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I. Introduction

Ensuring every Minnesotan has access to affordable, high-speed broadband remains a critical objective of the Governor's Task Force on Broadband. Broadband Internet is the infrastructure of the 21st Century economy, just as the national highway system was the infrastructure for latter half of the 20th Century. Broadband expands opportunity to those with access to it; those without access are left behind.

Minnesota's future economic vitality will depend on the degree to which Minnesota's residents, public institutions, and businesses are connected to high-speed Internet. During a 2013 Broadband Task Force visit to a library in Alexandria – an area of the state with sparse access to broadband – a librarian told a story of arriving to open the doors of the library, only to find a student and a test proctor sitting outside the library in a truck, using the library's wireless Internet connection to take an online test because broadband wasn't available elsewhere in the community. This story is still all too common across large areas of rural Minnesota.

As the Governor's Task Force on Broadband concludes its fourth year of work, the state has not yet achieved the border-to-border broadband speed goals that the state legislature established during the 2010 Legislative Session (Minn. Stat. §237.012):

> *Subd. 1.* ***Universal access and high-speed goal.***
> *It is a state goal that as soon as possible, but no later than 2015, all state residents and businesses have access to high-speed broadband that provides minimum download speeds of ten to 20 megabits per second and minimum upload speeds of five to ten megabits per second.*
>
> *Subd. 2.* ***State broadband leadership position.***
> *It is a goal of the state that by 2015 and thereafter, the state be in:*
> *(1) the top five states of the United States for broadband speed universally accessible to residents and businesses;*
> *(2) the top five states for broadband access; and*
> *(3) the top 15 when compared to countries globally for broadband penetration.*

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The 2010 Broadband Task Force wanted a goal that would be ambitious and reflect "a base-level standard of broadband service…predicated upon basic level of functionality available to every person in the state."[1] Minn. Stat. §237.012, Subd. 1 reflects that base-level standard. The Task Force also believed that aspirational goals were necessary to achieve a leading position both nationally and globally in broadband speed and penetration. This is reflected in Minn. Stat. §237.012, Subd. 2. These goals are referenced throughout this report. However, toward the end of the report, we discuss updating the state's speed goals to reflect changing technologies and broadband applications.

With a cost estimate of $900 million to $3.2 billion, expanding broadband Internet throughout the state remains a challenge. Over the last two years, the legislature and governor have made a financial commitment of more than $30 million to the state's Border-to-Border Broadband Development Grant Program, leveraging $41.3 million in private investment.

Despite this investment and the other policy changes enacted over the years, much work remains to be done. As of February 2015, 91.45 percent of Minnesota households have broadband access available at a speed of at least 10 Mbps download and 5 Mbps upload, while 80.16 percent of rural Minnesota

[1] http://archive.leg.state.mn.us/docs/2009/mandated/091056.pdf, page 51.

households have a broadband connection that meets these speeds (these figures include broadband service provided by wired, fixed wireless and wireless technologies as Minnesota Statutes did not specify a technology). The Task Force continues to work to close this gap.

As the Task Force looks ahead to 2016, much has changed over the last five years – from the creation of the Office of Broadband Development to funding the Border-to-Border Broadband Development Grant Program to policies supporting one-to-one devices in Minnesota's schools and the expansion of telemedicine throughout the state. The Task Force continues to monitor advances in broadband applications and delivery technology, and will update its recommendations accordingly.

As Minnesota competes with other states for today's top talent and businesses, we must ensure that Minnesota maintains and enhances its economic competitive edge – broadband is a critical of this.

This report highlights the work of the current Task Force throughout 2015.

II. Broadband – A primer

Broadband is a general term that refers to a high-speed, ubiquitous connection to the Internet. Access to broadband is supplied via a number of potential sources, including *fiber*, *digital subscriber line (DSL)*, *cable*, *wireless* and *fixed wireless* technologies. Appendix A provides a more complete list of technical terms used throughout this report. Appendix B provides a more complete description of the technologies noted here.

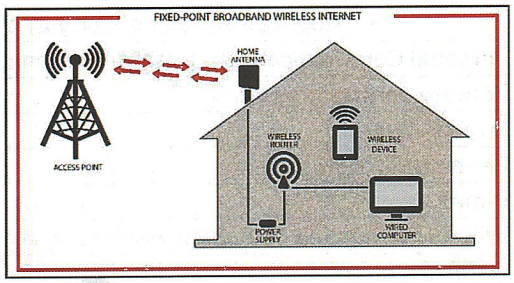
Fiber: A hair thin strand of glass carries the communications signal between the provider and the premise. The signal is via light instead of electricity, so has great capacity (bandwidth) over long distances in both directions (downstream and upstream) without degradation of the signal.

DSL: Digital subscriber line service is provided over the wires of a local telephone company. The most common DSL deployment in Minnesota is Fiber-to-the-Node which extends fiber from the telephone company central office to a local node. Existing copper telephone lines carry the communications signal from the node to the home. The broadband speed that can be achieved depends on the distance that the signal must travel between the node and the home (the copper loop).

Cable: Cable broadband service uses a hybrid fiber-coaxial cable plant, initially installed to deliver cable television services. Most cable systems in Minnesota have deployed DOCSIS 3.0 (Data Over Cable Service Interface Specifications). Work is currently underway to deploy DOCSIS 3.1 technology which will have the capacity to deliver broadband at higher speeds than is currently available. Many Minnesota cable operators are also using a fiber-based PON (Passive Optical Networks) to provide even higher speeds.

Wireless: Wireless broadband enables mobile devices, like smartphones or tablets, to connect to the Internet wherever coverage is available. The current technology in use is fourth generation long term evolution, more commonly called 4G LTE. While the wireless signal for broadband emanates from towers, the connection from each tower to the providers' backbone networks is generally fiber.

Fixed Wireless: Fixed wireless is an Internet technology medium that refers to a radio frequency (wireless) based system comprised of radio transmitters and receivers that connect a customer to the Internet. A subscriber's radio connects to the provider's facility (access point or base station transceiver) most typically with an external radio/antenna; within certain systems, indoor radios and mobile devices may connect to a fixed wireless system. Fixed wireless systems can operate in both licensed and unlicensed radio frequencies.



These technologies allow for a number of applications, ranging from education to agriculture. Below is a brief description of some of the applications enabled by broadband.

1. Broadband Applications and Bandwidth Consumption

The table below lists, in ascending order of use of bandwidth, common activities done over the Internet and the bandwidth that is needed. Data confirms that as higher broadband speeds are made available, consumers are adopting. The FCC 2015 Broadband Progress Report and Notice of Inquiry includes a table showing that adoption of fixed broadband at speeds of 25 Mbps download and 3Mbps upload increased fourfold – from seven percent in 2011 to 29 percent in 2013.

Application (one activity at a time)	Data Rate Required
Personal Communications, Instant Messengers	300 bps to 9.6 kbps
Remote control programs	9.6 kbps to 56 kbps
Streaming radio	Less than 0.5 Mbps
Phone calls (VoIP)	Less than 0.5 Mbps
E-mail	0.5 Mbps
Web browsing: job searching, navigating government websites	0.5 Mbps
Database query	Up to 1 Mbps
Web browsing: Interactive pages and short educational videos	1 Mbps
Basic video conferencing	1 Mbps
Game console connecting to the Internet	1 Mbps
Skype HD video calling	1.5 Mbps symmetrical
Download a 1 MB book in 2.7 seconds or a 4 MB song in 10.7 seconds or a 6144 MB movie in 4 hours and 33 minutes	1.5 to 3 Mbps
Digital audio	1-2 Mbps
Access images	1-8 Mbps
Skype group video-3 people	2 Mbps download/512kbps upload
Compressed video	2-10 Mbps
HD quality video streaming/HD video conferencing/telelearning	4 Mbps
Two-way online gaming in HD	4 Mbps
Skype group video-5 people	4 Mbps download/512 kbps upload
Netflix recommended download speed for HD	5 Mbps
Skype group video-7+ people	8 Mbps download/512 kbps upload
Telecommuting (high quality video)	10 Mbps to 100 Mbps
Netflix recommended download speed for Ultra HD	25 Mbps
Medical Transmissions (At 50Mbps, a digital chest film takes 3 seconds, an MRI takes 30.5 seconds, an echocardiogram study takes 10.1 minutes)	Up to 50 Mbps
Download a 1 MB book in 0.1 seconds, or a 4 MB song in 0.3 seconds or a 6144 MB movie in 8 minutes	50 to 100 Mbps

Table 1: Broadband Applications and Bandwidth Consumption

2. Residential Applications of Broadband

Residential broadband usage can be simple, from checking e-mail, to very complex and encompassing most or all of the applications shown in the chart above. A growing area of residential broadband use is within what is known as the "Internet of Things" – or connected devices. This technology, for example, allows individuals and families to remotely monitor and control their heating, cooling, home security systems, and energy consumption.

Broadband also enhances civic engagement activities (watching city council meetings, subscribing to neighborhood group websites, reporting where government services are needed such as street light outages or potholes). It enables online shopping (the $3.1 billion spent on Cyber Monday 2015 was the largest online shopping day

> "We see the Internet usage of our customers doubling every year. The more you have the more you use." Keven Larson, CTC, to Governor's Broadband Task Force, July 17, 2015.

ever[2]), social media use, or the growth in over the top viewing. Regardless of which activities a household prioritizes, the ability to be online is of increasing necessity.

3. Broadband Application to Business/Economic Development

Between 1998 and 2002, communities with broadband availability, compared to those without it, were associated with higher levels of growth: in employment, number of businesses, and number of businesses in the information technology industry.[3] Moreover, non-metro counties with relatively high levels of broadband adoption (i.e. county-level adoption rates greater than 60 percent) "had significantly higher levels of growth in median household income and significantly reduced growth in unemployment when compared with otherwise similar counties that did not meet this threshold."[4] Higher download speeds (i.e. greater than 10 Mbps) in rural areas are also associated with poverty levels 2.6 percentage points lower than similar areas without broadband.

The Internet Innovation Alliance (IIA) recently released a report that found that access to the Internet is associated with an American household saving, on average, $10,500 per year. This figure takes into account the cost of connecting to the Internet as well as data plans for mobile devices. The savings arise from consumers shopping online, including online-only discounts and comparison shopping. The gross consumer savings associated with online shopping is $11,944 per year. In 2010, the last year that IIA released its estimate, the annual savings was estimated to be $7,707.

> "Three years ago we started our online store, it is now half of our production. With our online presence we have been able to expand our business to $3.5 million, which is incredible for such a small town." Marie Rivers, Sven Comfort Shoes, Chisago City.
>
> Source: http://blandinonbroadband.org/2015/11/04/chisago-county-broadband-video-features-local-businesses

Broadband connectivity is also a key factor to a business's ability to drive growth. From communicating with suppliers or selling products to customers, a reliable, high-speed broadband connection is vital. While the reliance on connectivity may be obvious to see for large businesses, small to medium-sized businesses (SMBs) need it just as much.

One costly barrier for SMBs has been access to technology. Traditionally, businesses buy fixed technology assets that have fixed capacity. This has a significant upfront expense that limits options for many SMBs. The emergence of cloud technologies has transformed this segment, allowing SMBs to pay only for the storage they consume. A Deloitte survey[5] found that SMBs utilizing the cloud to meet their technology needs grow 26 percent faster and are 21 percent more profitable than their peers who do not. Reliable, high-speed connectivity is one key to enable SMBs to successfully utilize the cloud. Many backend office systems (i.e., accounting, payroll, human resources, Adobe, Microsoft Office, etc.) are

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[2] http://www.twincities.com/business/ci_29192877/record-cyber-monday-spending-tops-3-billion.

[3] Lehr, W., Osorio, C., and Gillett, S. (2005). Measuring broadband's economic impact. Presented at the 33rd research conference on communication, information, and internet policy (TPRC), Arlington, VA, http://www.andrew.cmu.edu/user/sirbu/pubs/MeasuringBB_EconImpact.pdf.

[4] Whitacre, B., Gallardo, R., and Strover, S. (2014). Broadband's contribution to economic growth in rural areas: Moving towards a causal relationship. *Telecommunications Policy*, http://dx.doi.org/10.1016/j.telpol.2014.05.005.

[5] http://www2.deloitte.com/content/dam/Deloitte/global/Documents/Technology-Media-Telecommunications/gx-tmt-small-business-big-technology.pdf.

migrating to a software as a service (SaaS) model. This puts small businesses located in rural areas without access to broadband at a competitive disadvantage.

