PIMA ASSOCIATION OF GOVERNMENTS

Regional Assessment of Advanced Communications Infrastructure

Magellan ADVISORS

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FINAL

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1.1 ABOUT PIMA COUNTY

Pima County is in the south-central region of the U.S. state of Arizona, and includes the Tucson, Arizona, metropolitan statistical area. The county seat is Tucson. The county covers over 9,187 square miles with a population density of 106.7 people per square mile, almost twice the statewide average of 56.3. The county is named after the Pima Native Americans who are indigenous to Arizona.

Other urban areas include the Towns of Marana, Oro Valley and Sahuarita; the City of South Tucson, and a large ring of unincorporated urban development, including the growing unincorporated community of Green Valley. The rest of the county is sparsely populated; the largest towns are Sells, the capital of the Tohono O'odham Nation, and Ajo in the county's far western region.

Pima County contains parts of the Tohono O'odham Nation and the Pascua Yaqui Tribe reservations, as well as all of the San Xavier District of the Tohono O'odham reservation, Organ Pipe Cactus National Monument, Ironwood Forest National Monument and the eastern and western sections of Saguaro National Park.

1.2 ABOUT PIMA ASSOCIATION OF GOVERNMENTS AND THIS STUDY

Pima Association of Governments ("PAG") is a Tucson-based, federally designated metropolitan planning organization, operating as a 501(c)4 not-for-profit entity. PAG's mission is to address regional issues through cooperative efforts and pooled resources, and to provide accurate, relevant data that leads to effective regional planning decisions. PAG members include the Cities of South Tucson and Tucson, the Towns of Marana, Oro Valley and Sahuarita, Pima County, the Pascua Yaqui Tribe, the Tohono O'odham Nation, and the Governor-appointed Pima County representative of the Arizona State Transportation Board ("ASTB"). The ASTB representative votes on transportation matters only.

PAG contracts with the Regional Transportation Authority ("RTA"), which is the fiscal manager of a 20-year RTA regional transportation plan and sales tax through June 2026. PAG also established a nonprofit affiliate, the Regional Partnering Center ("RPC", which advances policies, practices and solutions to regional planning, environmental and energy challenges in Pima County. One of PAG's committees is the Economic Vitality Advisory Committee (EVAC), which seeks ways to align the region's transportation planning efforts with economic development opportunities. EVAC members are representative of PAG's member jurisdictions, including city and town managers, along with representatives of higher education institutions and organizations focused on economic development.

Competitively priced broadband is acknowledged to be a key factor in enabling economic development and long-term growth in Pima County and the region. EVAC and PAG both recognize that broadband alone is insufficient to attract new businesses. A lack of high-speed broadband

services, however, can disqualify the region and may cause companies to choose not to locate in Pima County.

Upon the recommendation of the EVAC, PAG issued a Request for Proposals ("RFP") to select a strategic consultant for Advanced Communications Infrastructure ("ACI"). PAG commissioned Magellan Advisors (Magellan) to perform a Regional Assessment of Advanced Communications Infrastructure. ACI includes physical plant and infrastructure, policies and governance to support high-speed broadband for economic development and quality of life improvements.

The objectives of this Regional Assessment were to evaluate current broadband offerings, survey current uses and limits, identify opportunities for expansion of the infrastructure, and enable economic development and regional growth utilizing broadband.

1.3 SUMMARY OF METHODOLOGY AND RESULTS

Magellan initiated an assessment kickoff meeting at Pima Association of Governments' (PAG) offices in Tucson. PAG issued invitations to all its members, local interested parties, local and regional economic development entities, utilities, communications providers, members of Arizona State Agencies, and groups interested in providing or seeking advanced communications infrastructure, to encourage expansion of high-speed communications, and to promote economic development.

Following the kickoff, Magellan analyzed and summarized the benefits of ACI on economic development activities, on increasing opportunities for government innovation and services, including improved transportation efficiency, and on improved and enhanced community and public safety applications. Other applications of ACI include improved municipal efficiency, adoption of 5G and other wireless technologies, more efficient and complete environmental monitoring, better and broadened use of utilities to support communications, and a more connected community generally. "Evaluation of Regional Benefits," Section 2, details the findings.

In parallel, Magellan, through PAG, constructed a regional survey, of which the link was sent to city, town, and tribal nation members, local businesses, and through several chambers of commerce to their memberships. PAG managed the outreach and solicitation for survey responses. Survey questions included location, usage, information on nominal and actual measured bandwidth speeds, along with import of broadband on respondent operation. Survey results consistently suggest that there is need for improvement in value, with lower pricing and higher speeds required; that broadband is an increasingly important part of most businesses plans. Magellan assessed Federal Communications Commission "FCC") data collected from commercial providers and the Tohono O'odham Utility Authority, analyzing coverage by ZIP code for each of the major providers in Pima County, and developed maps comparing coverage. Magellan studied commercial long-haul and dark fiber networks in the region. The data reveal that investment in advanced communications infrastructure, such as fiber optics by third-party private companies, is mainly limited to the City of Tucson. This leaves much of the PAG region, especially more rural areas where development is beginning to boom, without access to robust, reliable high-speed internet that will support the coming economic growth in the area. Magellan details this information, along with analyses of many survey questions, in the "State of the Market Report," Section 3.

Magellan, along with PAG's project team, interviewed many organizations to assess needs and to establish a forward plan for the region. Magellan conducted seventeen (17) interviews, including with PAG members and staff; with PAG's member cities and towns; with economic development groups; with the Arizona Department of Transportation ("ADOT"); with the Arizona Commerce Authority ("ACA"); with the Transportation and Technology Policy Advisor in Governor Ducey's office; with the University of Arizona and Arizona State University; with Pima Community College; with the Pima County Wireless Integrated Network ("PCWIN"), which supports interoperable communications for public safety agencies throughout the region; with some local carriers, and with local technology organizations. Using this input and the contributions of the county's Economic Development Office, Magellan developed a list of planned initiatives which can be leveraged to expand the region's advanced communications infrastructure in key areas where roadwork, commercial development, and other growth-enabling activities are taking place. This includes such varied projects as Arizona's Smart Highway Corridors project, which, if funded, will install conduit, fiber, and transportation safety technologies along I-19, south from Tucson to Nogales, to strategic development projects, such as the future I-10 ADOT new traffic interchange at Houghton Road, to regional development projects, such as the several hundred-acre development at Vail Crossings. A complete list of the candidate projects which can be leveraged is included in "Assessment of Current State of Broadband," Section 4.

A complete assessment of Arizona and tribal nation regulatory considerations is also provided in Section 4, covering Federal and State Laws, Policies and Regulations. Most significant of these are the Dig Once and Joint Trench policies, which would encourage, if not require, the placement of conduit along new road and public work projects. Placement of conduit while trenches are open can be achieved at marginal cost and, with the bulk of project money committed through other funding sources, can provide great leverage of advanced communications infrastructure inexpensively. Also discussed are wireless ordinances, to support 5G and other wireless communications, and master licensing agreements with communications providers, which can enable the exchange of services and reciprocal use of assets to benefit the region.

1.4 SUMMARY OF RECOMMENDATIONS

Magellan recognizes that PAG is a council of governments, which itself does not administer nor directly manage local assets, operations, or policies. PAG can, however, be an advocate with its members for development and adoption of consistent, if not identical, policies and governance frameworks. PAG can support outreach with its members and other public or private entities, encouraging collaboration, exchange of ideas, capabilities, and use of assets, to enhance economic development within the region and county. As such, Magellan makes the following recommendations:

Establish Master Agreement Among Entities to Plan ACI Expansion

PAG should work to establish a Master Agreement ("Agreement") to govern coordination, communication and outreach initiatives for the Advanced Communications Infrastructure initiative. The most likely candidate for the lead coordination role is PAG.

Parties to the Agreement would include the nine PAG member entities, including: Pima County; the Cities of Tucson and South Tucson, the Towns of Oro Valley, Sahuarita and Marana, the Tohono O'odham Nation and Pascua Yaqui Tribe, and the Arizona Department of Transportation.

The scope of the agreement would cover planning for conduit expansion, fiber expansion, communications and outreach.

Coordinate Countywide Ordinances and Policies to Support Broadband

PAG should work to define and standardize key broadband governance and policy frameworks for the county and the PAG municipalities and tribal entities. Once defined and agreed upon, these can be submitted through the two City and several Town Councils, the Pima County Board of Supervisors, and the Tribal Councils for their individual approvals.

These ordinances and policies include Dig Once with Joint Trenching policies, Master Licensing Agreements ("MLAs"), and Wireless Ordinances. Dig Once and Joint Trenching policies control right-of-way management and coordination while reducing construction, installation, and road resurfacing costs when installing conduit, fiber and other utilities. Wireless lease agreements for 5G pole attachments support 5G networks, WiFi, and Smart City applications that will promote economic development and enhance county and cities' services.

PAG, supported by ADOT, can provide leadership on these policies to enhance the likelihood of adoption. ADOT's Smart Highway Corridors program, down Interstate 19 south of Tucson, originally planned to begin this coming year[1], will be proving ground for these policies, likely starting in Tucson.

Finally, PAG should advocate on the value of including terms for conduit expansion and fiber expansion into cities' and towns' Development Agreements in both residential and industrial areas. These agreements should include placing conduit with innerduct capacity in new development areas to support multiple providers being able to serve each lot. This could also include sponsoring a forum to educate members on the specifics of policy and governance issues, including Dig Once, Joint Trench, Wireless Agreements, MLAs, and Dark Fiber Lease Agreements, with the goal of adopting a consistent set of policies across the region. Each policy would have to be formally adopted by each jurisdiction, so coordination up front will be highly advantageous.

Plan Expansion of Fiber Networks

Based on the Master Agreement recommended above, PAG should begin working with Pima County, PAG municipal members, utilities, ADOT, local telecommunications providers, the Tohono O'odham Nation and Pascua Yaqui Tribe, and other interested parties, to plan the vision of a regional or county-wide fiber network. This network should plan for extended backbone fiber throughout the county, later to be extended regionally, passing along major highways, including the I-19 Smart Highway. RTA will also play a critical role in defining a backbone fiber network along major highways and main roads in the region, and will be able to provide advice on rights-of-way,

[1] Due to COVID-19 crisis, funding for the Smart Highways Corridors program has been repurposed. Funding will likely be considered by the state in later years.

permitting, and transportation technologies. The fiber network expansion can leverage the planned projects outlined in Section 4.2, providing insight into current initiatives and plans.

This includes construction of the proposed new roadway facilities along the Old Vail Connection alignment, improvements to infrastructure along Sahuarita Road and the planned Sonoran Corridor route from Sahuarita to Vail, the new ADOT interchange and any other projects along Houghton Road, ADOT's Smart Highway Corridor project along Interstate 19, and the proposed Interstate 11 alignment that may run along Sandario Road. Each of these road and infrastructure projects would be ideal for ACI to be deployed in the major development areas of the region including the Town of Sahuarita's expansion, industrial development to the east of Tucson International Airport, new industrial areas to the west of Ryan airfield, and the planned business incubator between Sahuarita and Green Valley. They also will provide opportunities for residential connectivity in new developments such as Vail Crossings and the area near the Chuck Huckelberry Loop paved, shared-use path system.

In addition, the regional backbone network plan should include connections to at least two internet points of presence ("PoPs"). The resulting fiber backbone will enable the delivery of wholesale bandwidth to municipalities, tribes, businesses, and consumers, as well as providing lower-cost open access for internet service providers ("ISPs") and offering redundancy for backup and network resilience.

Fiber route planning should be coordinated in the context of existing and future planning efforts, related to population growth, land use, transportation planning, and development of commercial business parks.

Plan Expansion of Conduit Networks

Starting from Tucson, other cities and towns, and overlaying conduit from universities, PAG/RPC can plan an extension to create regional conduit network. ADOT will play a key role as their Smart Highways program and support for Dig Once and Joint Trench policies will accelerate conduit placement and create incentives for other municipalities to follow suit. Utilities such as Tucson Electric Power ("TEP"), Tohono O'odham Utility Authority ("TOUA"), Southwest Gas, and water and wastewater utilities have substantial infrastructure assets to contribute and can play a critical role in expanding conduit networks and in providing distribution and operational capabilities. Dig Once and Joint Trench policies should include standards for expanding conduit that can house innerduct to support multiple carriers' infrastructure to promote competition in the region.

Conduit planning for fiber should be coordinated in the context of existing and future planning efforts, related to population growth, land use, transportation planning, and development of commercial business parks.

Leverage Arizona Commerce Authority (ACA) Initiatives

The Arizona Commerce Authority ("ACA") has several programs and projects underway which can support and accelerate the Advanced Communications Infrastructure strategy. These ACA programs are sponsored by the ACA Broadband Office and the ACA Smart State Office.

ACA's Broadband Office is focused on bringing broadband services to rural Arizona, which includes significant parts of Pima County. Arizona Gov. Ducey has proposed more than tripling the

funding, to $10 million this year. As part of PAG's ACI initiative, PAG should apply for one or two grants to fund detailed planning and high-level design for broadband expansion.

ACA's Smart State Office has begun planning work on the Smart Highway Corridors. The program is reserved to 514 miles of three rural interstate highways, one of which is Interstate 19 heading south from Tucson to Nogales, to install new traffic safety technologies. This Smart Highway program also will install conduit and fiber along with the safety technologies. While conduit will be owned by the state, and the Arizona Department of Transportation governs the right-of-way, there will likely be opportunities to lease or install new fiber in Pima County along I-19. (Due to the COVID-19 crisis, funding for the Smart Highways Corridors program has been repurposed for the coming fiscal year. Funding will likely be considered later.)

