grant or Partnership	Subscriber Fees	Relatively Low	Higher
Boston, MA	●					●	●$$		●+	
Corpus Christi, TX		●*	●			●				●
Minneapolis, MN		●*		●				●		●
Oklahoma City, OK		●*	●			●		●$$		●
Ponca City, OK	●	●*	●			●				●
Port Angeles, WA	●	●*		●			●$$	●		●
Richmond, CA	●				●		●$$			●+
San Francisco, CA	●			●		●				●
San Jose, CA	●			●		●				●
Santa Clara, CA	●		●			●				●
Santa Monica, CA	●		●			●				●

**Network Purposes: Corpus Christi, Texas (AMR); Minneapolis, Minnesota (Anchor Tenant, City field staff); Oklahoma City, Oklahoma (Public Safety); Ponca City, Oklahoma (City Departments); Port Angeles, Washington (Public Safety)*

***Run by city department.*

$$Boston, Massachusetts – HUD; Oklahoma City, OK – fiber capacity for business, in-home residential modems; Port Angeles, Washington – ARRA; Richmond, CA – Partner

[+]*Boston, Massachusetts – 1Mbps; Richmond, CA – 16Mbps*

Regardless of the scale and scope of the wireless broadband network deployment chosen by the City of Naperville, there are successful best practice implementations to guide the City for its own successful network deployment. As the City moves forward with its wireless deployment strategy it is important to:

- Examine successful implementations and draw applicable lessons;
- Consider unique needs and challenges of the community and address them in planning;
- Strive for clarity of purpose among stakeholders regarding the purpose and goals for the network;
- Assess the marketplace for current providers and services;
- Use existing City infrastructure wherever possible in network design and planning;
- Start small before rolling out a network covering broader geography;
- Build opportunistically;
- Identify backhaul options and ensure adequate capacity;
- Plan to leverage the network for additional uses once initial deployment objectives have been satisfied;
- Maintain a long-term view of investing in and operating the network;
- Ensure clear financial expectations and sound financial projections; and,
- Promote open collaboration with partners and maintain the relationships.

APPENDIX C: SMART STREET LIGHT OPTIONS

The smart pole industry continues to grow and evolve, with innovations not slowing anytime soon. It will be important for cities and municipalities to choose a light pole partner that is prepared for the evolution of the market, with products that are easily scalable for future needs. A selection of products currently on the market are summarized below.

Phillips

Phillips, a multi-national, conglomerate organization, is the largest, most well-known organization implementing smart street lighting across the globe. Phillips touts the only "wrap and go" solution for smart street lighting delivering all equipment and technology bound within the confines of the shaft of the pole.

At the time of this report, Phillips offers the only completely self-contained solution, with the equipment and technology being housed within the pole. Other structures typically utilize a "can" antennae on the top of their pole structures. Phillips offers one variation of their light pole, with alterations possible on the external, bottom base of the pole. Fluting of the light poles are also possible as a customization option. The solution would be through a public-private-partnership, where the municipality would receive the poles for free and Phillips would receive a share of revenue generated from the potential leasing of access by wireless carriers.

Figure 1: Phillips Sample Pole

For more information please visit:

http://www.lighting.philips.com/main/systems/connected-lighting/connected-lighting-forsmart-cities.html

Valmont

Magellan Advisors was referred to Valmont Structures by Silver Spring and Ameresco, manufacturers of remote monitoring equipment and LED lighting organizations. Valmont has had great success in the street light pole market, although they have recently entered the DAS/small cell market within the past two years. All equipment, technology, and radios would need to be purchased from other organizations, such as Silver Spring, Ameresco and/or GE Current.

Valmont is able to produce a highly customizable street light pole and the sales team stated that the municipality would coordinate with their engineers regarding whether the radio equipment would be enclosed within the light pole, engineered with a vault in the ground, box at the base, or separate pole external to the street light pole. The sales team stated that the engineers could be consulted with regarding development of a light pole that would enclose the equipment and be larger in size to enable the pole to withstand hurricane force winds.

Figure 2: Valmont Sample Pole

For more information please visit:

http://www.valmontstructures.com/valmont-structures/lighting/small-cell-and-das-structures

Silver Spring Networks

Silver Springs is an international organization providing smart city technologies to cities and municipalities throughout the world, with customers such as Miami, Copenhagen, Paris, and Glasgow. While each city has different needs, Silver Spring works with municipalities to implement platforms that suit the clients' needs. The company presents an "app" store on the website providing applications from smart grid management, lighting maintenance, and environmental sensor technology. Silver Spring Networks provides the technology, not the pole. Therefore, the municipality would need to seek out a pole manufacturer such as Valmont or HAPCO to engineer the light poles.