Another area that is heavily reliant on this connectivity is freelance employment. According to a 2014 study for Freelancer's Union by Edelman Berland,[6] more than 53 million people are freelance workers. The workforce consists of independent contractors, moonlighters, and small freelance business owners and has grown nearly 25 percent since 2004. This population adds over $700 billion annually to the economy.

The result of more freelance workers is more business generation outside of a traditional office. This suggests that reliable, high-speed connectivity for homes, farms, and mobile users is critical to the success of this workforce. In fact, this connectivity is important not only in performing the job – 42 percent do all of their work online – but, is also critical to finding work. Sixty-nine percent of the survey participants found their employment on the Internet and nearly a third found jobs within 24 hours.

In addition to freelancing, another non-traditional work model enabled by technology, telecommuting, continues to be popular with many employers. One program that is promoting telecommuniting is Minnesota's eWorkplace.[7] Over 4,000 employees from more than 40 Twin Cities employers participate in their program. The success of these telecommuting strategies depends on reliable, high-speed connectivity.

Telecommuting is also helping to diversify the economy in Greater Minnesota. In Chisholm, for example, the Delta Airlines call center is providing its employees with telework opportunities to strengthen its workforce and reduce demands on workspace. These jobs also support families with full and part-time employment options.

4. Broadband Applications in K-12 Education

It is imperative that K-12 students have access to adequate broadband at school and at home so that Minnesota's K-12 education system can employ technologies to modernize their curricula and learning environments without furthering the digital divide among students. As FCC Commissioner Jessica Rosenworcel noted, "There was a time when doing basic schoolwork required no more than a little bit of quiet, a clear workspace, and a pencil. No more. Today, 7 in 10 teachers assign homework that requires Internet access. Kids may be connected in the classroom, but if they are disconnected at home getting basic schoolwork done is hard."[8]

Broadband applications in K-12 education range from virtual learning to improved communications between teachers and parents. For example, broadband allows students to access educational opportunities through institutions such as historical societies, zoos, creative arts and other virtual fieldtrips. Virtual field trips for Greater Minnesota include visiting the Minnesota Zoo, Minnesota Historical Society, Great Lakes Aquarium and International Wolf Center in Ely – all of which provide educational opportunities students would not normally have access to due to time constraints and transportation costs. Educational opportunities also include interactive experiences to classrooms from the National Park Service, NASA, the Smithsonian, medical facilities and many more.

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[6] https://www.upwork.com/press/2014/09/03/53-million-americans-now-freelance-new-study-finds-2/.
[7] http://www.eworkplace-mn.com/.
[8] https://apps.fcc.gov/edocs_public/attachmatch/DOC-333103A1.pdf.

Broadband also supports the creation of robust digital learning environments to improve student achievement. Increasingly, schools are breaking down the walls of the classroom, connecting students to students and teachers to teachers via videoconferencing. This allows students to take advantage of Advanced Placement or foreign language courses to which they would not otherwise have access.

Broadband is also becoming increasingly important at home. While 70 percent of teachers assign homework requiring online access,[9] 40 percent of households with school-age children[10] do not have access or subscribe to broadband. Without access to broadband, many students are not able to complete homework assignments or must find alternative access points, such as libraries or other institutions.

"Changes in curriculum require broadband. Five years ago much school material was still in books, but now so much of curriculum in is a digital format. They can learn from home and should be able to access those resources 24/7. Having the ability to access the Internet from where they are is a huge advantage." Troy Anderson, ISD 728 (Sherburne) from a video produced by Sherburne County.

Source: http://blandinonbroadband.org/2015/11/05/sherburne-county-video-on-need-for-broadband-in-the-community

5. Broadband Applications in Higher Education

Broadband plays an important role in today's higher education infrastructure, from the University of Minnesota to the Minnesota State Colleges and Universities (MnSCU) system and Minnesota's private colleges and universities. Many of these institutions now offer distance learning programs or online degrees that offer the student the ability to remotely connect to the class in real-time. According to the National Center for Education Statistics, in 2012 (most recent data available), 39 percent of post-secondary, degree-seeking students in Minnesota were enrolled in one or more distance education courses.[11]

Within MnSCU, the type of content accessible to students ranges from online courses to fully immersive video presentations and remote hands-on training using simulators. South Central College, for example, developed iMEC— a distance learning model using online, simulation, and remote access delivery methods which allow institutions to share curriculum and specialized equipment across multiple campuses as well as with other education and industry partners. Through this approach, for example, students can attain their Mechatronic Industrial Maintenance Certificate anywhere they have internet access.[12]

The College of Saint Benedict and St. John's University are concluding a redesign of the nursing department learning spaces. The newly created spaces feature seven simulation areas and two classrooms, all of which utilize video and audio streaming to improve the educational outcomes for nursing students. Students in the classroom will watch live video feeds of other students who engage in simulations in the nearby rooms enacting scenarios they will encounter in the practice setting. The

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[9] http://www.huffingtonpost.com/jessica-rosenworcel/bridging-the-homework-gap_b_7590042.html.
[10] http://www.pewresearch.org/fact-tank/2015/04/20/the-numbers-behind-the-broadband-homework-gap/
[11] http://nces.ed.gov/pubs2014/2014023.pdf.
[12] "Mechatronics is the synergistic application of mechanical engineering, electrical engineering, controls engineering, and computer science to build and maintain high-tech equipment," The Association for Packaging and Processing Technologies, http://www.pmmi.org/Education/content.cfm?ItemNumber=1010.

technology is connected to a central control room where educators can watch the unfolding simulations, record video, and provide feedback to the students.

The University of Minnesota also offers instructors the ability to record classroom demonstrations using Techsmith Relay and in-room video conferencing. Using a software platform known as Milestone, the University also provides researchers with the ability to record, archive, and playback video content traditionally used for lab environments. Web-conferencing also enables users to connect with up to a thousand participants.

As institutions of higher education prepare students for careers and life in the 21st Century, broadband is more important now than ever before. If colleges and universities are to equip our students with the skills they need to thrive in today's economy, they must have access to adequate technologies and the broadband infrastructure to support those technologies.

6. Broadband Applications in Libraries

Minnesota's libraries are critical components of digitally inclusive communities and for bridging the statewide digital divide. Across 87 counties and 7 reservations, 356 public libraries and 8 tribal libraries provide broadband connections, computer access, and technology training to people who may not otherwise be able to access or afford these essential services. As detailed by the Pew Research Center,[13] 27 percent of Americans who have visited a public library in the past 12 months report having used a library computer or broadband connection while there. People of color and people from low-income households are more frequent users of libraries' technology services, with African Americans and Hispanics reporting library technology usage rates of 38 percent and 32 percent, respectively.

Libraries throughout Minnesota—where annual public library use is 4.5 visits per capita—are especially active providers of broadband access, public computers, and technology training. In 2014, Minnesota's public libraries offered broadband access over a combined total of 5,759 desktop computers and 529 mobile devices; from these access points, library users statewide conducted 5,594,135 Internet sessions. Wireless Internet access, available at 97 percent of public libraries, receives similarly high usage: About 30 percent of reporting public libraries indicated a total of 918,102 Internet sessions conducted wirelessly during 2014.

For example, as mobile device ownership increases, librarians provide free technology training in the use of all devices and programs. People submitting online job applications or accessing e-government services receive technical guidance from librarians while using library computers. Adult students completing online degrees or job certifications ask librarians for assistance with course assignments, technology use, and exam proctoring. As K-12 schools integrate technology into classrooms, often through 1:1 device programs, librarians collaborate with educators

> More than 60 percent of public libraries offer download speeds equal to or greater than 10 Mbps, and 47 percent offer comparable upload speeds. In only two years—from 2012 to 2014—the number of public libraries with download speeds over 20 Mbps has increased from just three to 123. Likewise, while fewer than 150 public libraries had fiber optic broadband connections in 2012, 211 public libraries (62 percent) boasted the same in 2014. These infrastructure improvements and speed increases all support library activities.

[13] http://www.pewinternet.org/2015/09/15/libraries-at-the-crossroads/.

to provide support and learning opportunities beyond the classroom walls. Libraries are hubs of activity; increasingly, these activities focus on improving digital literacy.

7. Broadband Applications in Healthcare

Although there are many examples of the growing use and demand for broadband in medical facilities none are quite as explosive as the growing field of telemedicine and telehealth applications. Telemedicine technology and new models of healthcare service delivery using high speed broadband applications are quickly evolving in primary care and urgent care settings in Minnesota. This is partly related to the existing and upcoming provider shortages. Virtual distance technologies such as real-time live interactive audio and visual conferencing allow scarce provider resources to be stretched and shared between urban and rural Minnesota locations. These relationships and access decrease the sense of isolation for rural providers and provide support for rural practices. A strong medical service is an important socio-economic driver for all Minnesota communities.

Currently, medical or healthcare telehealth professionals conduct outreach to rural hospital, clinic and nursing home settings from the typically metro location of the specialist. Behavioral health professionals at community mental health centers also provide support crisis services to nearby rural hospital emergency rooms 24 hours per day, seven days per week. For example, Northwest Mental Health Center in Crookston has 22 licensed behavioral health professionals providing crisis support to the Essentia Health-Fosston Hospital and Clinic using Telehealth outreach, mobile devices and hotspots. The goal for this service is to support the rural ER and rural Fosston citizens with behavioral health needs.

Rural communities also utilize community-based emergency rooms and intensive care units, which connect to the tertiary care centers for support for the advanced practice provider (nurse practitioner or physician assistant) to function at the top of their licensure.

Additionally, Nurse Practitioners and Physician Assistants in Aurora's ER e-connect using high speed broadband secure VPN connections and live interactive videoconferencing to the Board Certified Emergency Medicine doctors in the Essentia Health Duluth-St. Mary's Medical Center ER for remote supervision and support for patients with heart attacks, strokes and trauma.

> "Doctors can help detect congestive heart failure by having patients regularly weigh themselves and send in the results via the web. If the data shows a weight gain of several pounds in just a few days, that could mean the patient's heart isn't functioning property. Telemedicine helps patients limit health care expenses and travel, and it allows them more freedom in their living situations." Maureen Ideker, RN, Essentia Health, Broadband Task Force member

Telemedicine holds promise in the future. For example, remote interactive video guidance for surgical procedures and ultrasound diagnostic imaging will continue to be a tool of medical practitioners. Medical practitioners will also likely continue to use direct-to-consumer, in-home, on-line interactive videoconferencing. Future applications could include arranging medical and therapy appointments or relaying medical updates via text message. These applications could result in maintaining independent living for the elderly, chronically ill and disabled through central monitoring services. Hospice medical visits of the future will also likely include the option of using a secure Skype-like connection direct to the patient and family in their home.

The University of Minnesota, for example, conducted research related to tele-home monitoring of vital signs. Vital signs, such as weight and blood pressure, were downloaded to a central monitoring station,

which allowed nurses to review the data on a daily basis. The research involved 150 home care patients. Results showed that patients who received daily monitoring entered the hospital, nursing home, or emergency room at a lower rate (17 percent) compared to those that did not receive such monitoring (42 percent).

Primary care practices and specialty medical and healthcare professionals will incorporate virtual applications into their daily working routines and delivery of care models. Patients in any geographic setting, whether rural or urban, will be incorporated into the daily work flows in most clinics.

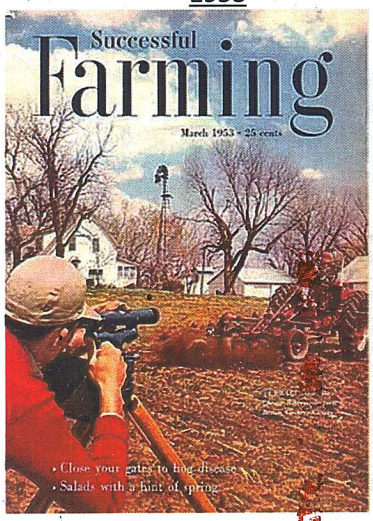
The applications noted above are not available for those areas of rural Minnesota, including tribal areas, which lack adequate broadband service. For example, a Mille Lacs Band of Ojibwe clinic close to the Wisconsin border has state of the art equipment for diagnostic imaging and electronic medical records, but not enough broadband availability to download digital images for interpretation or to connect with outside entities for interoperability purposes with the electronic medical record.

8. Broadband Applications in Agriculture

For precision agriculture, which includes remote monitoring of machines in fields and livestock in barns, broadband Internet plays an important role. Today, farmers are using Big Data and the Internet of Things to analyze and manage productivity, crop yield, and improve energy efficiency. The Internet of Things allows different devices or equipment, including farm equipment, to communicate with one another remotely.