Identify Opportunistic Expansions

Significantly based on conversations with economic development staff at Pima County as well as others, Magellan recommends that PAG and its member agencies leverage current infrastructure and economic development plans already in place to develop ACI, including arterial fiber and underground conduit. Large business parks, new commercial expansion zones, new schools and other new community anchors offer similar opportunities for maximizing installation of ACI. Magellan has identified many locations as likely opportunities for broadband expansion in the county. These are consistent with known short-, medium- and long-term initiatives and planning already underway. A detailed list of the projects is enumerated in Section 4.2.

Create Outreach Program to Possible Partners

At PAG's ACI Kickoff meeting in October 2019, several parties showed interest in participating in the planning of regional broadband expansion to support economic development, enhance the region's quality of life, and make the region more competitive in attracting and retaining businesses. PAG/RPC should develop an outreach program to work with each utility and broadband service provider to define what contributions might be made by PAG, its member agencies and the interested entities to improve advanced communications infrastructure and broadband services. The utilities include Tucson Electric Power, Tohono O'odham Utility Authority, Trico Electric Cooperative, and commercial service providers include Cox, Comcast, and CenturyLink. The utilities can directly provide broadband capabilities, or partner with private ISPs, to increase choice, enhance competition, and improve speeds, value, and service.

Explore Other Funding Opportunities

PAG should explore other funding opportunities, including:

- Department of Commerce Economic Development Agency, Economic Adjustment Assistance Program, CARES Act - The CARES Act appropriated additional funding of $1.5B for the Federal Economic Development Agencies Economic Adjustment Assistance Program. No funding deadline exists, grants are first-come, first-served until funds are exhausted, and the funding will be highly competitive to local and tribal governments as well as universities.
- Indian Energy and Economic Development: National Tribal Broadband Grant - The Indian and Energy and Economic Development Agency is soliciting proposals from Indian Tribes, as defined at 25 U.S.C. § 5304(e), for grant funding to hire consultants to perform feasibility studies for

deployment or expansion of high-speed internet (broadband) transmitted, variously, through digital subscriber line (DSL), cable modem, fiber, wireless, satellite and broadband over power lines (BPL). Grants are funded to tribal agencies in amounts ranging from $40,000 to $50,000. The Tohono O'odham Nation and Pascua Yaqui Tribe should review all funding guidelines and action items detailed in the Funding Opportunity Announcement to determine whether and how to apply.

- USDA ReConnect Grants – ReConnect provides loans and grants to fund costs of construction, improvement and/or acquisition of land and property, along with electronics, to bring service to eligible rural areas. Funding window for this year is closed, but preparations can begin now for 2021.
- USDA Distance Learning and Telemedicine – DLT grants can be provided to eligible entities to acquire equipment to support synchronous, real-time, interactive use of broadband to link teachers and medical service providers with students and doctors and patients, respectively.
- FCC's Universal Service Programs – Federal Communications Commission's (FCC's) Universal Service Administrative Company (USAC) administers four separate funding programs which support expansion and subsidy of broadband in, especially, rural areas. E-Rate (for schools and libraries), Rural Health Care (self-descriptive), Lifeline (subsidies for broadband subscriptions to households), and High Cost (providing funding for companies to expand infrastructure into unserved or underserved areas, especially rural).
- Arizona Office of Grants and Federal Resources (GFR) - GFR offers training and technical assistance programs for public entities in Arizona. As a central location for funding opportunities, GFR is available to support PAG/RPC with grant application training, streamlining the application process and improving the likelihood of securing grants.
- FCC Rural Development Opportunity Fund - Auction 904 - The reverse auction 904 or Rural Development Opportunity Fund (RDOF) is a $20B fund aimed at servicing unserved and underserved census blocks with less than 25Mbps/3Mbps broadband services available. Census blocks and groups have been identified by the FCC and some rural areas of Pima County may be eligible. Funding is done by two phases: a short form and long form. Short forms are required to be submitted by July 15, 2020 and the auction is schedule for October-November 2020. Submitting a short-form application does not obligate an auction bid; conversely, however, failure to timely submit a short-form application precludes bidding in the auction. A second auction wave of funding for residual blocks will occur in 2021.
- Municipal Debt Financing - It is premature to consider debt financing, whether general obligation or revenue bonds. Municipalities -- whether cities, towns, or Pima County -- would have to issue the debt, not PAG.

Details on the grant and funding programs are included in Section 5.8, along with links to the funding sources' websites.

Tribal Considerations

The Tohono O'odham Nation and the Pascua Yaqui Tribe offer development and possible partnership opportunities, as well. The Tohono O'odham Nation was the indirect recipient of Broadband Technology Opportunities Program ("BTOP") grant funding, which resulted in an extensive underground and aerial fiber network being constructed on its lands. The Pascua Yaqui Tribe is currently planning developments around the Tucson area, which will permit dig once and joint trench opportunities for the tribe within its lands that can result in additional fiber to serve its needs.

PAG should continue outreach efforts to jointly develop a working plan to support the nation and tribe and their respective broadband plans. TOUA, as the electric utility serving the nation, can be a key partner in delivering broadband on the reservation. Tribal areas are often given priority for federal funding opportunities including the CARES Act and the Indian Energy and Economic Development National Tribal Broadband Grant. Because these communities are often harder hit by economic inequities, bridging the digital divide by connecting the tribal areas should be a key consideration for PAG.

Issue RFI for Network Expansion Opportunities

PAG/RPC should consider developing and issuing an open-ended Request for Information ("RFI") seeking ideas for how to expand the broadband and fiber network in Pima County. Much work must be done prior to issuance, including securing engagement with potential partners which would evaluate, help select, and support the efforts of preparing a complete RFP for construction and/or services. The partners, especially utilities and commercial providers, bring grant and operational experience, along with a substantial pool of assets for potential use. For complete information, see Section 5, "Detailed Recommendations."

Appendices

The FCC has a Spectrum Acquisition Offer to Tribal Nations, providing a six-month head start window to apply for unassigned wireless bands on the 2.5 GHz spectrum. The window for Tribal Nations closes on September 2, 2020, so time is of the essence for outreach to the nation and tribes, and their actions.

In Appendix A, Magellan provides a guide to unit costs for construction. For underground conduit and backbone fiber along major County roads, installing 2" x 4" conduit tubes and 144-strand fiber. For budgeting purposes, Magellan estimates $36.57 per linear foot, assuming a minimum five-mile construction segment, including Arizona prevailing wages[2] required for any municipally, state-, or federally funded projects. (At shorter intervals, unit costs will naturally be higher, due to the higher proportion of overhead labor required to start, stop and resurface projects.) For new backbone aerial fiber assuming 144-strand fiber, construction costs are much lower, estimated at $7.50 per linear foot. For unit costs of a short 500' lateral into a building for new fiber services, Magellan estimates costs at $32.80 per linear foot. (For remote areas, with its relatively flat terrain in some areas, wireless may be an option for last-mile services to the premises.) There may be

[2] https://www.ebacon.com/prevailing-wage-info/arizona-prevailing-wage/

other design and construction considerations based on local code, ordinances, within municipalities, within the county and state.

In Appendix B, Magellan enumerates coverage for broadband services and maximum speeds for each ZIP code in Pima County, broken down by provider.

2. Evaluation of Regional Benefits

One needs only to glance around and observe the intricate ways in which technology has become embedded into the global culture. From smartphones to social media, digital currency to smart infrastructure, day-to-day life has become inseparable from the devices and information. According to Cisco, by 2023, there will be 5.3 billion (66 percent of the world's population) internet users and the number of connected devices worldwide will be more than three times the global population[3]. Naturally, our economy has followed suit; virtualization has allowed for dynamic changes in the ways that we conduct business across every sector. With improved collaboration, open source information, expansive globalism, crowdsourcing, and a proliferation of start-up entrepreneurship, we find ourselves in a technology-based economy.

Inventory tracking for the region's major supply chain participants and large retailers, such as the Port of Tucson, the Amazon Fulfillment Center, Target.com and HomeGoods, exemplify how the new economy is becoming digitized. Other examples include digital platforms for major publications and automated transportation technologies for the delivery of manufactured goods. Governments are no exception; with the coming of Fifth Generation ("5G") mobile wireless technologies, municipalities large and small find themselves at the center of enabling changes in how people live, work, and play. As these changes occur, local governments will be key players in ensuring the efficacy, equality, and sustainability involved in these digital interactions. The actions, plans, and decisions made will have lasting effects on the economic, social, and ergonomic fabric and futures of regions around the globe.

Advanced communications infrastructure, including conduit, towers, antennas, vaults, splice boxes, handhelds, and data centers is the framework that is used to deliver broadband, high-speed internet access, across a Smart Region. Fiber optics is one component of an advanced communications infrastructure that enables broadband by transmitting large amounts of data securely over long distance and, with high reliability, is considered the gold standard for municipal and business communications, broadband services, and internet access (see Figure 2-1, below, for bandwidth capacity comparisons of several technologies). It supports a wide range of applications and is scalable to support nearly unlimited data capacity. Local and regional governments that own fiber consider it a capital infrastructure asset similar to water, gas, roadway, and electric infrastructure that has a lifespan of up to 40 years.

[3] Cisco's Annual Internet Report, 2018-2023
https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html

Figure 2-1. Physical Bandwidth Capacity Comparisons

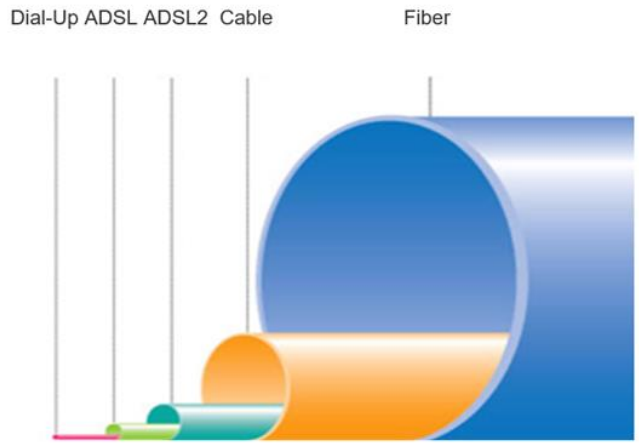
Dial-Up – 56Kbps
- *Legacy Technology*
- *Shared Technology*

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

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

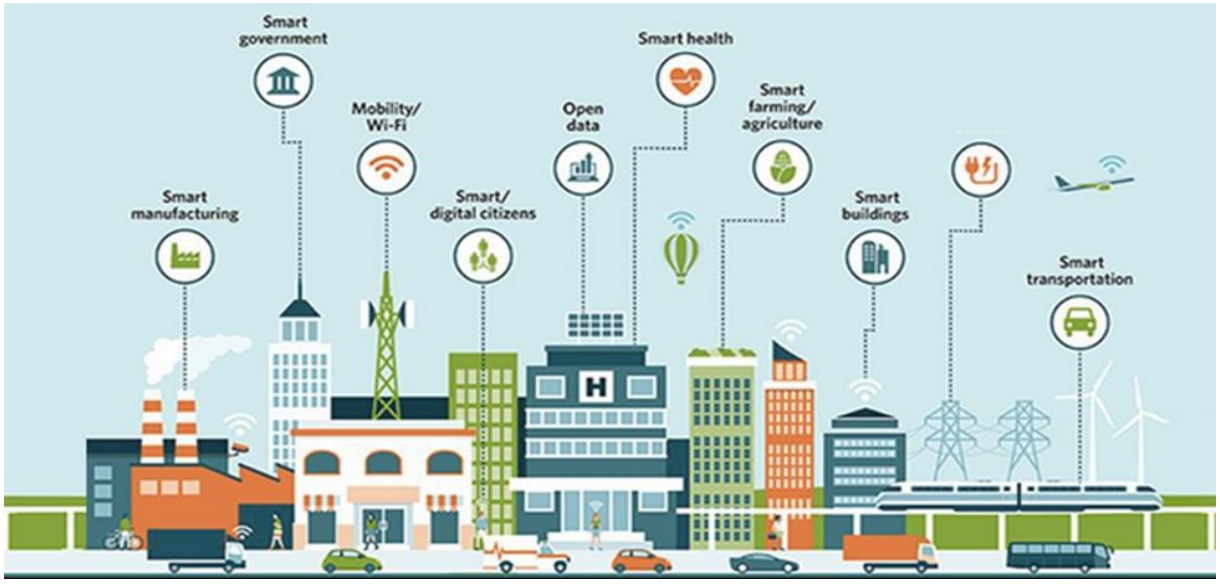
Cable – 150Mbps
- *Data Over Cable (DOCSIS 3.0)*
- *Shared Technology*

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



The benefits of such infrastructure are extensive. These networks are becoming increasingly important to cope with the rapid growth in connected devices, from utility assets, to streetlights, to traffic signals, to surveillance cameras, combining "Smart City" technologies to create Smart Regions of interconnected infrastructure that allow governments to be more efficient, reducing costs and increasing the value they deliver to their constituents. Figure 2-2 displays some elements of Smart City technologies.

Figure 2-2. The Smart Region[4]



[4] Source: Smart Cities Library. www.smartcitieslibrary.com.