For more information please visit: www.silverspringnet.com

Ameresco

Ameresco is leading the green energy movement by providing energy saving LED lighting along with solar powered lighting to cities, municipalities, and organizations internationally. Some of the Ameresco local government clients include: Lowell, MA; San Antonio, TX; Englewood, CA; and Emmock, AK. Organizations can save 50-60% on energy consumption and expenses through implementation of LED lighting and even more when solar technologies are used. Ameresco could be considered a partner for LED and solar lighting in the event that the municipality would decide to purchase technology, poles, and luminaires separately. Upon Magellan making contact with the Ameresco sales team, the manager referred Magellan to Valmont for pole structures capable of supporting DAS/small cell technology.

For more information please visit: www.ameresco.com

GE Current

GE Current provides smart city technology applied to smart light poles. Typically, the organization partners with Valmont or HAPCO for the physical light pole. The trademarked technologies GE Current utilizes include:

- Evolve LEDs – delivering 50 - 65% energy savings for municipalities.
- LightGrid – providing remotely controlled lighting, by letting city staff control metering, maintenance, and light output.
- Evolve IQ LEDs – built-in data-collecting sensors that can access real-time reactive and predictive information.

Typically, the intelligent nodes are attached to the door in the case of standard roadway LED cobra head type fixtures. Depending on the fixture style, GE Current could explore options of inserting the intelligence into the fixture slip fitter, base of the fixture that mounts to the pole, or via an external node which would be external to both the pole or fixture. At this time, GE Current does not offer DAS or 5G compatibility, but the organization is researching these capabilities.

For more information please visit: http://www.currentbyge.com/cities

Metro Smart

Metro-Smart International is an organization located in Dubai, United Arab Emirates. They participate in conferences such as the Middle East Smart Lighting and Energy Summits, forging the way for energy saving street lighting as well as smart city initiatives. Metro-Smart partners with Sapa Pole Products, located in the Netherlands for environmentally sustainable poles

constructed from aluminum. Metro-Smart is truly international, with projects in Australia, the United States, the Middle East, China, Singapore, and Europe.

Through email communications with the company's group chairman, Magellan has learned that Metro-Smart can provide the following capabilities– LED dimming, control, and maintenance; security cameras; Wi-Fi deployment with the potential for 5G; sensor technologies; and solar capabilities. However, the chairman would need more information from the client to provide significantly more information. Their engineers created generic renderings for review, although through further discussion with the client, other models could be developed.

Magellan has included the renderings and an image of another lighting project for additional depictions.

Figure 3: Metro-Smart Engineered Rendering Figure 4: Metro-Smart Sample Pole

For more information, and a gallery of photos, please visit: www.metro-smart.com

Lumca

Lumca is a light pole manufacturer based in Quebec, Canada. Within the past two years they have made significant advances in developing smart street lighting poles for cities and organizations across the world. Lumca incorporates the various technologies within a "can" antennae attached to the top of the pole. 95% of the light poles sold by Lumca are LED based. Although LED lighting typically comes in a white hue, the company could offer hue options to suit the city or town needs. For instance, the LED utilized could be in the amber hue or the LED could possibly be half amber and half white to enable the municipality in selecting which hue to use during various seasons. Also important to the municipality would be the suitability of the pole for nautical conditions. Lumca is conscious of nautical environments and has placed poles in Vancouver and other seaside areas in Canada. They use a plethora coat, which is a high-quality, non-toxic coating which endures a 5,000-hour salt spray test and is treated with a special primer to enable the pole to withstand extreme weather conditions, including hurricanes.

The company is focused on manufacturing and producing the highest quality pole possible and does not produce the technology housed inside the remote node. Partnerships have been

formed through which the company works to incorporate the monitoring and Wi-Fi mesh technologies, sensors, security cameras, and hotspots. Lumca desires to get the full operating parameters of what their clients' functionality requires, however, some of the partners they have worked with in the past include: DASBOX for environmental sensors, Imposa for variable messaging board, Digital Watchdog for digital cameras, Wicastr for Wi-Fi, Leviton for electronic vehicle charging stations, and ROAM for lighting control systems. The design of the structural pole in part will determine how and where the various technologies and nodes will be placed. The Lumca engineers would work with the client to assist in developing the product in a manner that would suit the client's needs, along with establishing the appropriate functionality requirements.