To gain a better appreciation and understanding of how broadband impacts agriculture in Minnesota, the Task Force visited Farmfest in August of 2015. During the first day of the event, which organizers declared "Rural Broadband Day," the Task Force heard from a number of companies and individuals about the importance of broadband on farms and in rural areas of the state. For example, the Task Force heard from a manufacturing facility based in Jackson, Minnesota, who noted that all new tractors come equipped with the ability to connect wirelessly to each other, with the focus on helping make equipment operate more efficiently.

1953[14]



2005[15]

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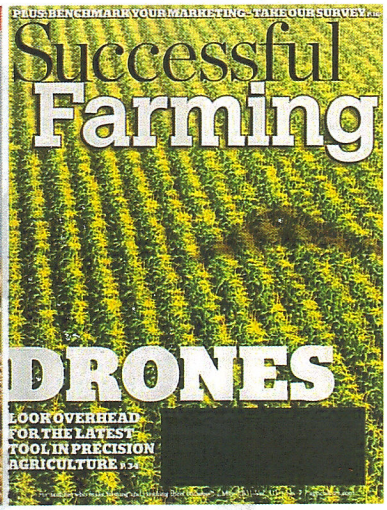

2014

2015

A survey of covers of the farming magazine, *Successful Farming*, illustrates the degree to which Internet-based technology is taking hold in today's agricultural sector. The topics noted on the covers of the magazines reflect the interests of the agriculture community and the available technologies.

Today, precision agriculture helps farmers manage their crops and livestock more efficiently. Precision agriculture concerns the "application of geospatial techniques and sensors (e.g. geographic information

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[14] *Successful Farming*, March 1953, retrieved from https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcS7538ziFac5K56ixD_pC6ykkTzXRQunEpptlpfvfEmvYRSzv4s, accessed December 14, 2015.

[15] *Successful Farming*, February 2005, retrieved from https://thomasfarleyblog.files.wordpress.com/2013/09/farming.jpg, accessed December 14, 2015.

[16] *Successful Farming*, March 2013; November 2014; February 2015 retrieved from http://www.magazine-agent.com/Successful-Farming/Covers, accessed December 14, 2015.

systems, remote sensing, GPS) to identify variations in the field and to deal with them using alternative strategies."[17]

Image 1: Image of a drone.[18]

A 2012 article in *Precision Agriculture* notes that drones (see the above image for an example of a drone) have been used to detect small weed patches and water stress in crops, monitor crop biomass and nitrogen treatments, among other areas of application.[19]

A related component of precision agriculture and the application of broadband in the farm field is the use of robots to improve operations and increase yields. A 2009 article in the *Economist* notes "crop-tending robots that use vision systems, laser sensors, satellite positioning and instruments to measure things like humidity can build up a database of information about each plant."[20] This, in turn, can be used to help detect disease and predict crop yields.

As the volume of data increases so too does the need to store, analyze, and make meaningful interpretations of the data. Big Data concerns the collection, analysis, and interpretation of large, complex datasets – which, due to the volume and complexity of the data and the speed at which it is received, often cannot be analyzed using traditional methods. Some of these non-traditional methods include predictive analytics, pattern recognition and spatial analysis. Precision agriculture, robots, and drones all contribute to the collection and storage of data and, as these methods of farming continue to take hold, with agribusiness finding value in such methods, the opportunity to glean insights from data will also continue to grow.

III. Where we are now: Availability, Adoption and Speed Goals

Ensuring that Minnesota's businesses, public institutions, residents and visitors have the opportunity to take advantage of the applications noted above requires a broadband Internet connection. Over the last

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[17] Zhang, C. and J. M. Kovacs (2012). "The application of small unmanned aerial systems for precision agriculture: a review," *Precision Agriculture*, 13, pp. 693-712. (Abstract).

[18] https://droneservicescompany.files.wordpress.com/2015/07/drone-imagery-for-agriculture-the-future-of-farming-e1436649026266.jpg.

[19] Zhang, C. and J. M. Kovacs (2012). "The application of small unmanned aerial systems for precision agriculture: a review," *Precision Agriculture*, 13, pp. 693-712. (Page 699).

[20] "Fields of Automation," *The Economist*, http://www.economist.com/node/15048711, accessed October 20,2015.

five years Minnesota has made progress toward expanding access to broadband and increasing adoption rates.

Legislation was enacted in 2010 that put Minnesota's broadband goals into Minn. Stat. §237.012:

> *Subd. 1.* ***Universal access and high-speed goal.***
> *It is a state goal that as soon as possible, but no later than 2015, all state residents and businesses have access to high-speed broadband that provides minimum download speeds of ten to 20 megabits per second and minimum upload speeds of five to ten megabits per second.*
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> *(3) the top 15 when compared to countries globally for broadband penetration.*

These goals have guided the work and policy recommendations of the Governor's Task Force on Broadband since they were established in 2010. These goals have also served as the benchmark upon which Minnesota measures progress toward connecting the state with border-to-border broadband service.

1. Availability and Adoption

Broadband availability has increased across the state since measurement began approximately five years ago. The following bar chart shows that progress, measured in terms of household broadband availability at speeds of 10 Mbps download and 6 Mbps upload. Note that the chart shows broadband availability at 10 Mbps download and 6 Mbps upload, whereas the state broadband speed goals are at least 10 Mbps download and at least 5 Mbps upload. However, because data under the State Broadband Initiatives (SBI) program, funded by American Recovery and Reinvestment Act (ARRA), was collected using federal parameters, the ability to measure broadband with an upload speed of at least 5 Mbps did not exist until the fall of 2014. For comparison over time, therefore, the Task Force retains the speeds of 10 Mbps download/6 Mbps upload for this chart.

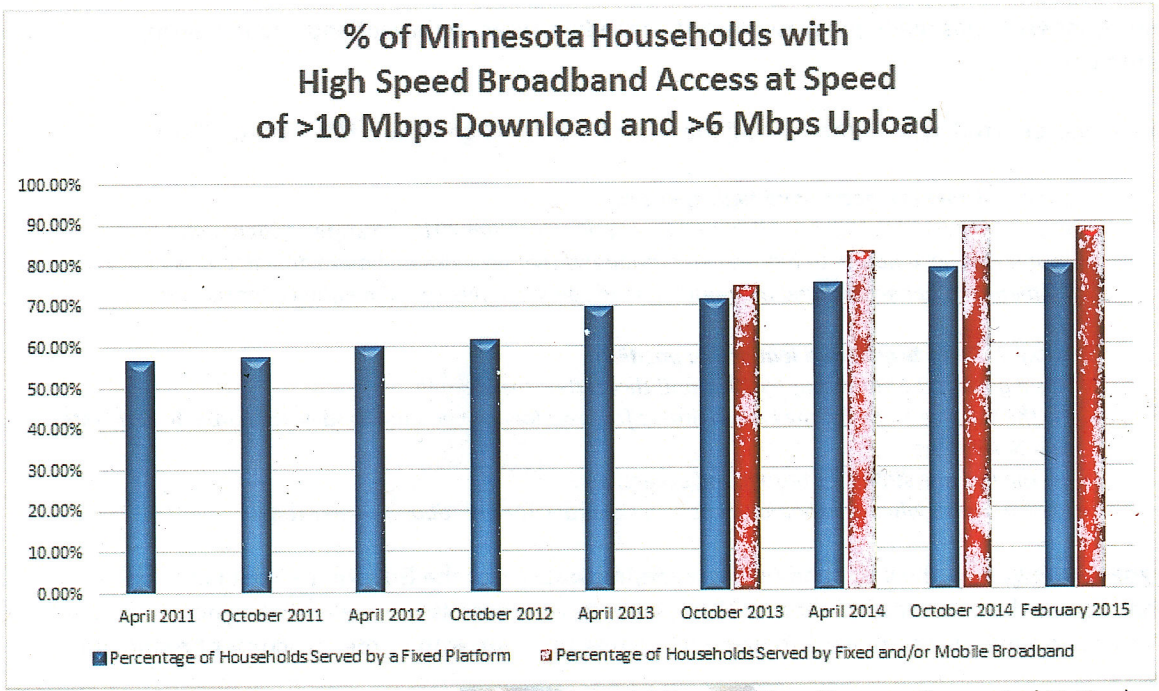

Chart 1: Percent of Minnesota Households Served at 10 Mbps/6 Mbps (Source: Connected Nation)

With regard to home broadband adoption, between 2010 and 2013 (the years that Connect Minnesota conducted residential broadband adoption surveys), home broadband adoption slightly increased:

Minnesota Home Broadband Adoption			
2010	**2011**	**2012**	**2013**
72%	72%	78%	79%

Table 2: Minnesota Home Broadband Adoption
Source: Connect Minnesota

Unserved or Underserved Areas

According to the National Telecommunications and Information Administration (NTIA), a substantial gap remains between urban areas and rural and tribal areas with respect to access to high-speed broadband. The FCC's 2015 Broadband Report found that "nearly 2/3 of residents lack access to today's speeds."[21] In Minnesota, 99 percent of urban areas have access to speeds of 25 Mbps download and 3 Mbps upload, while only 47 percent of rural areas, including many tribal areas, have such access.

The FCC also noted in its 2015 Broadband Report that many rural areas, including tribal lands, remain unserved, at least in part, because of the cost of building infrastructure over long distances to sparsely populated areas. The FCC indicated affordability of services remains a key concern, stating that for legitimate broadband to be adopted on tribal lands, the price of services must be addressed. "Not only do tribes need basic POTS lines, plain old telephone service, it has become more important than ever to

[21] https://www.fcc.gov/reports/2015-broadband-progress-report.

build out fiber based telecommunications in order to address such areas as education, healthcare, public safety, cultural heritage and economic development."[22]

K-12 Education

Access to broadband in Minnesota's K-12 schools also remains a challenge, especially in the state's rural school districts. EducationSuperHighway, a 501(c)(3) non-profit committed to helping schools across the country upgrade their broadband networks, notes that:

- 22 percent of districts are not meeting the Federal Communications Commission's (FCC's) 2014 education Internet access goals of 100 Kbps/student or staff;
- 80 percent of districts are not meeting the FCC's 2018 education Internet access goals of 1 Mbps/student or staff and a wireless area network (WAN) scalable to 10 Gbps/school; and
- 26 percent of schools in Minnesota need upgrades to fiber.[23]

2. Progress Toward Minnesota's Broadband Speed Goals: 2011-2015

Data collected by Connected Nation indicate that, as of February 28, 2015, 91.45 percent of Minnesota households have broadband access available at a speed of at least 10 Mbps download and 5 Mbps upload.[24] Generally, rural areas are less likely to have broadband service available. As illustrated by the maps below, data confirms that rural areas, especially areas outside of a regional center, must remain a priority to meet the state's broadband speed goals. Indeed, 19.84 percent of rural households in Minnesota lack access to broadband of speeds of at least 10 Mbps download and 5 Mbps upload. If only fixed, non-mobile broadband service is considered, 24.62 percent of rural Minnesota households do not have access to these speeds.

Rural Availability Estimate of Broadband Service of at Least 10 Mbps Download and 5 Mbps Upload				
Platform Type	**Total Rural Households ('000)**	**Unserved Rural Households ('000)**	**Percent of Rural Households Served**	**Percent Households Served Statewide**
Fixed, Non-Mobile Broadband Service	**897**	**221**	**75.38**	**88.98**
All Broadband Platforms, Including Mobile	**897**	**178**	**80.16**	**91.45**

Table 3: Estimate of Broadband Service Availability in Rural Minnesota

With regard to the goal that Minnesota be in the top five states for broadband speed universally accessible to residents and businesses, Minnesota's average connection speed was 12.9 Mbps, placing the state 21st amongst other states. Under the Akamai measurement,[25] the average connection speed is a reflection of what customers choose to purchase and not necessarily the speeds that are available.

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[22] http://www.convergecomm.com/converge/Broadband%20in%20Indian%20Country.pdf.

[23] For additional details see http://mn.gov/deed/images/education-superhighway.pdf. Data here does not include charter schools.

[24] The 91.45 percent figure includes broadband service provided by wired, fixed wireless and wireless technologies as Minnesota Statutes did not specify a technology.

[25] Akamai's average connection speed is a metric calculated by taking an average of all of the connect speeds calculated during the quarter from the unique IP addresses determined to be in a specific state.