2.1 ECONOMIC DEVELOPMENT

One of the primary sponsors of this assessment is PAG's Economic Vitality Advisory Committee (EVAC), which focuses on economic development planning in Pima County. EVAC and PAG both recognize that broadband alone is insufficient to attract new businesses, but that the lack of broadband can be disqualifying to the region. Competitively priced broadband is therefore critical to enable economic development and long-term growth in the region.

Pima County's proximity to major ports in California, including the Ports of Long Beach, Los Angeles, and San Diego, and its contiguity with the U.S.-Mexican border, makes it an ideal location for a variety of manufacturing and distribution enterprises. Additionally, the University of Arizona in Tucson is piloting some advanced technologies related to advanced transportation, and advanced fiber wave-division multiplexing. There are opportunities for Smart City applications. The region also is home to pharmaceutical and biotechnology companies built around its research facilities, as well as industries such as mining that use new innovations and technology in sourcing the natural resources of the area.

In order to continue to drive growth, PAG should guide and assist Pima County agencies to focus on attracting tech-driven industries offering high-paying jobs. Sun Corridor Inc., an economic development organization in the region, has identified a variety of industries for economic development focus including Aerospace & Defense, Bioscience, Renewable & Mining Technology, and Transportation & Logistics[5]. Similarly, Pima County's Economic Development Office calls out attracting and retaining major aerospace and defense contractors such as Raytheon; building the region's reputation as a logistics and transportation hub, and leveraging the "intellectual capacity" of the University of Arizona, Arizona State University, Northern Arizona University and Pima Community College as key strategies to continuous economic growth within the PAG region[6]. These industries increasingly rely upon transmitting and receiving large amounts of data, and upon the internet to operate and thrive. Consequently, the availability and affordability of broadband has become a driver for decisions about where companies locate their headquarters, manufacturing facilities, distribution centers and satellite locations.

To attract and retain these industries, advanced communications infrastructure that supports a competitive environment for affordable, reliable, redundant broadband services must be readily available in areas where office, technology, and industrial parks and other major commercial developments exist today or are being planned and built. In some cases, local governments have taken it upon themselves to ensure that this infrastructure exists so they can continue to drive economic investment in their regions. This includes working with residential developers for the delivery of fiber-to-the-home for support of home-based businesses, telemedicine, aging in place, public safety, and emergency response. Other benefits include managing the energy grid and increasing housing and property values for the high-tech jobs needed to support economic growth supported by the internet.

[5] https://www.suncorridorinc.com/Industry-Strengths/ (accessed 2/24/2020)

[6] Pima County Economic Development Plan (updated through 2018) https://webcms.pima.gov/UserFiles/Servers/Server_6/File/Government/Economic%20Development/Econ%20Dev%20Plan%20Update%202018/3418%20-%20EDP%202016%20ALL%20loRes.pdf

For example, the South Bay Cities Coalition of Governments ("SBCCOG") in Los Angeles County, California, found that major industries were relocating from the area and commissioned a study of the availability of broadband to develop strategies for increasing fiber optic infrastructure in the region in order to boost economic development. The study found that the lack of affordable fiber-based internet service was a barrier to entry for new businesses and a hindrance to existing businesses, including aerospace, manufacturing, distribution, finance and health care. The same held true for government services and education. In order to address this concern, SBCCOG envisioned the creation of a regional fiber network that would connect its fifteen member cities and their existing assets, serving as the advanced communications infrastructure for a Smart Region.

In the near term, this fiber ring will allow the cities and other public agencies to reduce their telecommunications budgets and increase government innovation by enabling the connection of thousands of Smart City devices including intelligent transportation, traffic signals, traffic cameras, environmental sensors, and pedestrian and bicycle detectors, to name a few. As an added benefit, these assets may eventually be used to provide broadband to anchor institutions and businesses in the area through a third party, increasing broadband competition in the region and driving down the cost of connectivity and internet services, allowing the South Bay area to attract and retain businesses, as well as support virtual education and telemedicine.

As of November 2019, the South Bay Regional Fiber Network is being constructed and has been expanded to connect and interoperate with the Regional Integration of Intelligent Transportation Systems (RIITS) network, connecting South Bay Municipal Networks with CalTrans, Los Angeles County, and Los Angeles Metropolitan Transportation Agency systems and operations. The SBCCOG is in the process of fulfilling its Smart Region vision by investing in an asset that will last well into the future.

More locally, the Mesa Tech Corridor has capitalized on similar opportunities to build economic development and enhance smart applications. The City of Mesa attracted investment from broadband providers by leasing city-owned assets such as conduit infrastructure to create the Elliott Road Technology Corridor. In addition to these assets, the city leveraged the corridor's proximity to Phoenix-Mesa Gateway Airport and the 202 Loop freeway to entice tech-companies to occupy more than 1,000 acres of available land. The city designated the area as a Planned Area Development Zone to expedite development and permitting processes and touts the availability of power, gas, water, wastewater, and broadband infrastructure as well as the nearby resources of Arizona State University Polytechnic and Chandler Gilbert Community College.[7]

Mesa's efforts have been extremely successful. The Elliott Road Tech Corridor is now home to several data centers and large tech and manufacturing companies that include Niagara Bottling and Apple. In light of the demand, broadband providers are continuing to invest in the corridor as well. CenturyLink is the latest internet service provider ("ISP") to release its plans to expand fiber optic infrastructure in Mesa. Investment in broadband infrastructure will, in turn, increasingly contribute to economic development, as well as enabling benefits for the city's residents including

[7] https://www.selectmesa.com/business-districts/mesa-gateway-area/elliot-road-technology-corridor-6308 (accessed 2/24/2020)

improved residential broadband offerings and support for Smart City applications such as a recently approved smart water meter project[8].

Although it would be misleading to imply that the availability (or lack thereof) of broadband is the only factor by which businesses decide their locations, many companies do consider a lack of affordable, reliable broadband a major barrier to entry. In locations such as Santa Monica, California, major employers have been dissuaded from relocating because the local government was able to offer an alternative cost-efficient broadband service. Following in this effort, cities and counties across the country are implementing fiber and wireless networks for economic development and quality of life. These include Fort Collins, CO, Centennial, CO, Inglewood, CA, Culver City, CA, Santa Clarita, CA, Oxnard, CA, Ventura, CA, Paso Robles, CA, San Luis Obispo, CA, San Leandro, CA, Carlsbad, CA, Chattanooga, TN, and hundreds more throughout the country.

Key Locations for Advanced Communications Infrastructure for Economic Development

In Pima County, many of PAG's member jurisdictions house industries that rely on broadband to thrive. In the southern part of the county, the mining industry is a focus, and the region as a whole has developed into a formidable mining technology hub. In 2016, Caterpillar selected Tucson as the home of its Surface Mining & Technology Division, and the company's regional office is now located just west of Interstate 10, near downtown Tucson. Hexagon Mining and Modular Mining are also in the region; they chose Pima County for a variety of factors that included the natural resources in the southern area of the county and the convenience to the University of Arizona's campus for industry research and innovation.

Companies like Caterpillar and Hexagon have come to rely on smart devices including automated earthmovers and shovels that can be remotely operated and depend on broadband connectivity. Continued technological innovation in the field will likely require increasing amounts of bandwidth for the foreseeable future for device control. Therefore, to continue to attract and retain such businesses, advanced communications infrastructure should be made available in the southern areas of the county, as well as at the locations of regional offices such as downtown Tucson.

In addition to the University of Arizona assisting in attracting the mining industry, its location is also a boon to the biomedical, optics, and aerospace industries. While the campus itself has sufficient infrastructure for broadband for students and researchers to use, the areas surrounding the campus being prime locations for burgeoning biomedical, optics, and aerospace industries and start-ups should have the same broadband availability. For instance, in its white paper on the thriving optics industry in Pima County, the Arizona Tech Council makes the case that, in addition to the "premier educational and research institution in optics and photonics" offered by the University of Arizona, optics companies should consider the availability of office space at UA Tech Park and The Bridges Tech Park as benefits that come with locating in the area[9], indicating the link between the University and tech-driven businesses.

[8] https://www.eastvalleytribune.com/news/mesa-preparing-m-water-meter-replacement/article_08a8ded6-04a4-11ea-8c94-2b25e0e0bd49.html (accessed 2/24/2020)

[9] Commercial Real Estate of Tucson White Paper "Tucson, Arizona: Arizona's Optic Advantage"

Raytheon already has two main locations in Pima County, one near the Tucson International Airport and to the south of the City of Tucson, and the second at the University of Arizona Tech Park, along with several smaller buildings for operations and staff. An aerospace technology company at Aerospace Research Campus that manages high-altitude unmanned research balloon flights all over the world is also present. Recently, Pima County, with regional funding through Pima Association of Governments, worked to build and expand roads that connect some of its sites with Raytheon facilities. There are also several biotechnology firms, including Cancer Prevention Pharmaceuticals Inc. between Tucson and Oro Valley; Roche Tissue Diagnostics and Ventana Medical Systems, both in Oro Valley; and Nanopec, located in the UA Tech Park along Interstate 10 to the southeast of Tucson. These companies' decisions to locate in these areas are indicative of the value of having broadband available to attract economic development and job creation in other areas throughout the PAG region.

The Town of Oro Valley, a suburban community within the region, is currently updating its zoning codes to allow for more tech parks and similar developments. The town is also allowing more shovel-ready sites within designated Economic Expansion Zones ("EEZ") including pre-grading and fast track permitting. Oro Valley's Economic Development staff are very active in working to bring new commercial activity to the entire region; they recently engaged in a combined effort organized by Sun Corridor Inc., Pima County Supervisor Valadez, Sahuarita Mayor Murphy, and Oro Valley Councilmember Pina during which several local businesses, CEOs, and representatives from the region's higher education organizations provided high-level briefings to site selectors to encourage businesses to locate in the PAG region. Oro Valley's leadership and staff point out that ACI is integral to continued growth of these developments. More detail about these needs will be explored in Section 4.1 of this report.

The Town of Marana is similarly sized to Oro Valley and is the fastest growing town in southern Arizona, both commercially and residentially, according to a representative of its chamber of commerce. Many families are flocking to the town because the school ratings are desirable. Marana has several aerospace companies and seeks to bring in more high-tech jobs. As a representative for the town's chamber of commerce pointed out, however, the town does not have a lot of building inventory, so many large companies must build from the ground up. Marana has a startup industrial park that currently houses one business, with two more moving in soon. The town also seeks to attract the film industry; many companies making commercials have moved in because California studios are overburdened with streaming providers. The town would like to attract more large movie studios. Marana has a lot of retail, and agriculture is a significant industry as well. Several cotton farms exist both within and near the town. More detail about the town's needs for ACI will be provided in Section 4.1.

There are opportunities for additional aerospace companies, biotech, and other technology companies to locate in the southeast of the county near the airport and in locations such as Corona de Tucson, where Pima County is currently developing 1900 acres as the Southeast Employment and Logistics Center (SLEC) for employers with large scale property needs. The UA Tech Park presents an opportunity to invite more tech firms into the southeastern part of the county, between south Tucson and Vail. With new developments planned in areas such as Vail and the possibility of building a new connection road that traces the Old Vail Connection Road from roughly Interstate 10 to Interstate 19, the areas to the southeast of Tucson should be a major

focus for additional advanced communications infrastructure to support these developments. The City of Tucson, the City of South Tucson, and the Town of Sahuarita, the two tribal nations, together with the county and ADOT would be especially well served by locating advanced communications infrastructure in this area.

PAG and its member jurisdictions are in the planning process of attracting and assisting other major businesses outside of its traditional research-based industries of mining, aerospace, and biotechnology to locate to the area. In recent years, Pima County has welcomed several warehousing and manufacturing businesses that have come to PAG's region in pursuit of the advantages of the local economy and housing. Many of these are taking advantage of the Port of Tucson's location, a day's drive from the ports of Long Beach, Los Angeles, and San Diego and with direct freight rail access to the Union Pacific Sunset Route, by using it as a hand-off between manufacturing and distribution of products. Because of this activity, transportation companies such as Tu Simple, an automated trucking company, are also taking an interest in the area and advancing economic development through partnerships with other distribution companies. In addition to the southeastern parts of the county, some of the county land in the northwest may be rezoned for use by distribution companies such as FedEx. With this in mind, the areas near the Town of Marana also may be considered as strategic locations for advanced communications infrastructure.

Tribal lands, including those of the Tohono O'odham Nation and the Pascua Yaqui Tribe, should be considered strategic areas for more robust advanced communications infrastructure. As in the rest of the county, the availability of broadband can provide immense benefits for economic development across a variety of sectors. The Tohono O'odham Utility Authority has already pursued deploying fiber through a federal grant program. The tribal lands are prime candidates for an award from the State of Arizona's $3 million Broadband Development Grant program. Magellan understands that investments in broadband infrastructure have been made in the tribal lands.

2.2 INCREASING GOVERNMENT INNOVATION AND SERVICES

The private sector is not the only major consumer of broadband. As technology becomes more integrated into daily life, government operations also have become increasingly reliant on transmitting and receiving large amounts of data via broadband internet connections. In addition to using internet connections for communications for field staff, the burgeoning Internet of Things (IoT) enables municipal applications that can promote citizen engagement and government innovation. These improvements can foster efficiency and innovation across a variety of community services including public safety, sustainability and energy efficiency, recreation, intelligent transportation, traffic and parking, and environmental monitoring.