Lumca offers multiple designs for their smart poles, providing options for the municipality. Part of the design of the smart poles includes four bands on the outside of the shaft of the pole. This eliminates the need for banding items onto the pole (i.e. signage, wreaths) that could potentially damage the pole. These bands also allow for the pole to be upgraded in the future. The organization realizes that this is a quickly changing market and they are attempting to create a product that is scalable into the future. The manufacturer also offers various add-ons to their poles such as: USB charging stations, electric vehicle charging stations, banners, and more are expected to come to the market.

Figure 5: Lumca Sample Poles

For more information please visit: http://www.lumca.com/en/series/smart-cities

Lumizone

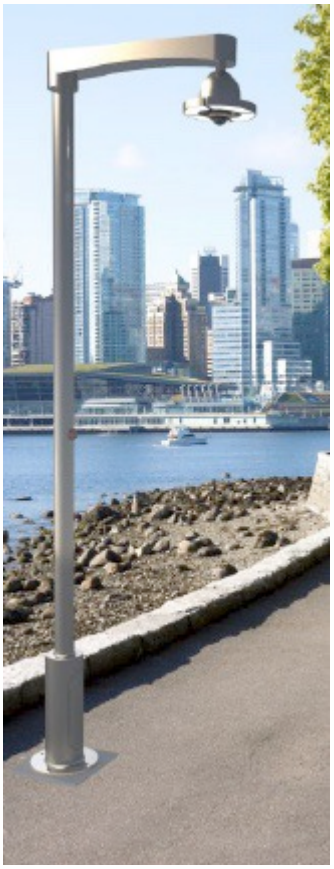
Lumizone is a smart street pole manufacturer that integrates technologies from premier manufacturers from all over the world. The CEO of Lumizone founded Valmont and successfully ran one of the largest street pole manufacturers for approximately 20 years prior to retirement. She came out of retirement to open Lumizone and work with talented engineers and designers to become an innovator in the smart city movement. While the street poles are their main focus of their business, Lumizone encompasses the technology side of the organization.

The Lumizone product is made from steel or aluminum poles and their engineers believe there is no limit as to what they can design. The engineers can work hand in hand with the client to deliver a pole that suits their aesthetic and functionality requirements. The poles are integrated with various modules that can be customized, changed, and added to over time. Members of the organization state that their organization partners with other companies for technology, in order to integrate the best features on the market onto their product – high-definition cameras, thermal cameras and face recognition; LED luminaries with photo cells and dimming capabilities; 2 way communication; card readers; Wi-Fi; motion sensors; public announcements; LCD touchscreen; radio-frequency identification (RFI) for entrance into a neighborhood; and electric vehicle charging stations. Solar panels are also available on the poles in different forms. Some clients need the poles to be completely off the grid, or solar can be added to simply further decrease energy costs. The poles are extremely scalable and flexible, according to the members of their team. Adding to and updating the modules is seamless, as technology changes and evolves. The city or municipality could potentially contact Lumizone and have the poles updated with new technology or add more modules to their systems. Clients can choose varying numbers of modules, or they can start with a certain number and add to their poles over time. Lumizone engineers would work with the client to determine the maximum number of modules available per pole based on the voltage of each module.

Some clients might require a pole made of aluminum or steel to stand up to extreme climate and the possibility of hurricane force winds. The engineers would work with the client to ensure that the correct metal is used to ensure that the pole would not rust or fail during a storm. The company has installed poles in areas of Canada that require strong structures to withstand extreme weather conditions and winds up to 200 mph. The client would have a choice of polished or brushed aluminum.

Lumizone has worked with communities in Florida and understand the climate and region. In one such project, they placed their product in a gated community with card readers for entry

and Wi-Fi enabled life-saving buttons for the older population. These buttons were placed on key rings or necklaces and were enabled through the 100% wireless coverage of the community. If pushed, the notification would immediately go to a response team with the location of the device. These devices are assisting the older population in aging in place through use of a functional Wi-Fi network.



The Lumizone product would be tailored to the specific needs of the client. The company also has branch offices moving to Nevada and Minnesota which would save the municipality in freight costs, as the main office is located in British Columbia, Canada.