While Minnesota's average connection speed has increased, that increase is not at a rate greater than other states which would enable Minnesota to move up in the rankings.

Rank	State	3Q 2015 Avg. Mbps
1	District of Columbia	19.5
2	Delaware	18.5
3	Utah	16.2
4	Massachusetts	16.2
5	Rhode Island	15.7
6	Washington	15.2
7	Maryland	15.0
8	New Jersey	15.0
9	Virginia	14.9
10	New York	14.8
21	Minnesota	12.9

Table 4: States with the Highest Average Broadband Speed (Source: Akamai 3Q15 State of the Internet)

The Task Force has traditionally reported Akamai's average broadband speed as a measure of Minnesota's standing with respect to broadband speed universally accessible. However, Akamai indicates that the average peak connection speed is more representative of Internet connection capacity. By using the fastest measurement observed from each unique IP address, Akamai indicates it is capturing just those connections that reach maximum throughput rates. Unfortunately, under this measure, Minnesota's average peak connection speed of 55.5 Mbps results in a ranking of #32 compared to other states.

In addition to Akamai, there are other data sources that can be used to measure broadband access and adoption. These rankings are included in Appendix C.

American Recovery and Reinvestment Act (ARRA) funding, under the State Broadband Initiatives (SBI) program administered by the NTIA of the U.S. Department of Commerce, was used to map broadband availability within each state, including Minnesota, twice a year from 2010 through 2014. That data was aggregated to create the National Broadband Map.[26]

Upon the expiration of the ARRA funding, the Office of Broadband Development, through a contract with Connected Nation and the participation of broadband providers in Minnesota, updated maps

[26] See http://broadbandmap.gov.

showing broadband availability as of February 28, 2015 (below). Additional information on broadband availability can be found on the Office of Broadband Development website at http://mn.gov/deed/programs-services/broadband/maps-tests/index.jsp. Contingent on funding, the Office intends to update Minnesota's broadband data and maps on an annual basis.

Minnesota
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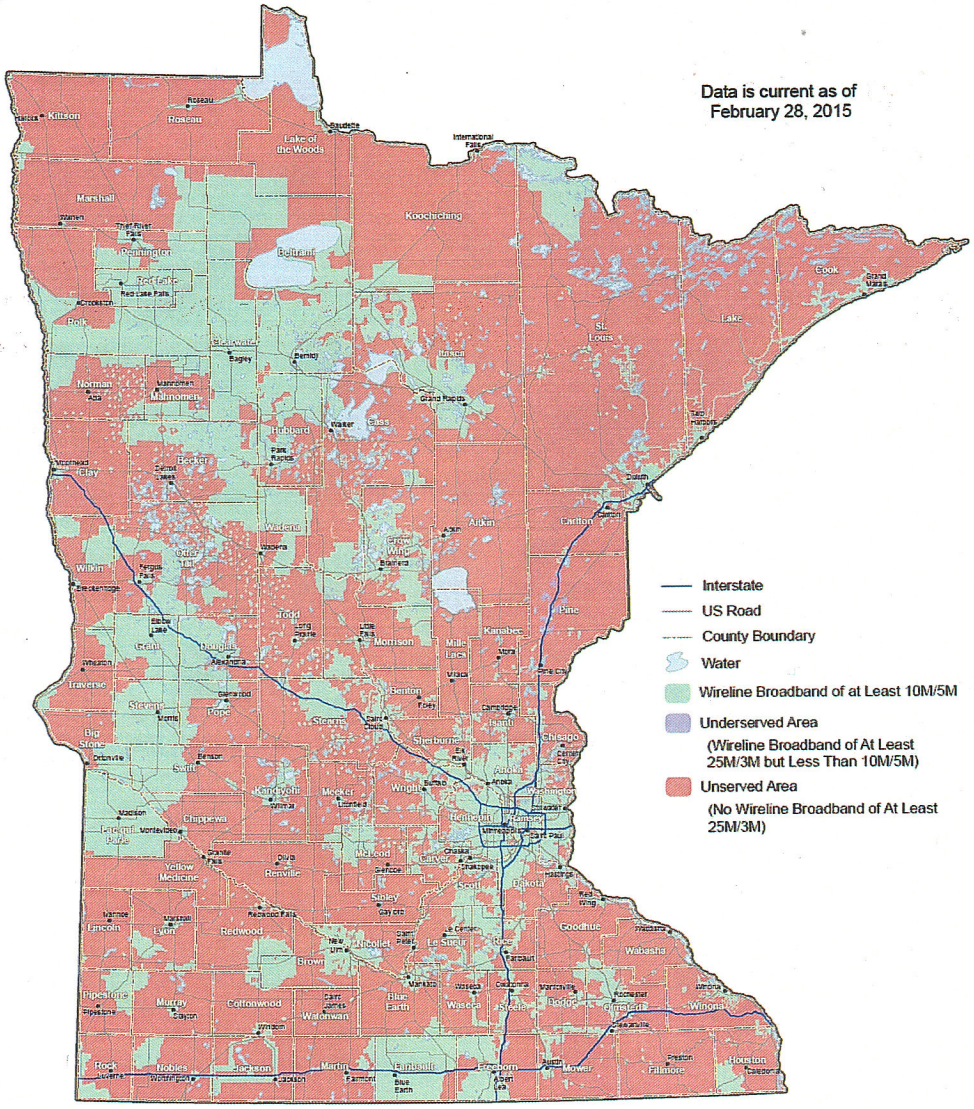
Broadband Service Inventory for the State of Minnesota

Areas Unserved by Wireline Broadband at 25 Mbps Download/3 Mbps Upload



Submit questions or recommended changes to:
DEED.broadband@state.mn.us

This map was prepared by Connected Nation under contract with the Minnesota Department of Employment and Economic Development. The map represents areas of broadband service availability based on provider data submitted to and analyzed by Connected Nation and modified based on validation tools. While not reflected on the map, satellite broadband services may also be available.

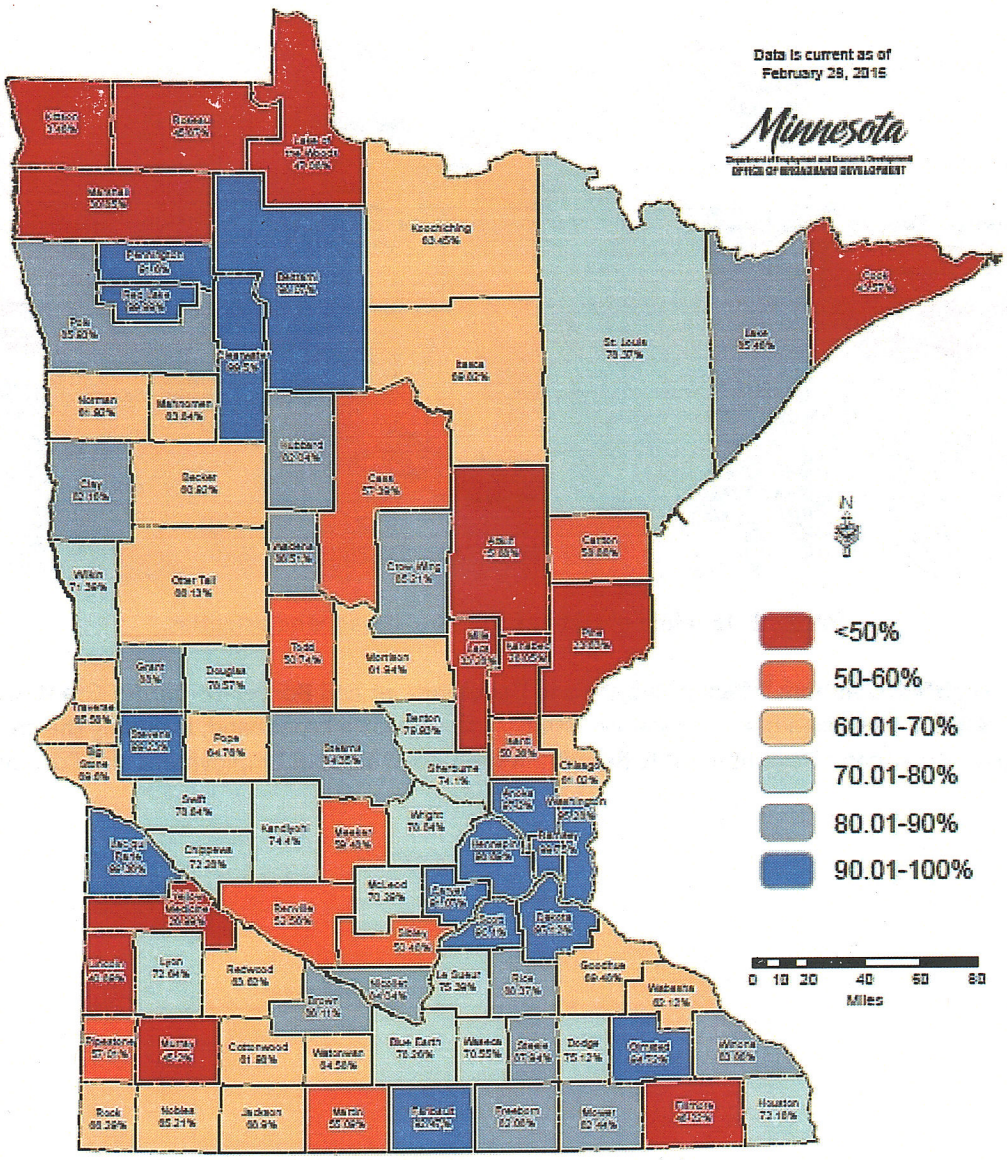
Additional maps and data are available at
http://mn.gov/deed/programs-services/broadband/maps-tests

Upon request, this information can be made available in alternate formats for people with disabilities by contacting the DEED Office of Broadband Development at 651-259-7610.

Broadband Availability in the State of Minnesota

Percentage of Households Served by Wireline Broadband Service

At Least 10 Mbps Download/5 Mbps Upload Speeds
Statewide Availability: 86.46%



This map was prepared by Connected Nation under contract with the Minnesota Department of Employment and Economic Development. The map represents areas of broadband service availability based on provider data submitted to and analyzed by Connected Nation and modified based on validation tools. While not reflected on the map, wireless broadband services may also be available.

Submit questions or recommended changes to:
DEED.broadband@state.mn.us

Additional maps and data are available at http://mn.gov/deed/programs-services/broadband/maps-tests

Upon request, this information can be made available in alternate formats for people with disabilities by contacting the DEED Office of Broadband Development at 651-259-7610.

3. Federal Communications Commission Updated Definition of "Broadband"

On January 29, 2015, the Federal Communications Commission (FCC) adopted its Broadband Progress Report and Notice of Inquiry on Immediate Action to Accelerate Deployment. The FCC found that having access to advanced telecommunications capability requires access to actual download speeds of at least 25 Mbps and actual upload speeds of at least 3 Mbps.

IV. Investments in Broadband: 2011-2015

The timeline below provides an overview of state and federal actions related to broadband.

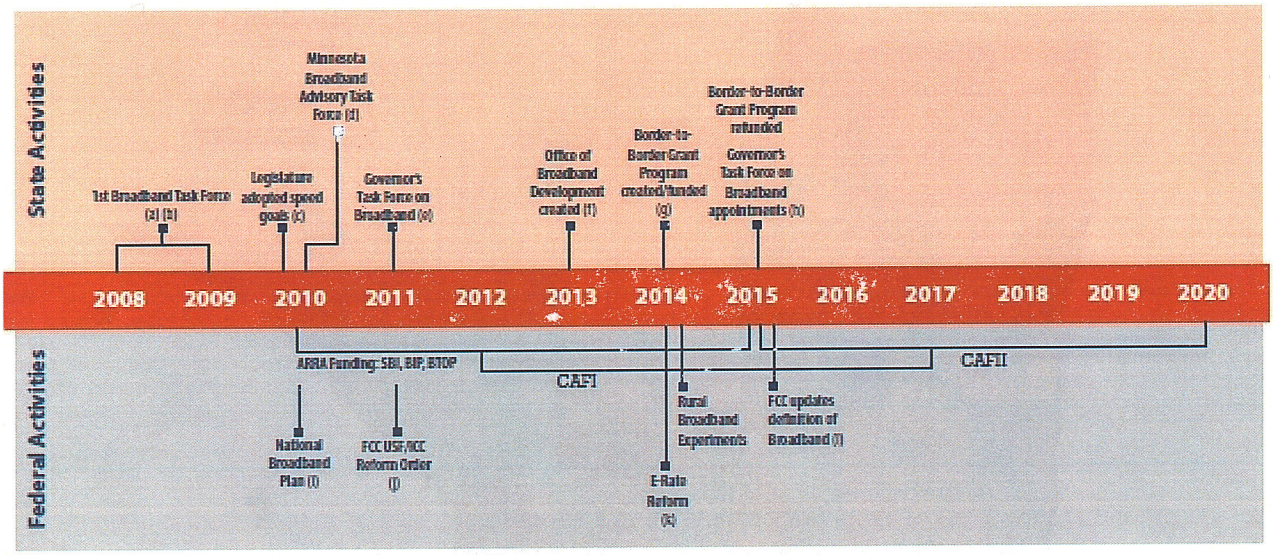


Image 2: Timeline of state and federal broadband activities.