Smart cities, towns, and municipalities capitalize on internet enabled smart IoT devices to make their organizations more efficient and effective while gathering data from devices to make more informed decisions regarding operations. The opportunities range from connected Supervisory Control and Data Acquisition (SCADA) networks, electric grids, traffic cameras and signalization systems, smart light pole grids for monitoring and control, people sensors, vehicle sensors, smart trash cans, smart park benches, smart parking and wayfinding, smart irrigation systems, IoT

systems within buildings for energy management, and access control systems, can all enable more responsive crowd management along with dynamic planning for public safety responses.

Reducing Municipal Telecommunications Spending

Many cities invest in advanced communications (broadband) infrastructure not only to enhance local internet services, but also to support their own operational needs and other public agencies, utilities, and transportation districts in their area. Investment in fiber backbone infrastructure is generally utilized to provide a foundation for broadband. This allows cities to allocate some of the costs of broadband to their own purposes, which has a positive impact on the overall cost structure for deploying broadband. Local governments can realize a return on investment by offsetting the monthly recurring fees they currently pay for connectivity. The telecommunications budget required for many of the applications used in Smart City applications, which are enabled by broadband purchased through a third-party internet service provider, will continue to grow as the need for bandwidth and the number of sensors and internet enabled devices increases. Owning the infrastructure within a Smart Region allows support for high-bandwidth connectivity without the need for increasing telecommunications costs from commercial providers.

2.3 COMMUNITY AND PUBLIC SAFETY APPLICATIONS

Police & Fire

Today all public safety agencies and first responders utilize mobile broadband for enhancing delivery of public safety services. Agencies nationwide are implementing regional interoperable communications systems based on broadband for radio communications, in-vehicle camera systems, emergency patient care records systems, fingerprint identification, video detection, automated license plate recognition systems, fire pre-incident planning, mapping of fire hydrants, and other applications to improve responsiveness and effectiveness. Without reliable broadband, these mobile communications technologies to support these advanced public safety services could not be delivered, impacting life and safety.

Fire personnel now use mobile communications for constant communication with doctors and hospitals during patient transport to prep hospital personnel, operating rooms, and other patient care services for expedient delivery of life-saving measures. Many public safety agencies also use a combination of social media data and Smart City applications such as pedestrian and vehicle counters to manage crowd control at festivals and other events that draw large numbers of participants. Such data allows for dynamic public safety requests, traffic management, and managing critical events that occur in public spaces.

Traffic Cameras and Signalization

Connecting traffic cameras and allowing for traffic signal synchronization assists public agencies in managing traffic congestion and public safety. Many police and fire departments are monitoring their roads with cameras, allowing for preparation when responding to traffic accidents or other emergency response activities. Automation of traffic signal timing, synchronization, and delivery of emergency and transit vehicle priority aids in managing traffic congestion, getting public safety

response teams where they need to be quickly and safely, and maintaining schedule adherence for mass transit vehicles.

Smart Parking and Wayfinding

Many cities struggle with the location of parking spaces, especially in particularly dense cities. Using a network of sensors and applications, drivers can be notified via smartphone applications, wayfinding signage on streets, parking structure and lot signage and in-vehicle navigation systems of available parking. Cities such as Santa Monica, CA, have decreased the time of locating parking spaces from 20 minutes to 3 minutes, saving motorist time, fuel, frustration, and carbon footprint through the implementation of this type of system.

Smart Trash Cans

Programs for reducing carbon footprints and improving sustainability efforts are being implemented by public agencies nationwide. Smart trash cans are equipped with sensors to alert public agencies when cans are full and ready to be emptied, saving time, energy, fuel, and cost to those agencies while lowering their carbon footprint. Additionally, these systems assist with beautification, public health, and keeping public places clean and friendly.

In Tucson, the Downtown Tucson Partnership has begun to install "Big Belly" sensor trash cans in the downtown area, and opportunities exist for other PAG members to install the same technology.

2.4 MUNICIPAL EFFICIENCY

Smart Irrigation Systems

Smart irrigation systems utilize sensors that monitor rainfall to determine when the landscape needs watering. This alleviates overwatering of landscapes especially in drought-ridden areas.

IoT Systems Within Buildings

In an effort to save energy costs, public agencies are installing connected thermostats, lighting controls, and automated smart building strategies such as window louvers and facades and intelligent HVAC systems. Smart buildings reduce water and energy consumption, improve occupant experience, and create sustainable structures that reduce operating costs.

2.5 ENVIRONMENTAL MONITORING

In a climate of extremes, such as the desert of southeastern Arizona, monitoring environmental conditions is an important function of government and public safety agencies. According to a recent study conducted at the University of Arizona's School of Government and Public Policy, Tucson leads many similar metropolitan areas in incidents of potentially deadly heat and flash flooding, with occasional severe hail storms, which, in addition to being dangerous for citizens,

results in net economic losses of nearly $9.5 million per year across Tucson and surrounding Pima County.[10]

Broadband can quickly transmit data about weather conditions that can be used to warn residents and business owners of these threats as early as possible. Environmental sensors are typically used to monitor:

1. Air quality
2. Water quality
3. Rainfall
4. Humidity
5. Temperature
6. Barometric pressure

Having reliable real-time data about these conditions saves both lives and property by allowing officials to communicate more effectively with citizens of the PAG region, public safety agencies, with municipal and private utilities on remediation efforts.

2.6 UTILITY-BASED APPLICATIONS

Supervisory Control and Data Acquisition (SCADA)

SCADA systems are connected to the internet, many times wirelessly, for the objective of gathering real-time data for decision making. Modern-day SCADA systems can take data, analyze it, and send commands back to the system. Additionally, the systems can forecast or make predictions based on historical data, assisting municipalities with planning activities. These networks can achieve cost savings, better maintenance, and improved service for citizens. Municipalities, however, should consider and plan for possible errors in communications, the additional cost to implement, and mitigate cybersecurity challenges.

Electric Smart Grids

Connected smart grids for electric utilities can save municipalities time and energy, while reducing carbon footprint. These grids connect to the internet allowing for real-time communication of meter reading, issues, and outages. This decreases the need for vehicle drivers to read meters and aids technicians in being prepared for service calls.

Smart Light Pole Grids

By establishing a grid for smart light poles, municipalities can automate and control their lighting effectively and efficiently. These streetlights have LED lighting, saving in recurring costs by allowing for dimming and brightening when vehicles and pedestrians come near. This also allows for decreased environmental impacts, which is especially significant in the PAG region which, due to its spectacular viewing conditions and well-established astronomy industry, adheres to a Dark Skies Ordinance that limits artificial lighting within most jurisdictions

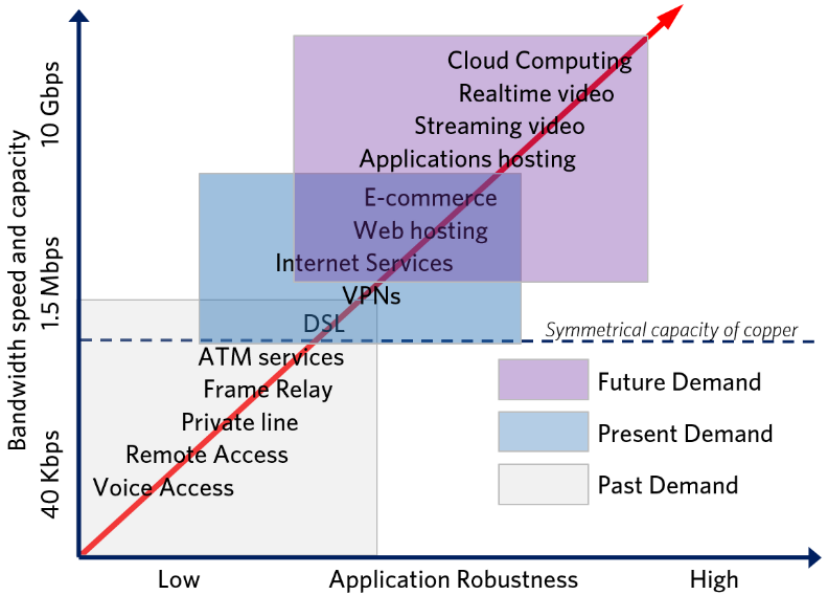
[10] "The Economic Impacts of Extreme Weather: Tucson and Southern Arizona's Current Risks and Future Opportunities." Laura A. Bakkensen, Ph.D. and Riana D. Johnson, School of Government and Public Policy, University of Arizona College of Social and Behavioral Sciences; Published 02-02-2017.

2.7 A CONNECTED COMMUNITY

In addition to private and public organizations, residents also have a need for broadband. Much like businesses and governments, many of the daily functions that citizens perform rely on internet connections. When deciding to purchase a home or relocate, most people would not consider moving to a community that does not offer internet connectivity, a fact that Magellan has confirmed many times through anecdotal evidence from around the country. Although the amount of data for residential use may not reach the levels needed for commercial or municipal use, broadband enables entertainment, healthcare, smart home applications, and telecommuting in homes around the United States and throughout the PAG region. Figure 2-3 illustrates the bandwidth needs for classes of applications.

Internet and Connectivity for Residents

Figure 2-3. Growth in Application Bandwidth Demand[11]



Although we are still early in the evolution of internet video applications, needs are expected to grow significantly over the next ten years as more users opt for video-based information over traditional text-based content. Cloud computing also has driven the need for more symmetrical[12] broadband as real-time, and cloud applications require additional bandwidth, both in download speed and upload speed. As these applications continue to proliferate, reliable high-speed internet connections will become an even bigger necessity in daily life.

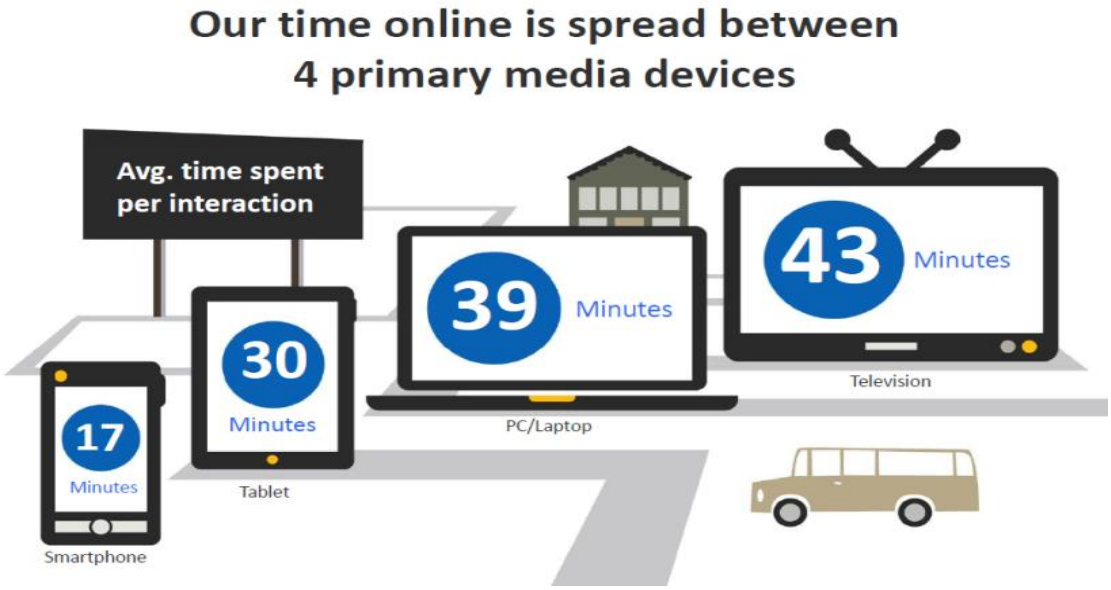
[11] West Ontario Wardens' Caucus Broadband Background https://wowc.ca/broadband-background

[12] Symmetrical broadband connections provide equal download and upload speeds, such as 10 Mbps down, 10 Mbps up, instead of traditional asymmetrical broadband services that provide unequal speeds, such as 10 Mbps down and 2 Mbps up.

A 2017 study revealed that individuals are spending an average of five hours a day across all devices for personal use, a 20% increase from the fourth quarter in 2015. [13]

Outside of personal use, many more devices are now connected to the internet to automate a variety of daily functions. Multimedia entertainment systems, thermostats, irrigation systems, food storage and preparation areas, and home security and monitoring systems are just some of the "smart home" innovations that have entered the scene. Each of these requires high-speed connectivity to function, further increasing demand for broadband inside the home.

Figure 2-4. The Proliferation of Broadband-Connected Devices[14]



Telemedicine

Telemedicine is a growing field and application as health care providers look to technology to empower healthcare through technology. Health care providers are implementing more telemedicine routines, for not only treatment, but for continued health and ongoing well-being care as well. Elderly patients can be significant telemedicine beneficiaries, given they do not always have transportation available to get to a clinic.

Many clinics use online teleconferencing platforms for discussions between doctors for consults, including specialists not actually employed by the clinics. Smaller clinics often cannot afford to have every specialist on staff, so they rely on a network of specialists, sometimes out of the state, to join them, and their patients, in joint video conference calls. Home health monitoring devices

[13] "U.S. Customers Time-Spent on Mobile Crosses 5 Hours a Day" Flurry Analytics, 2017. https://www.flurry.com/post/157921590345/us-consumers-time-spent-on-mobile-crosses-5

[14] The New Multi-Screen World. Understanding Cross-Platform Consumer Behavior" Google 2012. think.withgoogle.com/databoard/media/pdfs/the-new-multi-screen-world-study_research-studies.pdf

are also becoming more and more common place (such as glucose monitors, blood pressure monitors, etc.), but they too need broadband to function.