For more information please visit:
http://www.lumizoneglobal.com/smart-poles

Glossary of Terms

3G – Third Generation	The third generation of mobile broadband technology, used by smart phones, tablets, and other mobile devices to access the web.
4G – Fourth Generation	The fourth generation of mobile broadband technology, used by smart phones, tablets, and other mobile devices to access the web.
ADSL – Asymmetric Digital Subscriber Line	DSL service with a larger portion of the capacity devoted to downstream communications, less to upstream. Typically thought of as a residential service.
ADSS – All-Dialetric Self-Supporting	A type of optical fiber cable that contains no conductive metal elements.
AMR/AMI – Automatic Meter Reading/Advanced Metering Infrastructure	Electrical meters that measure more than simple consumption and an associated communication network to report the measurements.
ATM – Asynchronous Transfer Mode	A data service offering that can be used for interconnection of customer's LAN. ATM provides service from 1 Mbps to 145 Mbps utilizing Cell Relay Packets.
Bandwidth	The amount of data transmitted in a given amount of time; usually measured in bits per second, kilobits per second (kbps), and megabits per second (Mbps).
Bit	A single unit of data, either a one or a zero. In the world of broadband, bits are used to refer to the amount of transmitted data. A kilobit (Kb) is approximately 1,000 bits. A megabit (Mb) is approximately 1,000,000 bits. There are 8 bits in a byte (which is the unit used to measure hard disk storage space), therefore a 1 Mbps connection takes about 8 seconds to transfer 1 megabyte of data (about the size of a typical digital camera photo).
BPL – Broadband over Powerline	A theoretical technology that would provide broadband service over existing electrical power lines.
BPON – Broadband Passive Optical Network	BPON is a point-to-multipoint fiber-lean architecture network system, which uses passive splitters to deliver signals to multiple users. Instead of running a separate strand of fiber from the CO to every customer, BPON uses a single strand of fiber to serve up to 32 subscribers.
Broadband	A descriptive term for evolving digital technologies that provide consumers with integrated access to voice, high-speed data service, video-demand services, and interactive delivery services (e.g. DSL, Cable Internet).
CAD – Computer Aided Design	The use of computer systems to assist in the creation, modification, analysis, or optimization of a design.

CAI – Community Anchor Institute	Community anchor institutions (CAIs, sometimes called anchor institutions) are non-profit organizations that often provide essential services to the public. Universities, colleges, community colleges, K12 schools, libraries, health care facilities, social service providers, government and municipal offices are all community anchor institutions.
CAP – Competitive Access Provider	(or "Bypass Carrier") A Company that provides network links between the customer and the Inter-Exchange Carrier or even directly to the Internet Service Provider. CAPs operate private networks independent of Local Exchange Carriers.
Cellular	A mobile communications system that uses a combination of radio transmission and conventional telephone switching to permit telephone communications to and from mobile users within a specified area.
CLEC – Competitive Local Exchange Carrier	Wireline service provider that is authorized under state and Federal rules to compete with ILECs to provide local telephone service. CLECs provide telephone services in one of three ways or a combination thereof: a) by building or rebuilding telecommunications facilities of their own, b) by leasing capacity from another local telephone company (typically an ILEC) and reselling it, and c) by leasing discrete parts of the ILEC network referred to as UNEs.
CO – Central Office	A circuit switch where the phone lines in a geographical area come together, usually housed in a small building.
Coaxial Cable	A type of cable that can carry large amounts of bandwidth over long distances. Cable TV and cable modem service both utilize this technology.
CPE – Customer Premise Equipment	Any terminal and associated equipment located at a subscriber's premises and connected with a carrier's telecommunication channel at the demarcation point ("demarc").
CWDM – Coarse Wavelength Division Multiplexing	Is generally held to be WDM with less than 8 active wavelengths per fiber.
Demarcation Point (demarc)	The point at which the public switched telephone network ends and connects with the customer's on-premises wiring.
Dial-Up	A technology that provides customers with access to the Internet over an existing telephone line.
DLEC – Data Local Exchange Carrier	DLECs deliver high-speed access to the Internet, not voice. DLECs include Covad, Northpoint and Rhythms.
Downstream	Data flowing from the Internet to a computer (Surfing the net, getting E-mail, downloading a file).
DSL – Digital Subscriber Line	The use of a copper telephone line to deliver "always on" broadband Internet service.
DSLAM – Digital Subscriber Line Access Multiplier	A piece of technology installed at a telephone company's CO and connects the carrier to the subscriber loop (and ultimately the customer's PC).