1. Legislative Action: Office of Broadband Development and Border-to-Border Grant Program

Over the last five years significant legislative action with respect to broadband, including the creation of the Office of Broadband Development (OBD) within the Department of Employment and Economic

Development (DEED) during the 2013 Legislative Session,[27] and the establishment of the Border-to-Border Broadband Development Grant Program during the 2014 Legislative Session.[28]

OBD plays a critical role in developing Minnesota's broadband infrastructure, including working with partners on mapping broadband availability to more effectively direct state investment. OBD also assists the Governor's Task Force on Broadband, the Governor's Broadband Subcabinet, and oversees the state's Border-to-Border Broadband Development Grant Program.

The Border-to-Border Broadband Development Grant Program, created by the Legislature in 2014 and initially funded at $20 million, provides funding to build the state's broadband infrastructure and promote broadband access in unserved and underserved areas of the state. The grants provide up to a dollar-for-dollar match on funds, not to exceed $5 million for any one project, and are distributed to qualified entities, including:

1. an incorporated business or a partnership;
2. a political subdivision;
3. an Indian tribe;
4. a Minnesota nonprofit organization organized under chapter 317A;
5. a Minnesota cooperative association organized under chapter 308A or 308B; and
6. a Minnesota limited liability corporation organized under chapter 322B for the purpose of expanding broadband access.

The Office of Broadband Development considers a number of criteria, as defined in statute, in evaluating and awarding the grants to eligible entities, including cost, community support, the number of households and community institutions impacted by the project, among others.[29] More information about the Office of Broadband Development can be found in its annual report: http://www.mn.gov/deed/images/broadband-dev-report.pdf.

During the 2014 grant period, the Office of Broadband Development received 40 applications for broadband projects across the state, totaling $44.2 million. After reviewing the applications, the Office

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Notes for Image 2:

(a) 27 SF1918
(b) http://archive.leg.state.mn.us/docs/2009/mandated/091056.pdf
(c) Minn. Stat. § 237.012
(d) http://mn.gov/commerce/images/Broadband_Report__2010.pdf
(e) http://www.leg.mn/archive/execorders/11-27.pdf; http://mn.gov/deed/programs-services/broadband/task-force/index.jsp
(f) Minn. Stat. § 116J.39
(g) Minn. Stat. § 116J.395
(h) http://mn.gov/governor/newsroom/pressreleasedetail.jsp?id=102-163271
(i) https://www.fcc.gov/general/national-broadband-plan
(j) https://apps.fcc.gov/edocs_public/attachmatch/FCC-11-161A1.pdf
(k) www.fcc.gov/e-rate-update
(l) https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-10A1.pdf

Minnesota Session Laws, 2013 regular session, chapter 85 at Article 3, sections 13, 14, and 26.
[28] Minnesota Session Laws, 2014 regular session, chapter 312 at Article 2, section 2, and Article 3, sections 3 and 4.
[29] Minnesota Session Laws, 2014 regular session, chapter 312 at Article 3, sections 3.

funded 17 projects across the state (noted with blue flags in the map below), totaling $19.6 million.[30] More than half of the grant applications submitted in 2014, totaling $24.8 million, remained unfunded.

The 2015 Legislature allocated $10,558,000 to the Border-to-Border Broadband Development Grant Program. The Office of Broadband Development received 44 grant applications during the 2015 grant period for a total funding request of $29 million. In November 2015 the Office announced that it had awarded $11 million in grant funding to 15 recipients from across the state (noted with green flags in the map below), leaving unfunded $18 million in grant applications.

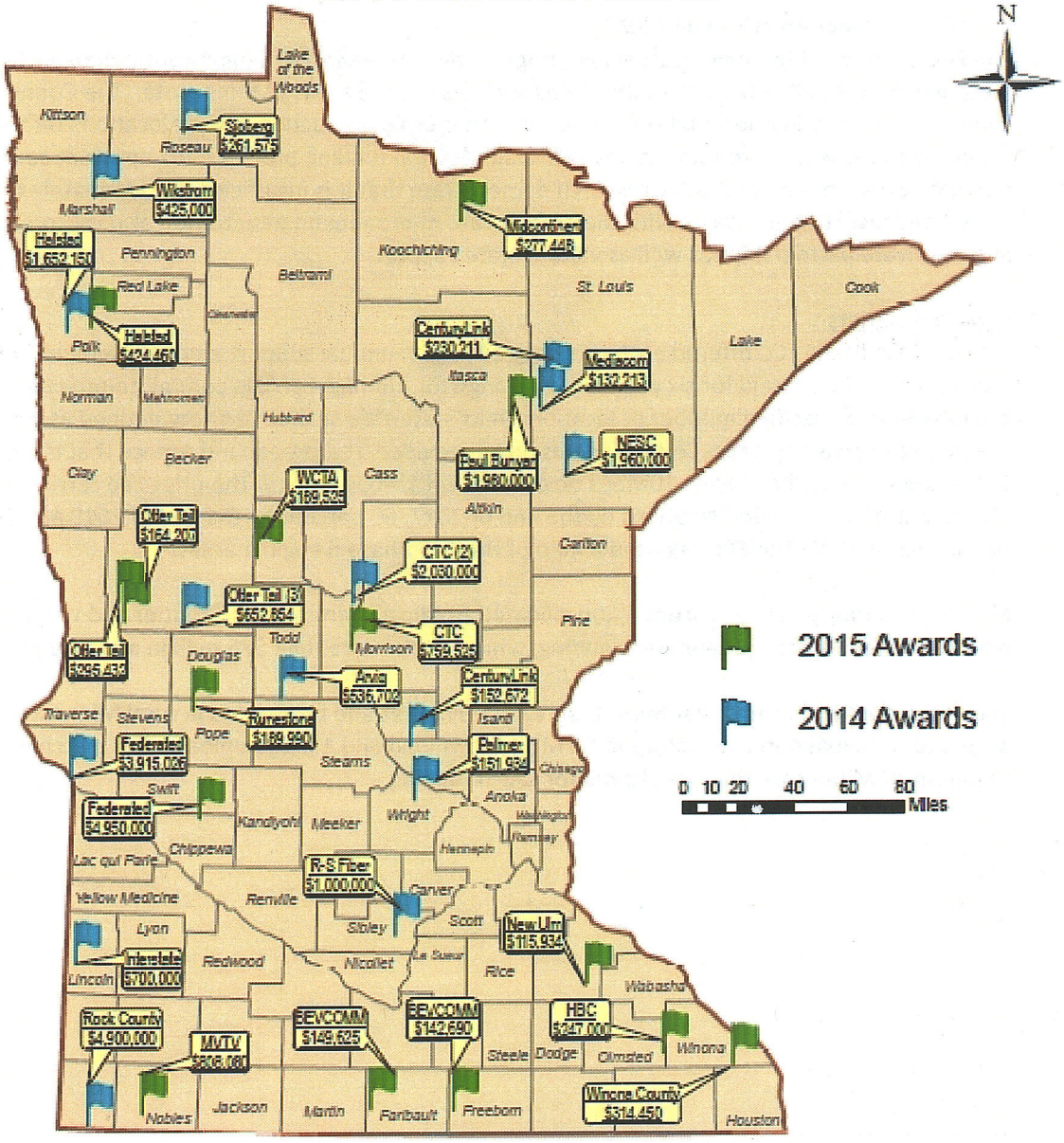
[30] For a complete list of grant applications and funded projects, visit http://mn.gov/deed/programs-services/broadband/grant-program/index.jsp.

Minnesota

Department of Employment and Economic Development

OFFICE OF BROADBAND DEVELOPMENT

Minnesota Border-to-Border Broadband Development Grant 2014 and 2015 Awards



Prepared by MN Office of Broadband Development 11/20/15

In addition to the creation and funding of the Office of Broadband Development and the Border-to-Border Broadband Development Grant Program, the legislature passed, and the governor signed into law, a number of bills that stemmed from recommendations of the Broadband Task Force. Some of this legislation includes: reinstating the sales tax exemption for telecommunications equipment (2014); the Minnesota Telemedicine Parity Law (2015); and efforts of schools to utilize one-to-one devices in the classroom (2015).

2. Connect America Fund (CAF) II

The FCC's reform of the universal service program that began in 2011 significantly changes the mechanism for funding telecommunications services in rural areas of Minnesota. The Connect America Fund (CAF) focuses support on broadband infrastructure construction in rural locations rather than supporting only voice communications. Although federal funding provides an important source of funding, experience and industry research demonstrate that it is insufficient to adequately fund broadband investment. States with the highest rate of broadband penetration also rely on public/private partnerships as well as vibrant state support.

Price cap carriers

In CAF Phase II, the FCC offered each price cap carrier an annual support amount, derived from a cost model, with support paid for six years. In exchange for funding, carriers commit to provide voice and broadband to a specified number of locations in its statewide service territory defined as high cost [31] that are not served by a competing, unsubsidized provider. The broadband service that is deployed with CAF II funding must be at least 10Mbps download and 1Mbps upload. The price cap carriers must reach 40 percent of their funded locations by the end of 2017, 60 percent by the end of 2018 and 100 percent by the end of 2020. The FCC released a map of the CAF Phase II eligible areas.[32]

Minnesota's four price cap carriers (Consolidated Holdings, CenturyLink, Frontier and Windstream) all elected to receive the model-based funding, which totals more than $85 million annually for six years.[33]

The FCC model anticipates that more than 170,000 homes and businesses in rural Minnesota will get access to broadband infrastructure at 10 Mbps download and 1 Mbps upload. The map below depicts the areas of Minnesota that are eligible for CAF II funding.

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[31] High cost locations are defined as falling above the specified cost benchmark, but below the extremely high-cost benchmark.

[32] *See* Connect America Fund Phase II – Accepted Areas Map, *available at* https://www.fcc.gov/maps/caf-2-accepted-map.

[33] *See* Connect America Fund Phase II Funding by Carrier, State, and County, *available at* https://www.fcc.gov/document/connect-america-fund-phase-ii-funding-carrier-state-and-county.