Other examples of the need for broadband to support medical care include:

- Electronic medical records and billing data is often off-site, which is a big driver for bandwidth needs. Health care providers and practitioners require reliable connectivity to the cloud to perform their jobs. Clinics and providers enter the data, then it goes to a remote clearing house, from which the bills are sent, mostly electronically.
- Trauma centers share records including MRI, CT scan, X-Ray, etc., via electronic means. Medical practitioners especially need to do this at the more remote clinics, requiring bandwidth to do it in real-time.
- Doctors and employees use laptops to record patient information and access EMR. Tablets are also used.
- Paramedics and EMT's use tablets to record first responder information in the field. Without broadband or cellular connectivity, the transmitting of information is delayed until returning to an area where WiFi or cell service is available.
- Voice-to-text applications for recording patient information.
- Scribing services.
- Medical imaging is shared and used via broadband between sites and for access to specialists in other parts of the state.
- Video chats made accessible via specialized portable carts that have screen, WiFi connections, cameras, software etc. The video chats provide access to specialists such as Infection Specialists, Psychology, and Stroke Specialists.
- Continuing education facilitated via web training and web conferences. This is extremely valuable, especially for busy doctors.
- Healthcare home visit services, where the practitioners visit patients using laptops equipped with WiFi cards to access patient information.

Aging in Place

Many of the region's residents and visitors are retirees and are part of an aging population. More frequently today, the aging population is desiring to age in place, in their home, instead of moving into nursing/assistance facilities or burdening family or loved ones by moving in with them. Some studies have begun to demonstrate that a person using aging-in-place applications and services, in some cases, may spend less per month than what they would spend on assisted-living facilities per month, all while being safe and comfortable in their own home. Supporting an aging population means that safety should always be a concern. There are organizations that provide the service of retrofitting the home for aging in place, using technology that is aiding in this movement through security systems, online services, telehealth and telemedicine, and an ever-expanding array of online services.

Distance Learning

Some schools in Pima County are already providing tablets or laptops to students so teachers can assign homework online and to enable students to access the internet for further research. Parents are also increasingly encouraged to track grades and progress reports via online portals. Without the availability of broadband, however, these students are put at a disadvantage in comparison to peers who have robust internet connections, placing them in what has become known as the Digital Divide.

Colleges and adult education programs also now have online components. Distance learning has made higher education and job skills training more attainable for many adults by providing convenient, flexible options for non-traditional students. Hybrid courses are offered at most schools, as are fully online programs that allow students to watch lectures, read course materials, and take tests through portals such as Canvas.

Digital Equity

High-speed internet has a net positive social impact on communities by enhancing opportunities for education, workforce development, and training. The availability of affordable, reliable broadband has become an important factor for ensuring equity across all communities. Access to broadband brings additional benefits to students and adults, including online learning platforms, resources for college applications and funding, and general availability of information.

The Digital Divide is most pronounced in areas that are rural or economically disadvantaged and puts already vulnerable communities at further risk of falling behind. Therefore, when considering the role of advanced communications in regions such as Pima County, special attention should be paid to these unserved and underserved areas. Digital inclusion efforts have become a significant priority at the state level to address these issues, with focus on rural areas of Arizona affected by the divide. These efforts are being spearheaded by Jeff Sobotka, Arizona's State Broadband Director, and grant funding is available to advance digital inclusion.

2.8 A NOTE ON WIRELESS & 5G TECHNOLOGIES

Fourth Generation or "4G" mobile wireless technology has been widely available for many years. Now "5G," the latest generation, is emerging, with forecasted commercial availability in 2021 and an increased maturity of the network in 2035. These new networks are designed to provide increased efficiencies while decreasing latency and are anticipated to improve the performance of connected devices, including the IoT and network architectures with an emphasis on massive multiple input multiple output technologies (MIMO) and device-to-device (D2D) communications such as autonomous vehicles, healthcare technologies (such as blood glucose monitoring), and ultra-high-definition video.

5G networks are distinguished from the present 4G technology by use of low power transmitters with a coverage radius of approximately 400 feet; 5G thus requires the use of wireless technology for maximum usability, meaning close spacing and increased numbers of antennas. These 5G antennas must be connected to and backhauled via fiber due to the vast amounts of data being transmitted and the high speed required to provide low latency and reliability. Therefore, we consider 5G wireless and fiber optics to be complementary, rather than competing technologies.

Many of PAG's member jurisdictions have already begun processing applications from wireless carriers to install 5G equipment in their communities. Regionally, the value of vertical assets such as streetlight poles is an important consideration in 5G deployment. To enable a Smart Region, cities, towns, Pima County, and the tribal nations should consider a collaborative approach to managing the proliferation of wireless equipment that is likely to come in order to protect the aesthetic character of the region as well as to understand what fiber infrastructure is or will be in place to support 5G technology, and the potential to leverage the installed fiber to advance the goals of a smart region. Policy implications of addressing growing demand for placement of 5G antennas and supporting fiber optic connections is addressed in Section 4 of this assessment.

3. State of the Market Report

Magellan developed a state-of-the-broadband-market in Pima County report to understand speeds, levels of coverage, and any gaps that exist among existing service providers. The data analyzed below is a combination of data received from the Federal Communications Commission (FCC), online resources including providers' websites, Magellan's Advanced Communications Survey for PAG, and GIS-based subscription tools that show metro and long-haul providers in the county. Survey and coverage information was analyzed by ZIP code, recognizing that Pima County is a large county made up of a combination of urban, tribal and rural lands that create a unique broadband market. Providers analyzed offer wired services.

The results below include trends that are both unique to Pima County, and issues that impact much of Arizona and the United States. Pima County has significant broadband gaps. Service providers are nominal or nonexistent in rural areas west of Tucson including tribal lands of the Tohono O'odham Nation and the Pascua Yaqui Tribe and western ZIP codes that encompass areas adjacent to the tribes, as well as far eastern ZIP codes that include rural national parks. Tribal lands have only one wired broadband service provider, Tohono O'odham Utility Service. Services in these areas are not accessible to all homes, and therefore we should consider these areas underserved, if not completely unserved.

Bandwidth availabilities vary by provider and ZIP code. Although there are providers who deliver speeds up to 987Mbps, those providers are concentrated in metro areas, serve only portions of those metro areas, and generally do not overlap with other service providers who can deliver comparable speeds. This leaves most businesses in Pima County with one to two choices for a broadband service provider, many of whom fail to deliver speeds that meet the FCC's current definition of broadband (25 Mbps download and 3 Mbps upload.)

Survey data from organizations within the PAG region supports the results and findings with many organizations pointing to lack of competition, low bandwidth offerings and relatively high prices from current providers. This lack of competitive offerings with relatively high prices is suppressing demand and artificially dampening investment. This is the current vicious circle: low demand leading to lower provider investment than desired, which in turn leads to relatively higher prices, continuing to dampen demand.

Several PAG members have Franchise Agreements ("FA") which reserve geographic territories for offering cable services. While these FAs are most likely non-exclusive, the existence of the agreement marginally diminishes competition. Negotiated MLAs provide greater flexibility for cities, towns, the nation and the tribe.

3.1 FCC REPORTED BROADBAND SUPPLY

U.S. Baseline Speeds and Coverage

In December 2019, Ookla, a worldwide leader in internet bandwidth speed testing, released U.S. fixed broadband speed test data for Q1 – Q2 2019. Ookla tests are submitted voluntarily by individual users, and test results are aggregated regionally and by provider.

Nationwide, the average internet download speed was 131 Mbps, and average upload speed was 49 Mbps. Mean download speed increased by nearly 36% from 2017, and upload speed by 22%, driven in part by the expansion of gigabit service across the U.S.

The state of Arizona's average download speed was 102 Mbps and upload speed of 25 Mbps. The fastest ISP in Arizona was Cox. Average download speeds for all providers in Arizona are below the nationwide average. Arizona's upload speeds of 25 Mbps is almost 10 Mbps below the U.S. average.

Kansas City, MO was the fastest city overall with downloads of 159 Mbps, and its top provider for speed was Google Fiber. Seattle averaged download speeds of 120 Mbps. Wave G was cited as the fastest ISP.

Figure 3-1 compares broadband speeds for City of Tucson, AZ, with eight other Western cities.

Figure 3-1. Broadband Speeds for Tucson, AZ and Eight Other Cities

City	Average Download Speeds (Mbps)	Average Upload Speeds (Mbps)	Fastest ISP	Download Speeds for Fastest ISP (Mbps)
Tucson, AZ	**88**	**18**	**Cox**	**94**
Albuquerque, NM	93	12	Xfinity	108
Austin, TX	144	71	Google Fiber	197
Colorado Springs, CO	110	18	Xfinity	117
Denver, CO	104	38	Xfinity	112
El Paso, TX	84	15	Spectrum	67
Phoenix, AZ	105	32	Cox	114
Portland. OR	110	34	Xfinity	100
San Antonio, TX	134	50	Grande Communications	150

Globally, the U.S. lags much of the developed world in broadband subscriptions per capita. According to the Organization for Economic Cooperation and Development's (OECD) recent data[15], of OECD's 37 member countries, the U.S. ranked 18th in broadband subscriptions, with per capita broadband adoption at home of 22.0 per 100 residents. This compares unfavorably with Switzerland's top-ranked broadband adoption metric of 43.7 per 100 residents and an overall OECD average of 30.9 per 100 residents.

Broadband "Access"

Broadband access is the measure of how many households could have broadband subscriptions at home. Broadband adoption is the measure of how many households do have broadband subscriptions at home.

The below charts show a 2018 snapshot comparison of broadband access numbers for the City of Tucson with eight other western U.S. cities, the State of Arizona, and the entire United States. Tucson ranks fifth out of these nine Western U.S. cities with a broadband rate of 86.9 per 100 households. Tucson ranks above the U.S. average of 84.2, but below the technologically advanced cities of Portland, OR, Colorado Springs, CO, and Denver, CO.

Please place emphasis on the fact that these metrics are specific to Tucson, AZ, which are much higher than Pima County access rates overall, for which aggregated data are not available.

Figure 3-2 compares 2018 broadband access rates and rankings for the City of Tucson, AZ, with eight other Western cities, the State of Arizona, and the entire United States.[16]

Figure 3-2. Broadband Access Rates for Tucson, AZ, and Eight Other Cities

City	Broadband Access, Per 100 Households	Rank
Entire United States	84.2	N/A
State of Arizona	84.2	N/A
Tucson, AZ	**86.9**	**5**
Albuquerque, NM	80.2	8
Austin, TX	87.7	4
Colorado Springs, CO	92.2	1
Denver, CO	89.5	3
El Paso, TX	79.0	9
Phoenix, AZ	85.9	6
Portland. OR	90.4	2
San Antonio, TX	82.9	7

Demographic Breakdown of Adoption, by Ethnicity/Race

[15] https://www.oecd.org/sti/broadband/broadband-statistics/
[16] https://mapazdashboard.arizona.edu/infrastructure/internet-access

The adoption metric is not homogeneous across all ethnicities and races. Broadband adoption is impacted by social and economic challenges as well as regional, rurality and coverage challenges. Figure 3-3 details broadband adoption in Tucson by ethnic class and race.

Note how much lower the access rates are for the American Indians/Alaskan Natives within the city of Tucson. Away from the concentrated Tucson ISPs, in the broader Pima County, access rates in tribal nations are likely significantly lower.

Figure 3-3. Broadband Adoption Rates for Tucson, AZ, by Ethnicity/Race

City of Tucson, AZ	Broadband Adoption ("Access"), Per 100 Households	Rank
Entire United States	84.2	N/A
State of Arizona	84.2	N/A
Tucson, AZ	**86.9**	**N/A**
Native Hawaiian, Pacific Islander	90.4	1
Asian	89.8	2
Two or More Races	89.7	3
White, non-Hispanic	89.1	4
White	88.3	5
Hispanic	85.5	6
Black/African American	83.4	7
Other	81.5	8
American Indian/Alaska Native	67.1	9

FCC Baseline Data for Pima County

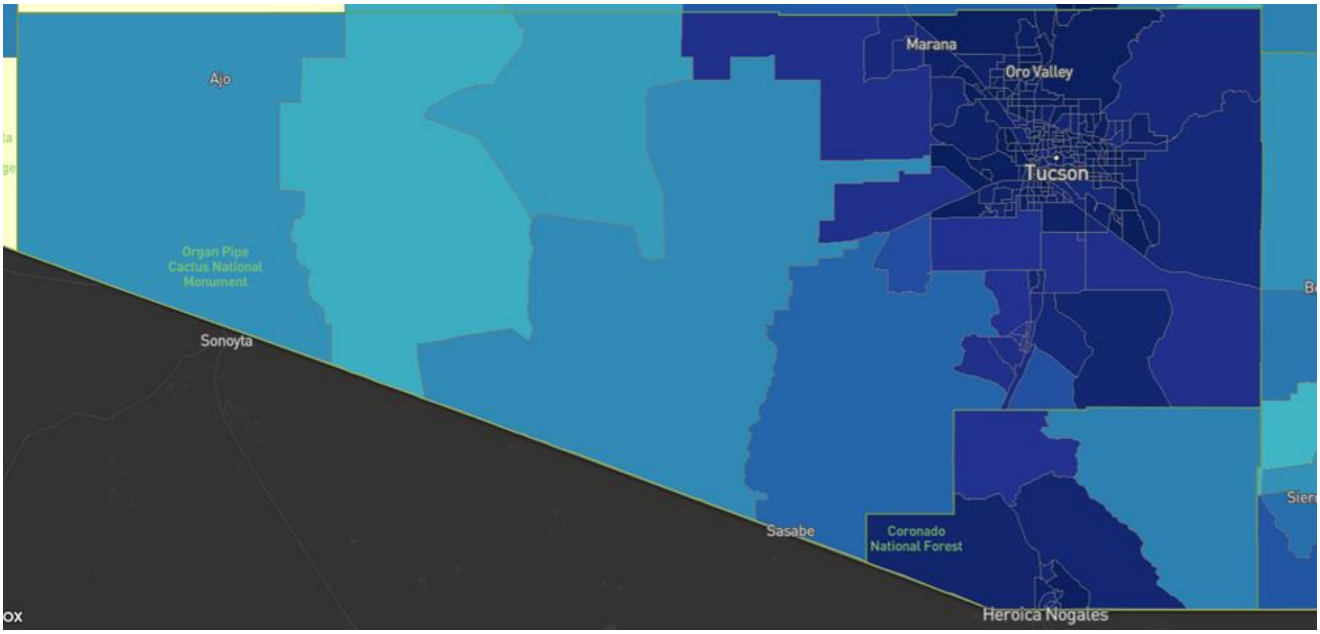
The Federal Communications Commission's (FCC's) most recent fixed broadband availability map, shown below, is based on data self-reported by Internet Service Providers (ISPs), with data as of September 2019. (The FCC updates the map semi-annually.)