DWDM – Dense Wavelength Division Multiplexing	A term which is the means of increasing the capacity of SONET fiber-optic transmission systems.
E-Rate	A Federal program that provides subsidy for voice and data lines to qualified schools, hospitals, CBOs, and other qualified institutions. The subsidy is based on a percentage designated by the FCC. CTF benefits are calculated net of the E-rate subsidy.
EON – Ethernet Optical Network	The use of Ethernet LAN packets running over a fiber network.
EvDO – Evolution Data Only	EvDO is a new wireless technology that provides data connections that are 10 times as fast as a regular modem.
FCC – Federal Communications Commission	A Federal regulatory agency that is responsible, among other things, for regulating VoIP.
FDH – Fiber Distribution Hub	A connection and distribution point for optical fiber cables.
FTTN – Fiber to the Neighborhood	A hybrid network architecture involving optical fiber from the carrier network, terminating in a neighborhood cabinet with converts the signal from optical to electrical.
FTTP – Fiber to the premise (or FTTP – Fiber to the building)	A fiber optic system that connects directly from the carrier network to the user premises.
GIS – Geographic Information Systems	A system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.
GPON- Gigabit-Capable Passive Optical Network	GPON uses a different, faster approach (up to 2.5 Gbit/s in current products) than BPON.
GPS – Global Positioning System	A system using satellite technology that allows an equipped user to know exactly where he is anywhere on earth.
GSM – Global System for Mobile Communications	This is the current radio/telephone standard in Europe and many other countries except Japan and the United States.
HD – High Definition (Video)	Video of higher resolution than is standard.
HFC – Hybrid Fiber Coaxial	An outside plant distribution-cabling concept employing both fiber optic and coaxial cable.
IEEE – Institute of Electrical Engineers	A professional association headquartered in New York City that is dedicated to advancing technological innovation and excellence.
ILEC – Incumbent Local Exchange Carrier	The traditional wireline telephone service providers within defined geographic areas. Prior to 1996, ILECs operated as monopolies having the exclusive right and responsibility for providing local and local toll telephone service within LATAs.
IP-VPN – Internet Protocol-Virtual Private Network	A software-defined network offering the appearance, functionality and usefulness of a dedicated private network.
ISDN – Integrated Services Digital Network	An alternative method to simultaneously carry voice, data and other traffic, using the switched telephone network.
ISP – Internet Service Provider	A company providing Internet access to consumers and businesses, acting as a bridge between customer (end-user) and infrastructure owners for dial-up, cable modem and DSL services.

ITS – Intelligent Traffic System	Advanced applications which, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.
Kbps – Kilobits per second	1,000 bits per second. A measure of how fast data can be transmitted.
LAN – Local Area Network	A geographically localized network consisting of both hardware and software. The network can link workstations within a building or multiple computers with a single wireless Internet connection.
LATA – Local Access and Transport Areas	A geographic area within a divested Regional Bell Operating Company is permitted to offer exchange telecommunications and exchange access service. Calls between LATAs are often thought of as long-distance service. Calls within a LATA (IntraLATA) typically include local and local toll services.
Local Loop	A generic term for the connection between the customer's premises (home, office, etc.) and the provider's serving central office. Historically, this has been a wire connection; however, wireless options are increasingly available for local loop capacity.
MAN – Metropolitan Area Network	A high-speed intra-city network that links multiple locations with a campus, city or LATA. A MAN typically extends as far as 30 miles.
Mbps – Megabits per second	1,000,000 bits per second. A measure of how fast data can be transmitted.
MPLS – Multiprotocol Label Switching	A mechanism in high-performance telecommunications networks that directs data from one network node to the next based on short path labels rather than long network addresses, avoiding complex lookups in a routing table.
ONT – Optical Network Terminal	Used to terminate the fiber optic line, demultiplex the signal into its component parts (voice telephone, television, and Internet), and provide power to customer telephones.
Overbuilding	Building excess capacity. In this context, it involves investment in additional infrastructure projects to provide competition.
OVS – Open Video Systems	OVS is a new option for those looking to offer cable television service outside the current framework of traditional regulation. It would allow more flexibility in providing service by reducing the build out requirements of new carriers.
PON – Passive Optical Network	A Passive Optical Network consists of an optical line terminator located at the Central Office and a set of associated optical network terminals located at the customer's premise. Between them lies the optical distribution network comprised of fibers and passive splitters or couplers. In a PON network, a single piece of fiber can be run from the