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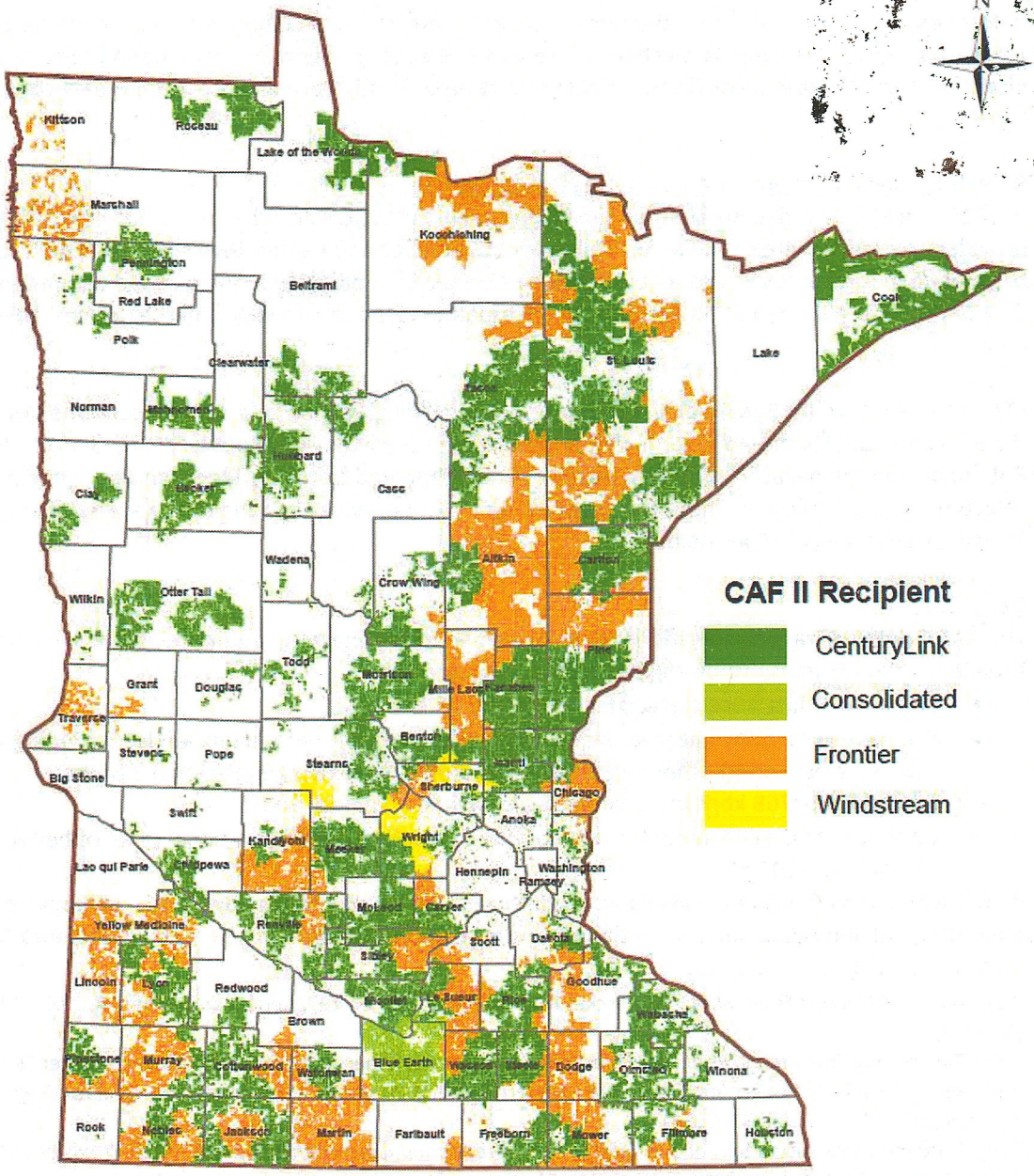
CAF II Eligible Area



0 10 20 40 60 80 Miles

Prepared by MN Office of Broadband Development 12/3/15

PUBLIC COPY

Rate of Return carriers

In December 2014, the FCC adopted a Report and Order implementing interim CAF support for rate-of-return carriers.[34] To continue receiving high-cost support, rate-of-return carriers must provide broadband at the standard of 10 Mbps download/1 Mbps upload upon reasonable request. If the request is unreasonable, but the carrier can reasonably meet the previous 4 Mbps download/1 Mbps upload standard, it must provide 4 Mbps download/1 Mbps upload.

Reform efforts for rate-of-return carriers continue to evolve. The FCC and industry are working toward establishing equitable support mechanisms to address legacy network investment and provide adequate incentive to modernize networks to provide robust broadband. Permanent reform is expected by mid-2016.

Rural Broadband Experiment Auction Areas in Minnesota

In 2015, the FCC awarded Rural Broadband Experiments (RBE) to test whether or not non-traditional providers, including wireless ISPs, rural electric cooperatives and competitive LECs could deliver broadband in rural areas in a more cost effective manner.[35] Following a single-round competitive auction, the FCC awarded $100 million to bring broadband under this experimental process to rural areas.

LTD Broadband LLC ($20 million), Lake County, ($3.5 million), Paul Bunyan Rural Telephone Cooperative ($1.9 million) and Federated Telephone Cooperative ($1.5 million) were provisionally selected to receive RBE funding in Minnesota.[36] LTD Broadband LLC was removed from consideration during the post-selection review process.[37] These Minnesota projects will provide broadband at a speed of at least 25 Mbps download and 5 Mbps upload.

Gaps

The CAF II program targets specific locations that meet rather narrow requirements for subsidized broadband deployment. To be eligible, a census block must:

- Be fully within a price cap carrier telephone service area,
- Not have access anywhere in the census block to current broadband service, including wired or fixed wireless service, that meets the (now outdated by two generations) 3 Mbps downstream/768 kbps upstream FCC broadband standard, and
- Under the FCC's cost model, have monthly deployment and operational costs of between $52.50 and $207.81.

If broadband service is already available at measured speeds of 3 Mbps download/768 kbps upload, or is built using CAF II funding but only to the minimum required standard of 10 Mbps download/1 Mbps

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[34] *See Connect America Fund, et al.*, WC Docket Nos. 10-90, 14-58, 14-192, Report and Order, FCC 14-190 (rel. Dec. 18, 2014).

[35] *See Technology Transitions, et al.*, GN Docket No. 13-5, *et al.*, Order, Report and Order and Further Notice of Proposed Rulemaking, Report and Order and Further Notice of Proposed Rulemaking, Proposal for Ongoing Data Initiative, FCC 14-5 (rel. Jan 31, 2014).

[36] *See Wireline Competition Bureau Announces Rural Broadband Experiments Support for 13 Provisionally Selected Bids is Ready to be Authorized*, WC Docket Nos. 10-90, 14-259, Public Notice, DA 15-1024 (Wireline Comp. Bur. Sep. 15, 2015); *Wireline Competition Bureau Announces Entities Provisionally Selected for Rural Broadband Experiments; Sets Deadlines for Submission of Additional Information*, WC Docket No. 10-90, Public Notice, DA 14-1772 (Wireline Comp. Bur. Dec. 5, 2014).

[37] https://apps.fcc.gov/edocs_public/attachmatch/DA-15-698A1.pdf.

upload, a gap will also exist between the FCC's new definition of 25 Mbps download/3 Mbps upload and also between Minnesota's current speed goals of at least 10 Mbps download/5 Mbps upload. By offering the price cap carriers the right of first refusal to the CAF II subsidy, the process favored the DSL services offered by the incumbent telephone company over other providers and other technologies.

To clarify, areas ineligible for CAF II funding:

- Have broadband services that exceeds 3 Mbps download/768 kbps upload, including service offered by a fixed wireless provider, anywhere in the census block (partially served census block).
- Lack broadband, but exceed the $207.81 high cost standard (extremely high cost locations).
- Exceed the total number of locations the price cap carrier committed to serve within a state. The total number of locations that a price cap carrier will serve was specified in the model results, with carriers able to modify that number until December 31, 2015, to reflect their own records.[38]
- Are located in rate-of-return company service areas where CAF II funding rules have not been established.

4. I-Nets

Information regarding institutional networks or I-Nets was provided to the Task Force at its February meeting. As described at that meeting, I-Nets were originally developed as part of a cable franchise for providing connectivity to municipal and county buildings, schools and libraries in partnership with the franchising entity. Today, some I-Nets continue to serve in the same role as they did historically, while others have evolved to co-mingled networks, dark fiber or managed services under different financial arrangements. Many communities continue to rely on I-Nets as they evolve. Therefore, I-Nets remain a consideration when understanding connectivity at the local government level.

5. E-Rate Fiber Potential

The FCC's Schools and Libraries program (referred to as "E-Rate") was created as a part of the federal Telecommunications Act of 1996. The goal of the E-Rate program is to make telecommunications and information services more affordable for schools and libraries in America. The amount of E-Rate funding to a school or library depends on its level of poverty and location. The discounts range from 20 to 90 percent, with higher discounts for higher poverty and more rural schools. The telecommunications equity aid fund was designed to help cover the remaining costs not funded by E-rate. However, that fund has not kept pace with the rising costs of telecommunications.

E-Rate was revamped in December 2014. E-Rate funding increased by $1.5 billion dollars (to a total cap of $3.9 billion). Several program changes that allow schools and libraries to focus on acquiring fiber optic connections were also made. School and libraries may choose to obtain traditional lit fiber (i.e. fiber that has electronics placed on each end enabling data to be transmitted), or may alternatively purchase capacity on dark fiber (i.e. fiber that has been deployed but is not being used) so that they don't have to be in charge of the fiber network; they may also choose to self-build their own networks if that is the most cost effective solution. The E-Rate program will provide an additional 10 percentage point match if the state matches that contribution.

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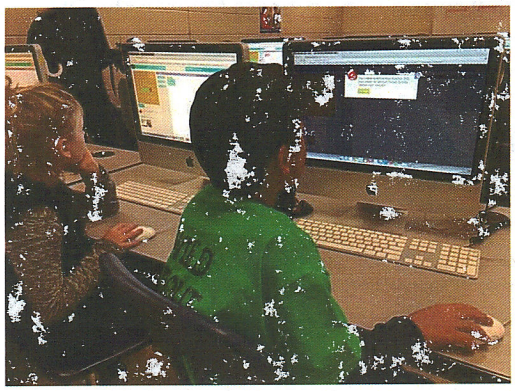
[38] In Minnesota, Frontier filed with the FCC indicating the eligible locations identified by the FCC cost model were overstated by 2,420 locations. On the other hand, CenturyLink has indicated that the number of locations it has committed to serve (114,739) based on the cost model is only 79 percent of the eligible locations its records indicate exist in the eligible census blocks.



"This historic FCC decision in support of $1.5 billion increase in the E-Rate program funding will help level the playing field in Minnesota by helping our students in low-income and rural communities have access to today's digital learning environment."

Denise Dittrich, MSBA, Broadband Task Force member

The growing importance of the Internet in connecting students to digital learning and information is creating increasing demands for bandwidth in schools. In 2014, responding to this need, the FCC adopted the E-Rate Modernization Order and the Second E-Rate Modernization Order as a part of a comprehensive review to modernize the program.[39]

6. Community Efforts to Expand Broadband

Communities across the state and the nation are working to bridge the gap in broadband access. For example, the Blandin Foundation has led statewide rural broadband efforts over the past decade, with resources directed towards stimulating and supporting both community-based infrastructure development and technology adoption. Blandin's efforts significantly accelerated just over five years ago when an American Recovery and Reinvestment Act (ARRA) grant award funded the Minnesota Intelligent Rural Community program (MIRC). Statewide partners included the Regional Development Commissions, the Minnesota Department of Employment & Economic Development (DEED), University of Minnesota (UM) Extension, Minnesota State Colleges and Universities System (MnSCU), PCs for People, and the Minnesota Renewable Energy Marketplace (MNREM).

Eleven demonstration communities created teams and implemented broadband adoption programs. School districts and various non-profits within the MIRC communities used MIRC funds to provide digital inclusion training to older adults, new Americans, and people with disabilities.

PCs for People, a 501(c)(3) non-profit, continues to expand its relationships with rural communities for collection and distribution of used personal computers. PCs for People has grown from supplying just over 1,000 computers to low-income families per year to just under 10,000 computers per year and now works in multiple states.

Regionally, both the Northwest Minnesota Initiative Foundation and Region Five Development Commission in central Minnesota continue their efforts to promote broadband network deployment and adoption efforts. The Upper Minnesota Valley Regional Development Commission in west central Minnesota is working on both network development and online inter-governmental collaboration.

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[39] www.fcc.gov/e-rate-update.

The RS Fiber Cooperative in Renville and Sibley counties is one of several innovative cooperative-based approaches. Anchored by existing agricultural and electric cooperatives and buy-in from cities and township governments in the counties, RS Fiber was formed as a broadband cooperative to deliver fiber to the home (FTTH) services in rural communities and provide rural high-speed wireless with a partner provider, Hiawatha Broadband Communications. The cooperative has a plan to ultimately deliver fiber-based services throughout its service territory.

Annandale, Minnesota has been pursuing improved broadband services for several years and has recently reached agreement with Midcontinent to build a new network providing a more competitive situation for Triple Play services (Internet, video & voice) in the community.

Additionally, Chisago Lakes is now in the midst of the America's Best Communities' competition sponsored primarily by Frontier Communications. Chisago Lakes is one of 50 quarter-finalists competing to be one of eight semi-finalists, each of which will receive $100,000 to implement their economic revitalization plan over the next year with the top three performing communities winning $3 million, $2 million or $1 million dollars. Chisago Lakes' plan includes a community technology center, social media marketing, and community Wi-Fi hot spots.

Communities such as Red Wing, Minnesota, Chattanooga, Tennessee and Kansas City, Missouri have all announced the deployment of gigabit Internet service (1,000 Mbps is the equivalent of 1 Gbps). In addition to providing ultra-high-speed broadband, these projects are also associated with economic development. In Red Wing, for example, the project is designed to provide public benefit in six areas of strategic importance: education and work force development, health care, advanced manufacturing, public safety, clean energy, and transportation.