Darker shading indicates a greater number of ISPs offering speeds of at least 25 Mbps download and 3 Mbps upload, which is the current FCC definition of broadband service minimums and is usually denoted 25/3. Data includes higher latency satellite service that affects usability for interactive applications such as gaming and voice calls. In addition, as with mobile broadband providers, satellite service providers often cap the amount of internet data that can be downloaded and uploaded each month, imposing additional charges for data overages.

(While new low-earth orbit satellite (LEO) networks may be an option for rural areas in the future, no concrete information regarding latency and data caps is available at this time. At present, there are no commercially available competitively priced LEO ISP services that resolve these problems. Robust fiber optics networks are still necessary for commercial areas, especially for tech-focused companies such as those in the PAG region as LEOs will not provide the bandwidth needed for these operations.)

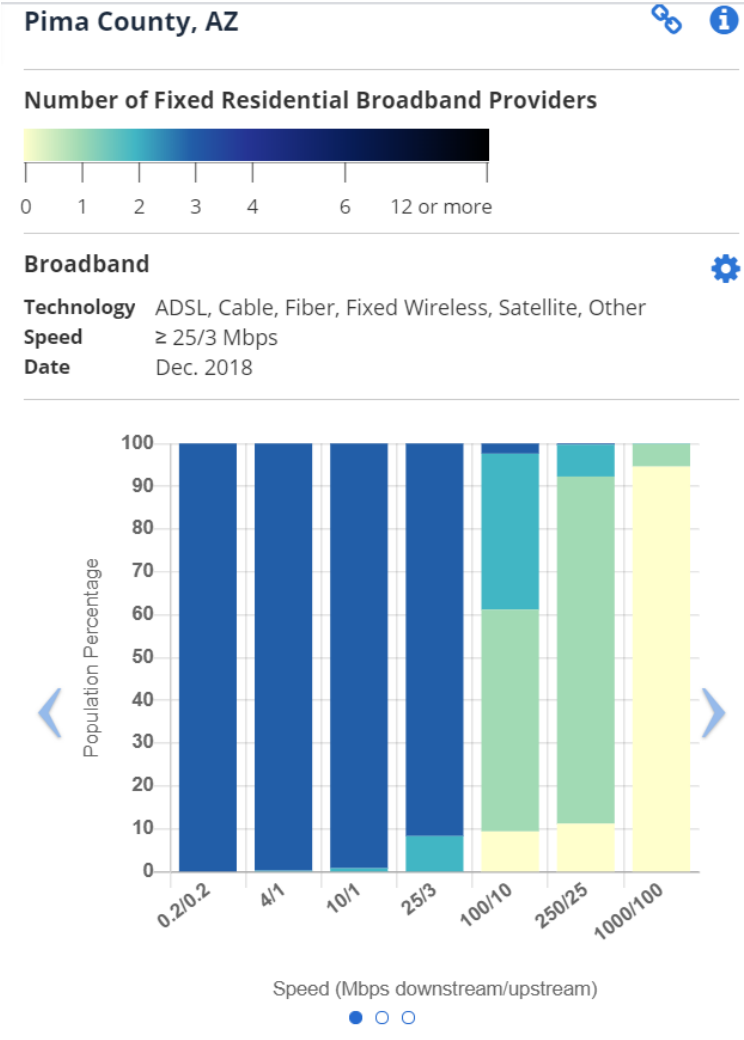
Figure 3-4 denotes the number of fixed broadband providers with darker hues denoting more prevalent providers and, therefore, more likelihood of choice.

Figure 3-4. FCC Fixed Broadband Availability Map – Pima County, AZ, Jan 2020



The stacked bar chart below denotes the percentage of the population that has greater or lesser choice in internet service providers. The horizontal bar above is a scale, showing a greater intensity of color for more ISPs. We can therefore see that 100% of the population has access to four providers at 0.2/0.2 Mbps, an extremely low speed. The fourth bar denotes that less than 10% of population has a choice of only two providers at FCC broadband minimum of 25/3, while more than 90% have several choices. The bar labeled 250/25 denotes that approximately 15% have no options; about 75% have one option; and the remainder have more than one option.

Figure 3-5. Population, Choice of Fixed Residential Broadband Providers



While this chart provides important information about the availability of broadband in Pima County, readers should note that the analysis is performed by census block and that not all locations in the same census block may be able to access the same level of service. Additionally, many of the speeds indicated are "best-effort" speeds, meaning that subscribers may not necessarily experience the maximum speeds available. We will return to actual performance speeds, as collected by Magellan through a survey tool, in the Broadband Performance section of this analysis.

Data reported to the FCC as of December 2018 in the map of the PAG region showed that there are several census blocks in the west of the county area with only a single provider offering 25/3 Mbps service. A closer examination of these census blocks revealed that only ViaSat, a satellite service provider, offered 25/3 Mbps service. Magellan does not currently consider satellite services as adequate broadband providers due to traditional issues with latency, data caps and price per Mbps. In the turquoise and blue blocks, Comcast, Cox and/or CenturyLink offered broadband service.

While the FCC claims that 100% of the population in Pima County has offerings of the lowest levels of speeds available, it shows zero to one provider available for gigabit speeds. This supports the understanding that providers are delivering low level speeds and services but have yet to advance their networks in Pima County to support gigabit level and symmetrical broadband services – the services needed to support economic development, Smart City, telehealth/telemedicine, advances in manufacturing, education and everyday bandwidth consumption.

3.2 MARKET SUPPLY

An assessment of private-sector telecommunications infrastructure and services in Pima County provides context for the availability, affordability, reliability, and competitiveness of broadband in the region. It also informs strategies for expanding advanced communications infrastructure, as these companies are prospective partners.

Incumbent Telecommunication Service Providers

The two major incumbent providers are Cox and CenturyLink. Cox is the primary cable provider in Pima County, having 50% availability throughout the area, consisting of primarily DOCSIS (legacy cable TV technology) infrastructure.

Cox

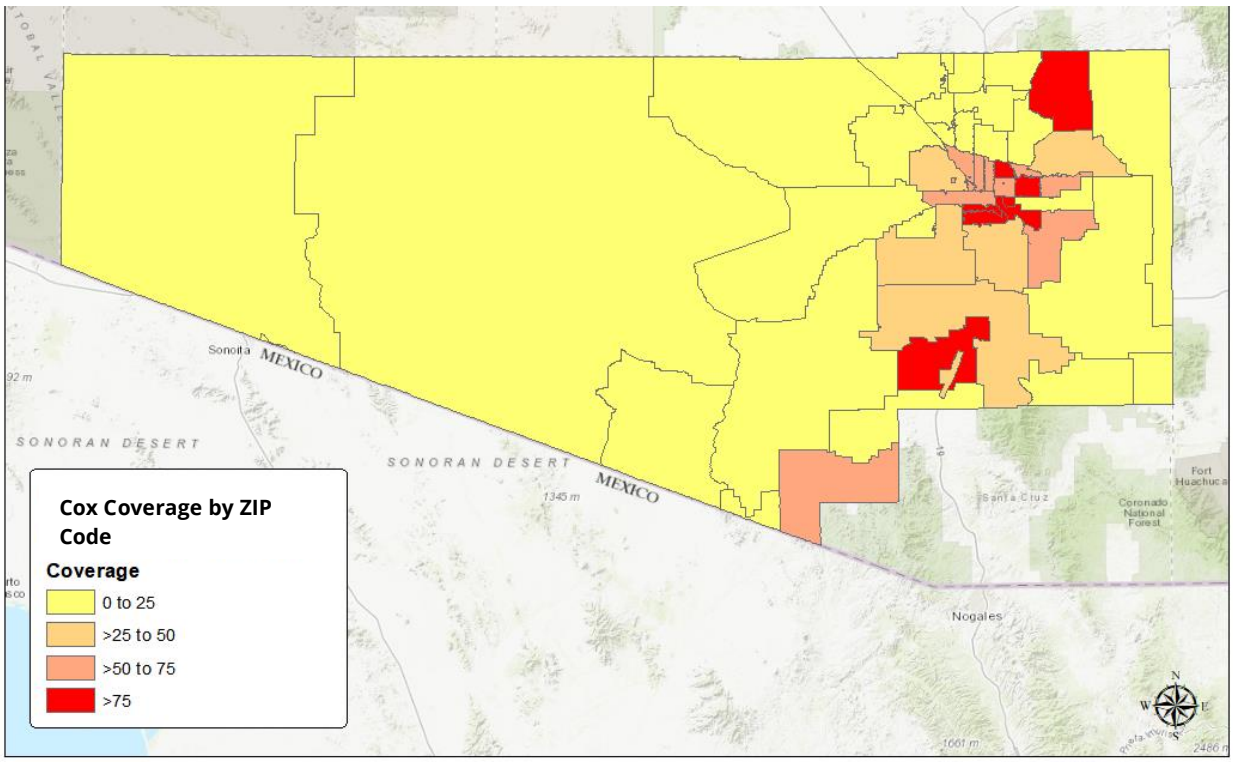
Cox services are delivered to subscribers via copper coaxial ("coax") cable. Cox is headquartered in Atlanta, GA, and is the third-largest cable internet service provider in the United States by coverage area, with a presence in nineteen (19) states. The following table lists offered packages, speeds, and sign-up incentives.

Figure 3-6. Cox Business Offerings

Package	Speed/Inclusions
BUSINESS INTERNET - 50	Speeds up to 50/10 Mbps. 1-year promo rate
BUSINESS INTERNET - 100	Speeds up to 130/20Mbps 1-year promo rate
BUSINESS INTERNET - 200	Speeds up to 200/20 Mbps 1-year promo rate
INTERNET ULTIMATE	Speeds up to 300/30Mbps 1-year promo rate
GIGABLAST	Speeds up to 940/35 Mbps, promo rate limited time offer. 1-year price guarantee

As indicated in the map below, Cox service is concentrated primarily in Tucson and the surrounding ZIP codes. They provide coverage in the eastern portion of the county from north to south, with their greatest coverages available in the Tucson metro. Cox does not provide coverage to the Western ZIP codes or tribal lands.