	serving exchange out to a subdivision or office park, and then individual fiber strands to each building or serving equipment can be split from the main fiber using passive splitters / couplers. This allows for an expensive piece of fiber cable from the exchange to the customer to be shared amongst many customers, thereby dramatically lowering the overall costs of deployment for fiber to the business (FTTB) or fiber to the home (FTTH) applications.
QOS – Quality of Service	Refers to several related aspects of telephony and computer networks that allow the transport of traffic with special requirements. In particular, much technology has been developed to allow computer networks to become as useful as telephone networks for audio conversations, as well as supporting new applications with even stricter service demands.
RF – Radio Frequency	A rate of oscillation in the range of about 3 kHz to 300 GHz, which corresponds to the frequency of radio waves, and the alternating currents which carry radio signals.
Right-of-Way	A legal right of passage over land owned by another. Carriers and service providers must obtain right-of-way to dig trenches or plant poles for cable systems, and to place wireless antennae.
RMS – Resource Management System	A system used to track telecommunications assets.
RPR – Resilient Packet Ring	RPR uses Ethernet switching and a dual counter-rotating ring topology to provide SONET-like network resiliency and optimized bandwidth usage, while delivering multi-point Ethernet/IP services.
RUS – Rural Utility Service	A division of the United States Department of Agriculture, it promotes universal service in unserved and underserved areas of the country with grants, loans, and financing.
SCADA – Supervisory Control and Data Acquisition	A type of industrial control system (ICS). Industrial control systems are computer-controlled systems that monitor and control industrial processes that exist in the physical world.
SNMP – Simple Network Management Protocol	An Internet-standard protocol for managing devices on IP networks.
SONET – Synchronous Optical Network	A family of fiber-optic transmission rates.
Steaming	A Netscape innovation that downloads low bit text data first, then the higher bit graphics. This allows users to read the text of an Internet document first, rather than wait for the entire file to load.
Subscribership	Subscribership is how many customers have subscribed for a particular telecommunications service.

Switched Network	A domestic telecommunications network usually accessed by telephone, key telephone systems, private branch exchange trunks, and data arrangements.
T-1 – Trunk Level 1	A digital transmission link with a total signaling speed of 1.544 Mbps. It is a standard for digital transmission in North America.
T-3 – Trunk Level 3	28 T1 lines or 44.736 Mbps.
UNE – Unbundled Network Elements	Leased portions of a carrier's (typically an ILEC's) network used by another carrier to provide service to customers.
Universal Service	The idea of providing every home in the United States with basic telephone service.
Upstream	Data flowing from your computer to the Internet (sending E-mail, uploading a file).
UPS – Uninterruptable Power Supply	An electrical apparatus that provides emergency power to a load when the input power source, typically mains power, fails.
USAC – Universal Service Administrative Company	An independent American nonprofit corporation designated as the administrator of the federal Universal Service Fund (USF) by the Federal Communications Commission.
VDSL – Very High Data Rate Digital Subscriber Line	A developing technology that employs an asymmetric form of ADSL, with projected speeds of up to 155 Mbps.
Video on Demand	A service that allows users to remotely choose a movie from a digital library and be able to pause, fast-forward, or even rewind their selection.
VLAN – Virtual Local Area Network	In computer networking, a single layer-2 network may be partitioned to create multiple distinct broadcast domains, which are mutually isolated so that packets can only pass between them via one or more routers; such a domain is referred to as a Virtual Local Area Network, Virtual LAN or VLAN.
VoIP – Voice over Internet Protocol	A new technology that employs a data network (such as a broadband connection) to transmit voice conversations.
VPN – Virtual Private Network	VPN is a network that is constructed by using public wires to connect nodes. For example, there are a number of systems that enable you to create networks using the Internet as the medium for transporting data. These systems use encryption and other security mechanisms to ensure that only authorized users can access the network and that the data cannot be intercepted.
WAN – Wide Area Network	A network that covers a broad area (i.e., any telecommunications network that links across metropolitan, regional, or national boundaries) using private or public network transports.
WiMax	WiMax is a wireless technology that provides high-throughput broadband connections over long distances. WiMax can be used for a number of applications, including "last mile"

	broadband connections, hotspot and cellular backhaul, and high-speed enterprise connectivity for businesses.
Wireless	Telephone service transmitted via cellular, PCS, satellite, or other technologies that do not require the telephone to be connected to a land-based line.
Wireless Internet	1) Internet applications and access using mobile devices such as cell phones and palm devices. 2) Broadband Internet service provided via wireless connection, such as satellite or tower transmitters.
Wireline	Service based on infrastructure on or near the ground, such as copper telephone wires or coaxial cable underground or on telephone poles.