Chattanooga leveraged its 10 Gbps network to attract Volkswagen and Amazon. More than 2,000 jobs created in Chattanooga over the last five years can be attributed to the establishment of the gig network. As part of Google Fiber, Google announced that it will deploy a gigabyte network throughout Kansas City. Leveraging this deployment, Kansas City has generated $1.25 million in direct financial support for programming and technology projects in digital inclusion, health care, education, events and community investment.

Despite the work that cities and counties are doing throughout Minnesota, more work remains to be done to close the gap between those with access to broadband and those without access to broadband. The efforts currently under way illustrate a willingness for communities to work together to expand broadband access. Additional funding for the Border-to-Border Broadband Development Grant Program will further stimulate partnerships between communities and broadband providers.

7. Continued Private Investment

The telecommunications industry in Minnesota continues to make significant investments in capital expenditures. In 2015, the telecommunications industry invested more than $553 million in capital expenditures.[40] This investment was directed toward upgrading existing plants, extending fiber further into networks, including fiber to the node and fiber to the premises. Private investment also replaced electronic equipment in central offices or headquarters, as well as adding, replacing or upgrading

[40] This figure is based on a survey of 28 members of the Minnesota Telecom Alliance, a non-profit trade association representing Minnesota's telecommunications industry.

equipment to maintain networks and cellphone towers. In 2016, the telecommunications industry is expected to invest more than $563.5 million in capital expenditures.

V. Barriers to Expanding Access to Broadband

1. Telecommunications Reform

Over the last 20 years, advancements in telecommunications technologies have dramatically changed our world. Today, Minnesota families and businesses are not only using, but demanding, new and innovative products that require faster and more advanced broadband networks and technology. The public switched telephone network (PSTN) is rapidly becoming displaced by a borderless IP "network of networks" that erases traditional jurisdictional dividing lines that characterized the "public utility" regulation model of the 20th century. Moreover, competitive alternatives to voice services are ubiquitous. Wireless voice and data services, text messaging, social media, video conferencing and the so-called "Internet of Things" have reduced voice services from the predominant method of communication to one of many applications consumers use to communicate.

Yet while technology has transformed our state, Minnesota's communications laws remain rooted in the past. The state has not updated its communications laws in over 20 years. In order to remain competitive and attract new investment in broadband to our state, Minnesota must take action to update its telecom laws to reflect today's world.

Today, two-thirds of Americans have chosen wireless or Internet-based (IP) services as alternatives to traditional telephone service – and another 450,000 people join them every month. Consumer and business demand for these new technologies is not only driving our economy, but advancing lives. A regulatory environment that encourages investment and innovation in broadband technologies, regardless of the technology used to deliver the service is critical for future growth in Minnesota's economy.

Already, over 30 states across the country have passed legislation to modernize their telecom laws and keep communications free from outdated rules not designed for today's IP world. Minnesota should pass similar legislation to help spur innovation, attract high-tech investment, develop rural broadband and showcase the state as a good place to do business.

A recent study by the Pell Center for International Relations and Public Policy "State-Level Broadband Policy" (September 2015) cited telecom reform legislation as a major component to the elements of good broadband policy. "To serve the public good, states should consider telecom modernization bills ensuring that residents have access to affordable and reliable communication service, including broadband."

Minnesota risks being left behind as neighboring states and states across the country enact legislation to make their states and cities more attractive for investment in broadband and the latest IP technologies. Minnesota's telecommunications laws need to be reformed to reflect the modern communications era, bringing regulatory certainty, competitive equity, and relevance to an industry in the midst of dramatic change.

2. Affordability

Broadband affordability remains a hurdle to expanding broadband access. The Pew Research Center shows that 96 percent of households earning greater than $50,000 annually are Internet users, compared to only 74 percent of households earning less than $30,000 annually.[41]

In Minnesota, more than 80 percent of residents in the ten wealthiest counties have access to broadband with download speeds greater than 25 Mbps; only three of the poorest counties can say the same.[42] Lower-income Minnesotans often do not have sufficient disposable income to afford broadband Internet access. Almost 20 percent of non-Internet users cite price as the reason they do not subscribe to the Internet. Lower income Minnesotans must have affordable access to the Internet for job searching, access to distance medical and educational opportunities. Discount programs – such as Lifeline from Midcontinent, Internet Essentials from Comcast, and Internet Basics from CenturyLink – are available to help reduce the financial impact on qualified low-income families.

For Minnesota schools, the cost of broadband can vary greatly between regions of the state. School districts purchase commercial-grade service that is dedicated and often need to buy transport (usually leased fiber) to get service to the school since most schools, especially those in rural areas, do not own fiber. The cost of leasing fiber can also vary based on geography, from $2.32/Mbps/month in east-central Minnesota to $23.46/Mbps/month in southwest Minnesota.

The cost of broadband access can range from $1.00/Mbps/month in south-central Minnesota to $9.72/Mbps/month in southwest and west-central Minnesota to $11.67/Mbps/month in northeast Minnesota.[43] EducationSuperHighway notes that the average cost of Internet access for schools in Minnesota is $10/Mbps/month while the mean of the top quartile of schools is $2.50/Mbps/month.[44]

E-Rate reimbursements and Minnesota Telecommunication Equity Aid help to offset these disparities, but there is still a large gap that exists, and costs will continue to rise as districts need more and more bandwidth.

VI. Policy Recommendations

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[41] *See* http://www.pewinternet.org/2015/09/22/digital-divides-2015/.

[42] *See* National Broadband Map, *available at* http://www.broadbandmap.gov/rank/all/county/minnesota/percent-population/demographics-income-median-income/ascending/speed-download-greater-than-25mbps.

[43] Provided by Marc Johnson of East Central MN Educational Cable Cooperative (ECMECC).

[44] http://mn.gov/deed/images/education-superhighway.pdf, slide 23.

APPENDIX A

Task Force Report Definitions

2G: Second generation wireless service. This level of wireless service was fundamentally used for voice communication and very basic data communication.

3G: Third generation mobile system. This level of wireless service includes voice communication and data service that provides up to 2 megabits per second or roughly equivalent to a DSL service.

4G: Fourth generation cellular wireless network. This level of wireless service can achieve download speeds of 10 to 20 Mbps.

ARRA: America Recovery and Reinvestment Act of 2009. An economic stimulus package signed by President Obama on February 19, 2009 to save and create jobs, to provide temporary relief programs and to invest in infrastructure, health, education and renewable energy. The package included approximately $7.2 billion for broadband programs, including the State Broadband Initiatives (SBI) program for broadband mapping, and the Broadband Initiatives Program (BIP) and Broadband Technology Opportunities Program (BTOP) for broadband infrastructure investment.

Bandwidth: The capacity of a telecom line to carry signals. Bandwidth is measured in bits per second.

Broadband: Evolving digital technologies that provide consumers a signal switched facility offering integrated access to voice, high-speed data service, video-demand services, and interactive delivery services.

Cable Broadband: High-speed Internet access provided by a cable TV company over its cable network.

CAF: Connect America Fund. The FCC replacement program for traditional universal service funding and deployed in two phases: CAF I and CAF II. Reforms have not been completely implemented for the smallest, rural carriers.

Dark Fiber: Fiber that has been deployed but is not being used.

DEED: Minnesota Department of Employment and Economic Development.

Download: To receive data from another computer or host computer (commonly referred to as the Internet) to your computer.

DSL: Digital Subscriber Line. A generic reference to the broadband provided by local telephone companies and competitors over a traditional copper network.

E-Rate: A federal discount program to assist schools and libraries with the cost of telecommunications infrastructure and services. The program has transitioned from voice service to broadband and Wi-Fi services.

EducationSuperhighway: A non-profit focused on upgrading the Internet access in every public school classroom in America.

FCC: Federal Communications Commission. Federal agency responsible for regulating telecommunications carriers and the services they provide.

Fiber Network: A telecommunications network based on the use of optical fiber ("Fiber Optics"). Instead of using electricity run over copper-based cables, a fiber network sends information using LEDs or lasers, which can travel at the speed of light. Wireless networks and many broadband networks rely on fiber to provide adequate capacity to carry data.

FTTH: Fiber to the home. A communications network where fiber is used all the way to the home.

Gigabyte: Technically defined as 2^{30} bytes. Commonly thought of as 1,000 megabytes, or approximately 1 billion bytes.

Landline: Traditional wired telephone service. Also referred to as Plain Old Telephone Service.

Lifeline: The Lifeline program is administered by USAC and is a federal program that provides a monthly discount of $9.25 on landline or wireless phone service to qualifying low-income households. Tribal households receive a discount of $34.25 to account for the higher costs of serving Tribal lands.

Lit Fiber: Fiber which has electronics placed on each end enabling data to be transmitted.

LTE: Long-Term Evolution. LTE is a wireless communication standard for mobile phones. Commonly marketed as "4G LTE," this level of wireless service includes voice communications and data service that provides up to 40 megabits per second download speeds.

Megabyte: Technically defined as 2^{20} bytes. Commonly thought of as 1,000,000 bytes.

MNPUC: Minnesota Public Utilities Commission. The MPUC is the State of Minnesota's regulatory agency, with oversight over telecommunications, electric and natural gas companies. The MPUC is a quasi-judicial agency that has both rulemaking and dispute settling authority.

OBD: Office of Broadband Development. Governor Dayton created the OBD in 2013 to facilitate border to border broadband connectivity in Minnesota. The OBD is located in DEED.

Price Cap Carrier: A term used by the FCC to classify the larger investor-owned telephone companies for purposes of the Connect America Fund.

Rate of Return Carrier: A term used by the FCC to classify the smaller telephone companies that generally serve in rural areas.

RBE: Rural Broadband Experiments. A $100 million program designed by the FCC and administered by USAC to fund new, robust broadband networks in rural areas.

RUS: Rural Utilities Service. Division of the United States Department of Agriculture that provides critical grant and loan support for rural broadband.

Terabyte: Technically defined as 2^{40} bytes. Commonly thought of as 1,000 gigabytes, 1 million megabytes, or 1 trillion bytes.

Underserved: By Minnesota law §116J.394(h), underserved areas means areas of Minnesota in which households or businesses lack access to wire-line broadband service at speeds that meet the state broadband goals of ten to 20 megabits per second download and five to ten megabits per second upload

Universal Service: The financial mechanism which helps compensate telephone companies or other communications entities for providing access to telecommunications services at reasonable and affordable rates throughout the country, including rural, insular and high costs areas, and to public institutions.

Unserved: By Minnesota law §116J.394(i) unserved areas means areas of Minnesota in which households or businesses lack access to wire-line broadband service at the FCC definition of broadband, currently 25Mbps download and 3Mbps upload.

Upload Speed: The performance of an Internet connection, as measured by the number of bytes per second that data travels from a device to the Internet.

USAC: Universal Service Administrative Company. USAC is the non-profit company that manages the contributions to and distributions from the Universal Service Fund. USAC oversees several programs, including Lifeline, E-Rate, and Rural Health Care.

Wi-Fi: Incorrectly believed to mean "Wireless Fidelity" when in actuality it is not an abbreviation. Wi-Fi is the wireless networking technology that allows computers, phones, and other devices to communicate via wireless signal.

APPENDIX B

Detailed Descriptions of Technologies Used to Deploy Broadband

Fiber: Data is transmitted over a hair thin strand of glass using light signals over fiber optics. There are two main types of Fiber to the Home (FTTH) systems that can be used to ensure that the transmitted data gets to its proper destination. The two types of systems are active optical networks and passive optical networks. An active optical network uses electrically powered switching equipment to manage and properly distribute the light signals. Under this network, a customer may have dedicated fiber running to the home. A passive optical network uses optical splitters to manage and distribute the light signals. Fiber strands are shared for portions of the network. Electric power is only required at the originating and receiving ends of the signal.

Active optical networks have the advantage of using Ethernet technology so interoperability among vendors is facilitated. Customers can also select hardware that meets their needs and change out the hardware as those needs increase. Drawbacks include reliance on power, so less reliable than a passive optical network. Active optical networks also require switching equipment for every 48 customers.

The advantages of passive optical networks include each fiber strand being able to serve up to 32 users, and lower building and maintenance costs than active optical networks. Disadvantages include a lower range so customers have to be geographically closer to the central source of data, greater difficulty in isolating a failure, and because of shared usage there can be slowdowns during peak demand periods.