Figure 3-7. Pima County Coverage – Cox (Percent Offered Coverage by ZIP Code)



CenturyLink

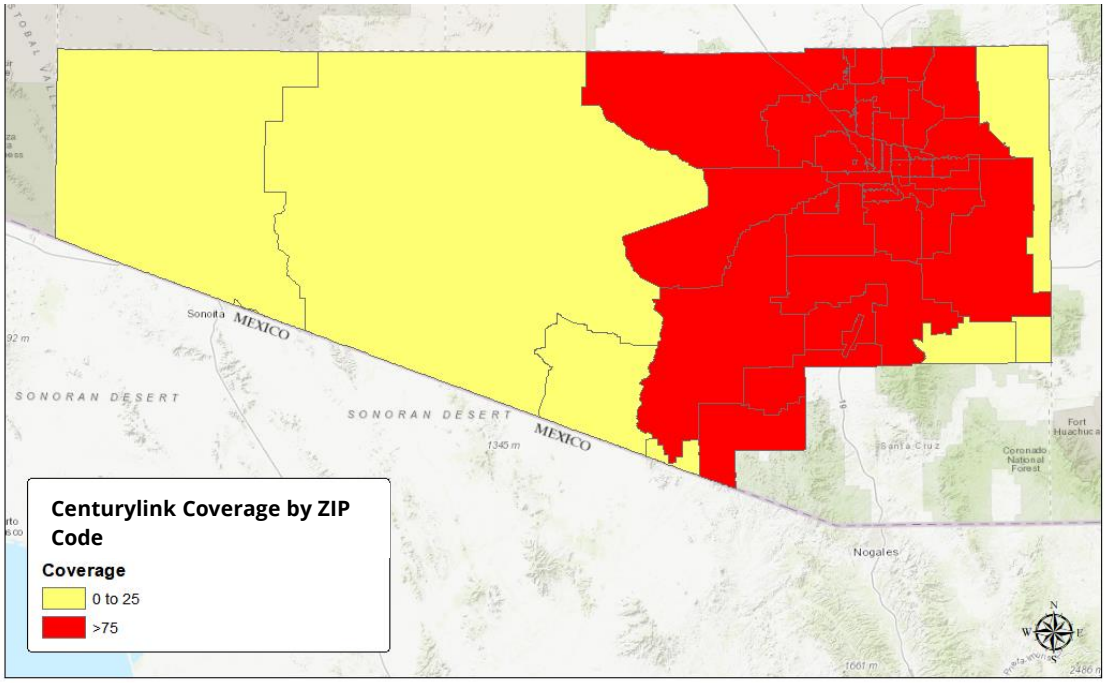
CenturyLink is the registered competitive local exchange carrier ("CLEC") in Pima County providing digital subscriber line (DSL) broadband services (primarily over telephone wires). Offered service speeds in most areas of the County outside metropolitan Tucson fail to meet the FCC 25/3 standard. CenturyLink's availability covers 99% of the county. Advertised offerings and packages include:

Figure 3-8. CenturyLink Business Offerings

Package	Speed/Inclusions
SIMPLE INTERNET -1.5	Speeds up to 1.5Mbps/586Kbps. No contract, pre-payment required
SIMPLE INTERNET	Speeds up to 140/10 Mbps. No contract, pre-payment required

CenturyLink is the county's largest ISP covering more ZIP codes across the county than any other ISP. The map below details CenturyLink's coverage area which includes the majority of eastern Pima County. Although they have the greatest coverage and availability, CenturyLink's speeds vary by ZIP code. The charts in Appendix B note that the highest available download speed for businesses in Pima County is 140 Mbps, and many businesses are unable to receive that level of bandwidth. Many businesses are no doubt stuck with lower speeds including its unsatisfactory 1.5 Mbps offering.

Figure 3-9. Pima County Coverage – CenturyLink (Percent Offered Coverage by ZIP Code)



Comcast

Comcast is the secondary cable provider throughout the county and delivers services over coax cable. They have upgraded many areas to DOCSIS 3.1 and are able to provide higher download speeds. Comcast does not provide symmetrical upload speeds, and the infrastructure is still dated coax cable.

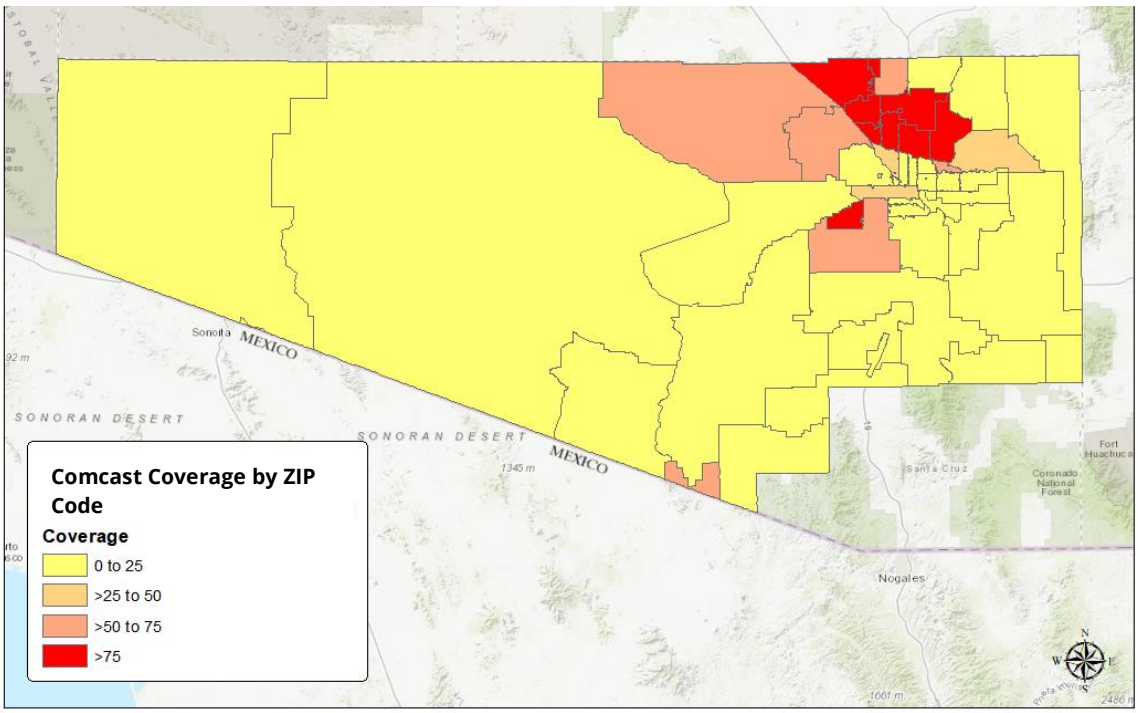
XFINITY Comcast is the largest cable provider in the United States reaching over 100 million customers and operating in 41 states. Comcast Business currently operates in 39 states. Advertised offerings and packages include:

Figure 3-10. Comcast Business Offerings

Package	Speed/Inclusions
STARTER INTERNET	Speeds up to 25/5 Mbps. 1-year promo rate with 2-year agreement.
BUSINESS INTERNET 200	Speeds up to 200/20 Mbps. 1-year promo rate with 2-year agreement.
BUSINESS INTERNET 1 GIG	Speeds up to 940/35 Mbps. 1-year promo rate with 2-year agreement.

Comcast is the region's second largest cable provider with a large proportion of its local coverage area concentrated in northeast Pima County, in the greater Tucson area. Although there are two cable providers in Pima County, their coverage areas are generally separated and not much overlap or competition exists. Comcast service is available up to 100% of businesses in several northeast ZIP codes but, as with other providers, lacks any availability in the tribal and western parts of Pima County.

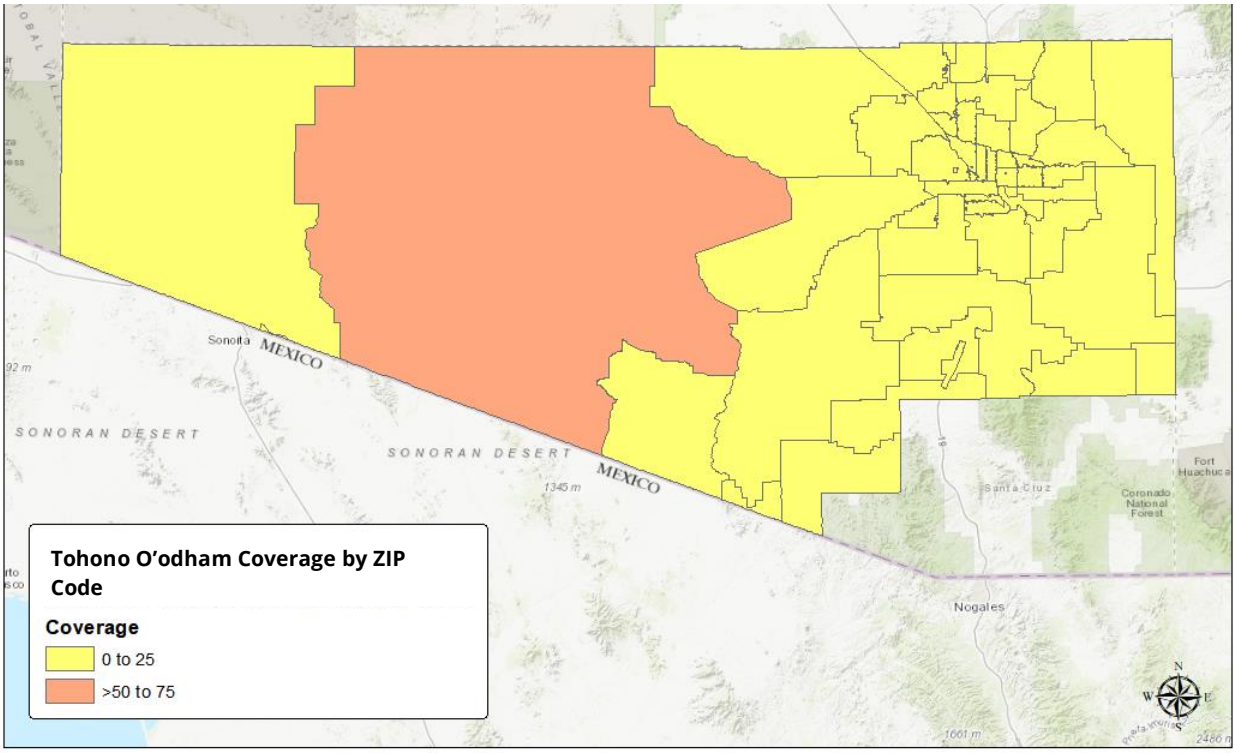
Figure 3-11. Pima County Coverage – Comcast (Percent Offered Coverage by ZIP Code)



Other Providers

Tohono O'odham Utility Authority (TOUA) is the only identified service provider for businesses in the tribal lands of the PAG region. They provide broadband download speeds up to 24 Mbps and cover 50%-75% of the ZIP codes in tribal lands with available service. They do not provide coverage outside of the tribal lands.

Figure 3-12. Pima County Coverage – TOUA (Percent Offered Coverage by ZIP Code)



The above service level availability maps by provider show a visual representation of the gaps that exist in both coverage and competition in the PAG region. The far western ZIP code in the region is completely unserved by documented wired providers, as is the case with several far eastern ZIP codes. Competition exists in the northeast and surrounding the major metro of Tucson but, even then, is limited in many cases to one DSL provider and one cable provider. Appendix B provides a full spreadsheet of providers, percentage of coverage and corresponding available speeds by provider. Any providers serving less than 20% of any ZIP code were not included in the above mapping.

3.3 AVAILABILITY OF FIBER

The PAG region holds significant potential for business and economic expansion. The PAG region is ripe with opportunities for growth around a tech ecosystem as identified by conversations with area stakeholders. The PAG region is also at a pivotal moment for developing advanced communications infrastructure for enabling a Smart Region including smart transportation. These opportunities are each highly dependent on the access to fiber optic infrastructure.

For this assessment Magellan was tasked to identify and map the location of fiber optic wireline networks within the county. Most of the network owners did not provide mapping to support this assessment. Magellan utilized online mapping subscriptions and its market analysis and survey data to identify providers in the county. Understanding provider infrastructure and gaps will allow PAG and its partners to identify providers' ability and willingness to expand and invest throughout the region, particularly providers who have invested in fiber infrastructure. Figures 3-13 and 3-14 indicate that several providers have fiber routes in Pima County. Both long-haul and metro fiber

networks were located. Municipally owned fiber is not included, as the fiber is used only for government services. However, municipal fiber will likely play a role in the future of ACI throughout the PAG region. During the engagement, requests to obtain maps of municipal fiber layers were not successful, due to appropriate concerns on security, privacy and use of the data. However, efforts to obtain these layers should continue.

Carriers with Advanced Communications Infrastructure in the PAG region include:

Zayo (http://www.zayo.com) owns and operates a 112,600-mile network in North America and Europe with connectivity to thousands of data centers, enterprise locations, carrier exchange points, wireless towers, media centers, entertainment venues, financial exchanges and cloud providers. It offers dark fiber service, which is dedicated high-capacity, low-latency bandwidth offering in which the end user is responsible for "lighting" the fiber with their own equipment. In addition, Zayo's offerings encompass a range of managed bandwidth, lit fiber solutions, including wavelength, Ethernet, IP and video transport, across an expansive network footprint. A map of Zayo's network is at http://www.zayo.com/solutions/global-network .

Crown Castle (https://www.crowncastle.com) International Corp. U.S. - Crown Castle is America's largest provider of shared communications infrastructure, with more than 40,000 cell towers and approximately 70,000 route miles of fiber supporting small cells and fiber solutions across every major U.S. market.

Fatbeam (https://www.fatbeam.com) is a business-to-business provider of reliable fiber-based network solutions to enterprise, healthcare, government and education customers looking to accelerate their growth in the Western U.S. Fatbeam provides service across 7 states in the Western U.S. including Arizona. The company provides services that include both lit and dark fiber, dedicated internet access and transport.

First Digital / CenturyLink/ Level 3 (http://www.centurylink.com/aboutus.html) On November 1, 2017, CenturyLink acquired Level 3 Communications and all of the organization's assets and networks. In May 2018, the US Justice Department approved CenturyLink's sale of these assets to Salt Lake City-based First Digital Telecom (https://firstdigital.com/), which offers internet, voice, cloud, hosting & colocation, and infrastructure management services in Tucson. As part of the acquisition, First Digital gave customers the option to remain with CenturyLink, which now leases the assets from First Digital.[17]

Metro fiber routes are routes that connect larger stakeholders including municipalities, healthcare, education and large employers. Metro networks can then be utilized as a backbone to develop last mile networks including residential and small businesses. Several providers have metro fiber assets in Pima County including Crown Castle, Fatbeam, Level 3 (First Digital), Valley Telecom, Windstream, Zayo and others. Metro network assets are utilized by providers to serve last mile subscribers. Many of Pima County's metro fiber network assets are owned by providers that tend to service enterprise businesses and larger stakeholders such as education and healthcare facilities. Figure 3-13 shows major metro fiber networks.