DSL: Digital Subscriber Line (DSL) is the family of technologies that provide digital data over the wires of a local telephone network. DSL is commonly used by traditional wireline telephone companies to deliver broadband service to consumers and small businesses. Over the years speed levels have increased dramatically. In the early 2000s, high end broadband speeds of 640 kbps and 1.5 Mbps were common. Today, telecommunications providers are offering speeds up to 100 Mbps through DSL due to hybrid fiber-copper networks and improved electronics in the network.

The most common DSL deployment in Minnesota today is through Fiber-to-the-Node (FTTN). FTTN networks rely on fiber from the central office to the neighborhood node and then ride on the existing copper network to the home. FTTN networks can achieve speeds up to 100Mbps depending on the distance of the end user from the node. FTTN networks are fully capable of providing a quality IPTV product.

In recent years, DSL acceleration techniques have been developed, such as vectoring and bonding. These techniques increase the maximum speed over the existing copper network. Bonding is the term applied to combining copper pairs to increase the total capacity of the communications channel to increase speed or extend the reach. Vectoring is a technology that reduces crosstalk between signals that results in optimization of the copper facilities.

Finally, G.fast trial deployments are underway that may result in speeds up to 1Gbps. G.fast is a DSL standard for relatively short local loops.

Cable: Data over a cable TV system has been around for years. In the 1980s, a service called Express would bring updated news, weather and stock market information to the desktop. In the earlier 1990s, several companies developed Internet based data transfer systems. The critical problem was that these products were not interchangeable. That changed in 1997 when CableLabs developed the DOCSIS (Data

Over Cable Service Interface Specifications) standards for the worldwide market. Now, a person with a DOCSIS modem can take it with them when they move and not have to buy another cable modem in the next community they live in.

The first DOCSIS 1.0 modems delivered the then astounding speed of 20 Mbps. This was followed by evolutions of DOCSIS 1.1, 2.0, 3.0 and 3.1. And speeds have risen significantly. The currently deployed DOCSIS 3.0 is enabling speeds of over 1Gbps download and 245 Mbps upload. The DOCSIS 3.1 standards which will be deployed in 2016 are capable of download speeds of 5 Gbps and upload speed of 1Gbps.

The DOCSIS service has traditionally run over a coaxial fiber hybrid system where the signals are sent out of the cable company's headend/central office to receiving nodes that generally serve 500 homes. The transportation to the individual customers is via coaxial cable. As data loading has increased, cable operators are moving the receiving nodes closer to the customer, reducing the amount of coax in the circuit. Coaxial cable has a theoretical upper bandwidth of 6 gigahertz. Current technology allows for 6 bits per hertz meaning that coaxial cable is capable of moving 36 Gbps in one direction or 18 Gbps symmetrically.

Two newer protocols are Fiber Deep and Passive Coax. Fiber Deep, as the name implies, is used to place fiber deep into the neighborhoods and business areas. This reduces the amplifier cascades and improves performance and reliability. Passive Coax brings the fiber to the curb so that there are no active devices other than the node. Since there are no additional electronics to maintain, reliability and bandwidths are further enhanced. Both technologies are currently being rolled out in cable systems in Minnesota.

Cable operators use PON (Passive Optical Networks) as a method of delivering specialized higher and symmetrical bandwidth to customers who need high capacity services today. The PON is used as an extension of the company's existing fiber network. These PON networks have the following capacities:

1) BPON -A typical BPON provides 622 megabits per second (Mbps) of downstream bandwidth and 155 Mbps of upstream traffic.

2) GPON -The standards permit several choices of bit rate, but the industry has converged on 2.488 gigabits per second (Gbps) of downstream bandwidth, and 1.244 Gbps of upstream bandwidth.

3) EPON/10G EPON – EPON provides symmetric 1 gigabit per second upstream and downstream rates. 10G EPON provide speeds of 10 Gbps downstream and 1 Gbps upstream. EPON/10GE PON is applicable for data-centric networks, as well as full-service voice, data and video networks.

Many cable operators in Minnesota are also using Radio frequency over glass (RFoG). It is a type of passive optical network that transports RF signals over fiber that were formerly transported principally over the hybrid fiber cable. In the forward direction RFoG is either a stand-alone Point 2 MultiPoint system (i.e. a cable system) or an optical overlay for existing PON such as GEPON/EPON. The overlay for RFoG is based on Wave Division Multiplexing (WDM) -- the passive combination of wavelengths on a single strand of glass. One of RFOG's advantages is that it does not require a new type of technology in the Headend/central office, nor does it require new test equipment or comprehensive training of the tech staff.

Fixed Wireless: Fixed wireless system may be designed with both point-to-point and point-to-multipoint topologies. A point-to-point being more similar to a dedicated connection, i.e. dedicated T-1, DS3, FTTH, while point-to-multipoint is considered a shared system, i.e. DSL, Cable, PON fiber systems. Point-to-point fixed wireless radios currently can sustain throughput greater than 1Gbps.

Performance of fixed wireless systems are dependent on the technologies employed and the selection of services offered. Wi-Fi or WLAN (Wireless Local Area Network) implementation, based on IEEE 802.11a/b and extensions, generally operate in the unlicensed ISM bands of 2.4GHz and 5.8GHz. Early implementation within FCC licensed spectrum of the 2.3GHz and 2.5GHz bands employed a converged platform utilizing the ITU DOCSIS (Data Over Cable Service Interface Specification) standard called wireless cable. Wireless Metropolitan Area Networks or WMAN, as defined in IEEE 802.16a-d and extension to 16e-2005 for mobility, represented the next generation of fixed wireless, TDD and WiMAX systems. Systems within this last group have been developed across a broad spectrum of frequencies; 700MHz, 2.4GHz, 2.5GHz, 3.65GHz, 4.9GHz, and 5.8GHz comprise the majority of frequencies utilized by these systems. Current subscriber radios can operate at speeds within the 10-20 Mbps+ speeds across a 100Mbps interface.

Convergence is occurring within the next evolution of fixed wireless coinciding with the 3GPP (3rd Generation Partnership Project) standards. 3GPP has defined an all-encompassing roadmap (GSM through LTE; 2G-4G cellular technologies) with LTE-Advanced standardization. Fixed wireless systems are currently being deployed under the LTE umbrella with a roadmap to LTE-Advanced. The long-term objective of the LTE-Advanced standard is to sustain a subscriber interface at 1000Mbps (1 Gbps) of throughput and maintain/expand all current services for voice, video, data.

Wireless: Consumers have adopted new, Internet-based technologies and mobile connections at an unprecedented rate. Internet-based products and devices, including smartphones and tablets, allow mobile access to applications like mobile health, distance learning, social media and a host of video-conferencing services, and are providing consumers everywhere with new choices to connect, to communicate, and to access information and entertainment. IP (Internet Protocol) technology allows consumers to use a range of devices – anything from your TV, phone, laptop and tablet -- to seamlessly communicate using voice, data, and Internet applications on wireless and wireline networks—opening the door to boundless opportunities.

People are actively choosing new and innovative products, services and devices that require faster, more robust and more advanced technology—whether wired or wireless. Every month, 450,000 consumers switch to phone services that run on wireless and Internet-based networks. In fact, across America in 2013, two in every five American adults lived in homes that were wireless-only and 40.2 percent of homes utilized VoIP.

Consumers no longer just use a phone to make a voice call. Now we use our cell phones, smartphones, tablets, netbooks, e-readers, laptops and more to communicate using more than just voice – through these new products and devices we can now share our schedules, photos, business plans, documents, contacts, location and thoughts. In 2013, Global Mobile Data Traffic grew by 81%, nearly 18x the size of the entire global Internet in 2000. By the end of 2014, the number of mobile-connected devices exceeded the number of people on earth. Increasingly, smartphones are the product of choice to perform these functions; as of January 2014, 58 percent of adults in the United States own a smartphone.

IP technology can also be a leading economic force. A 2013 study conducted by research firm Information Age Economics projects that wireless infrastructure investment will generate as much as $1.2 trillion in economic growth while creating 1.2 million new jobs over the next five years.

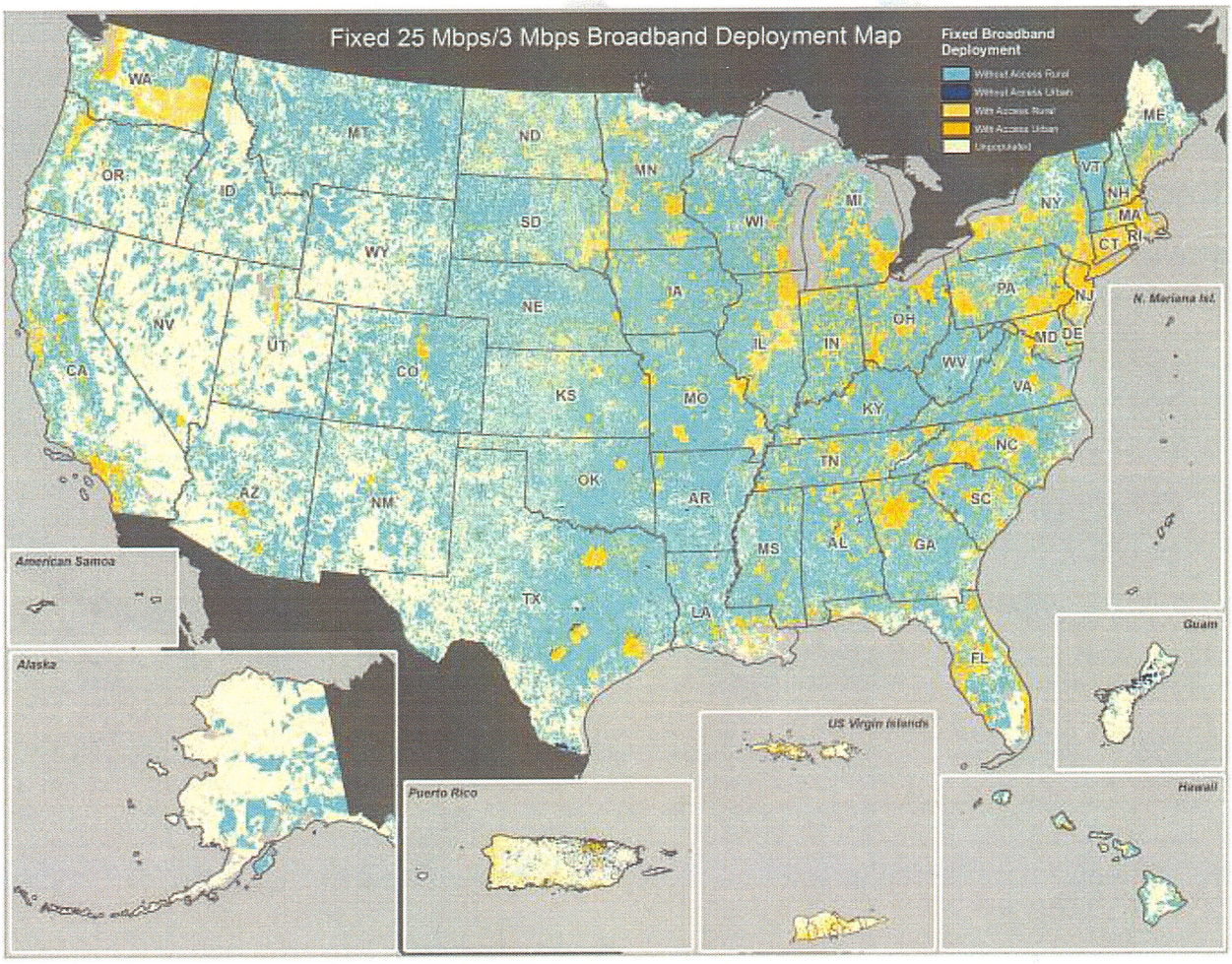
Appendix C

National and International Broadband Rankings

Minnesota is amongst the 18 states listed as having 100 percent availability at speeds of 3 Mbps download and 768 kbps upload according to the National Broadband Map (Data as of June 30, 2014.)

Minnesota is 42nd (between the United States at #41 and Slovenia) out of a combined 109 geographies (108 qualifying countries plus Minnesota) with an 80.49 percent adoption rate as measured by Akamai. Bulgaria and South Korea and ranked first and second, respectively, with adoption rates of 96 percent. This number considers broadband connections at 4 Mbps and above (download) compared to all connections in that state or country, to determine its broadband adoption rate. Thus, it is not a measure of adopters versus non-adopters but does allow for an adoption comparison to other countries.

The map below illustrates areas of the country that are meeting and failing to meet the FCC's broadband speed definition of 25 Mbps download and 3 Mbps upload (based on December 2013 data).



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