[17] https://firstdigital.com/storage/app/media/uploaded-files/FirstDigital%20Tucson%20Press%20Release.pdf

Figure 3-13. Metro Fiber Networks

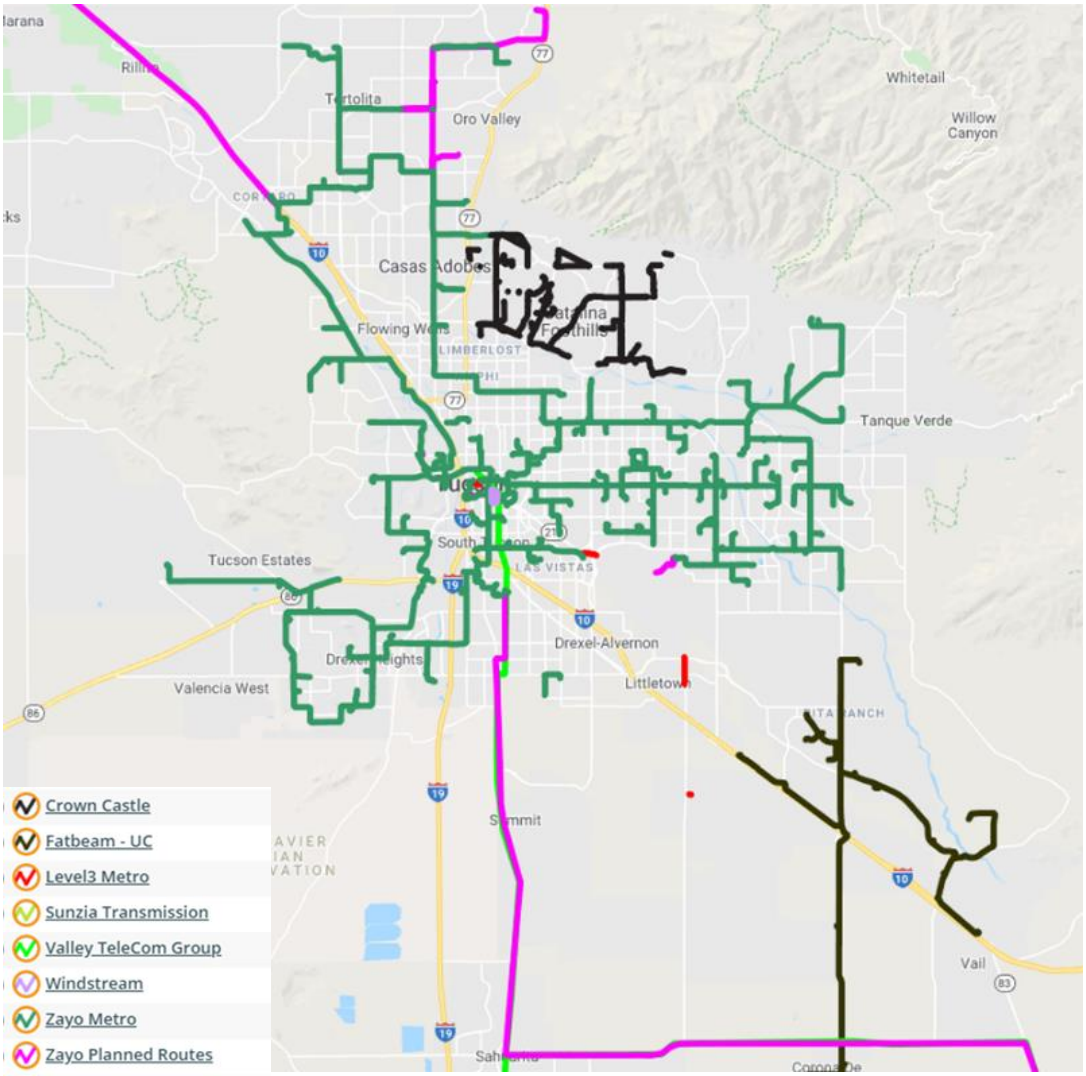


Figure 3-14 shows providers that have long-haul fiber network routes that cross through the PAG region. Long-haul fiber routes are routes that connect networks to internet points of presence (POPs). POPs connect to national and then international networks to transport data. Long-haul networks are important networks that connect the PAG region to the rest of Arizona, the United States, as well as globally.

Figure 3-14. Long-Haul Fiber Networks

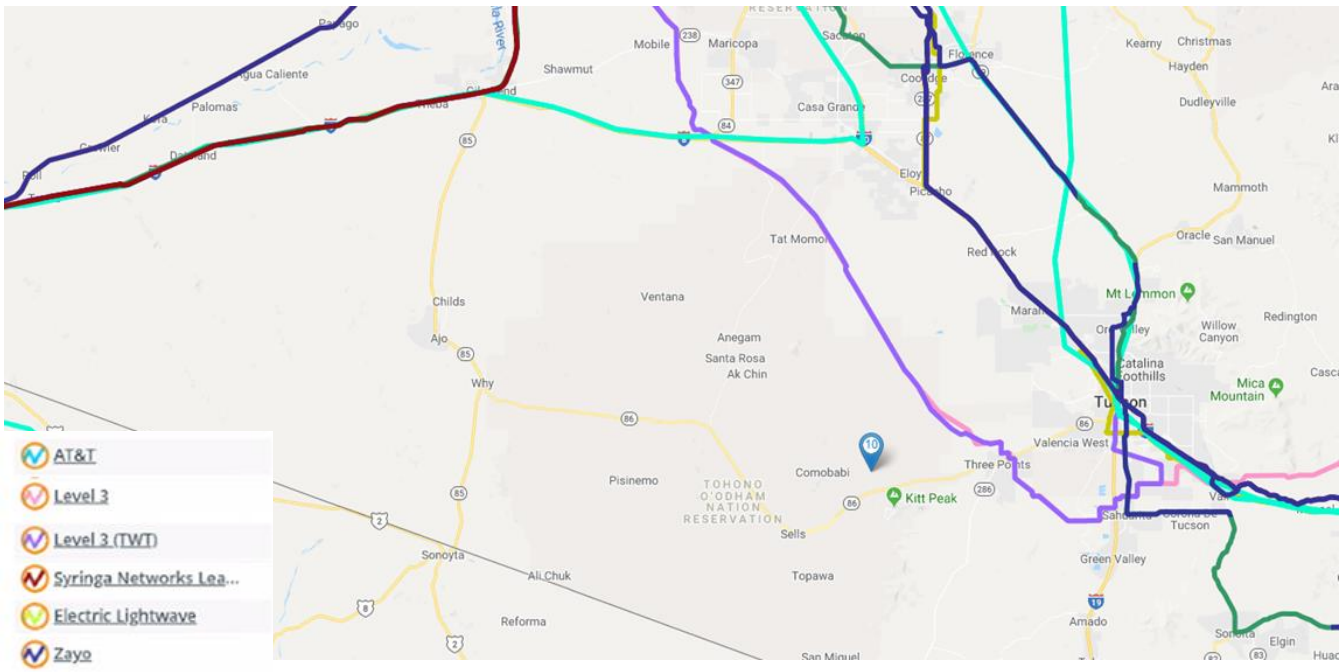


Figure 3-14 details providers that have developed metro fiber routes in the PAG region.

Long-haul fiber routes are carrier backbones, transmitting large amounts of data, and to which municipalities, commercial enterprises, health care facilities, universities and other entities can interconnect.

More information on the types of businesses subscribing to these services can be found in the survey analysis later in this report.

3.4 ADVANCED COMMUNICATIONS INFRASTRUCTURE SURVEY RESULTS

Magellan in coordination with PAG leadership developed an advanced communications infrastructure survey. The survey was released to participating PAG organizations including municipalities, large area stakeholders including healthcare and education institutions, large and small employers. No residents were surveyed. The survey was made up of 19 questions that addressed various concerns with advanced communication infrastructure uses, needs and impacts across the PAG region. Information from the survey is analyzed in the section below.

Magellan surveyed businesses and stakeholders in Pima County regarding their current supply and future needs and preferences for advanced communications infrastructure. The survey was open for over three months, with PAG advertising. The online survey received 70 responses, 44 of which were complete; 26 responses were partially complete; all responses are included in this analysis. (i.e., the respondents went all the way through the form to the end but may or may not have completed all items). Some questions may have fewer responses than 70, as some survey respondents failed to answer the question. While relatively few survey responses were received, the responses received, as well as interviews and written correspondence with stakeholders, provide anecdotal information about whether current needs are being met.

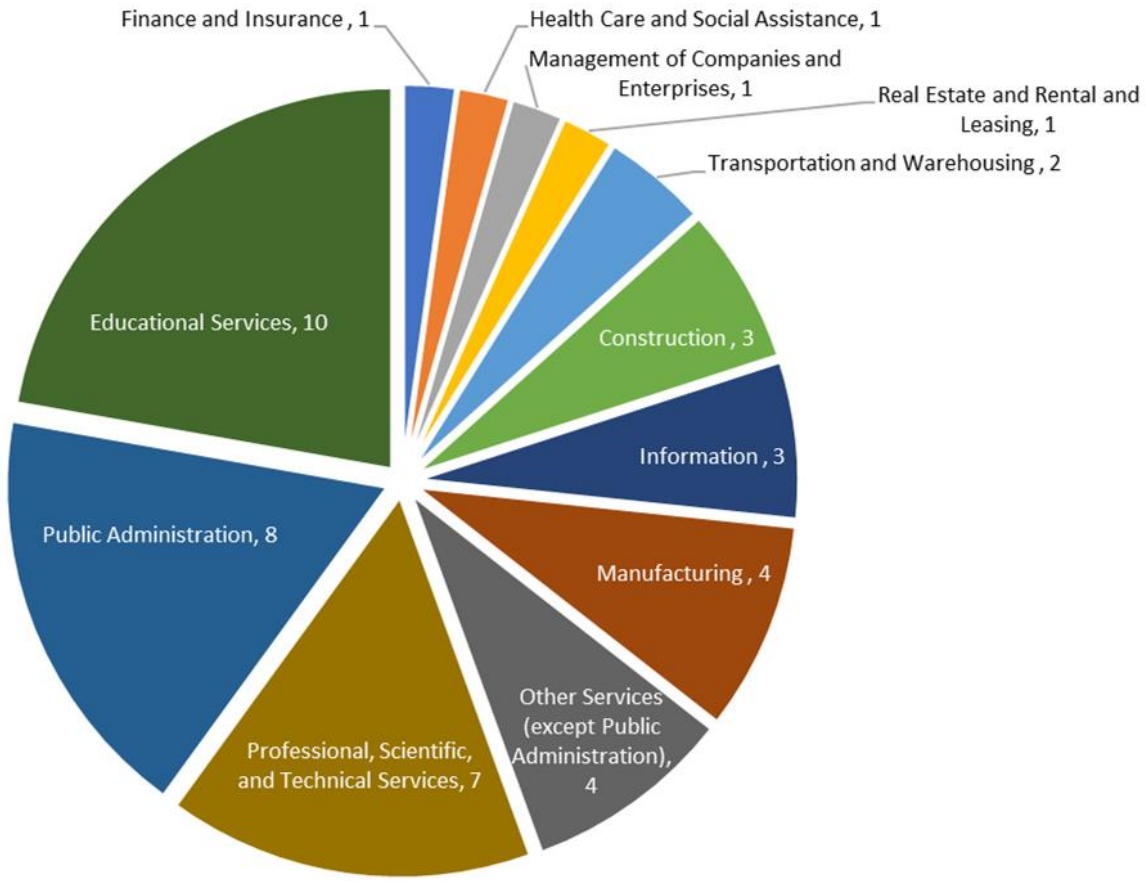
Figure 3-15 summarizes the percentage of responses by organizational type of the respondent. Most responses came from non-profits and public agencies including stakeholders such as education and healthcare with just under half coming from Pima County businesses.

Figure 3-15. Pima County ACI Survey Responses by Organization Type (n=70)

Responses	**100.0%**
Public Agency	37.1%
Not-for-Profit	16.1%
Private Business	38.7%
Home-Based Business	8.1%

As shown in Figure 3-16, the industries that responded come from a variety of business sectors, the largest percentage of which is education.

Figure 3-16. Percentage of Responses by Sector (n=45)



Internet Access Service and Importance

Respondents (61) indicated that most (98.4%) of locations for which they were responding had broadband internet service (see Figure 3-17), while only 1.6% of locations had no internet access. Respondents (59) were unanimous in the belief that internet access is an essential service to their organization – as important as water and electricity.

Figure 3-17. Broadband Access (n=61)

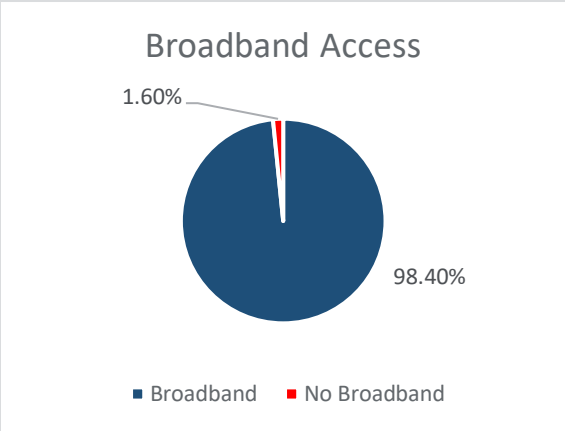
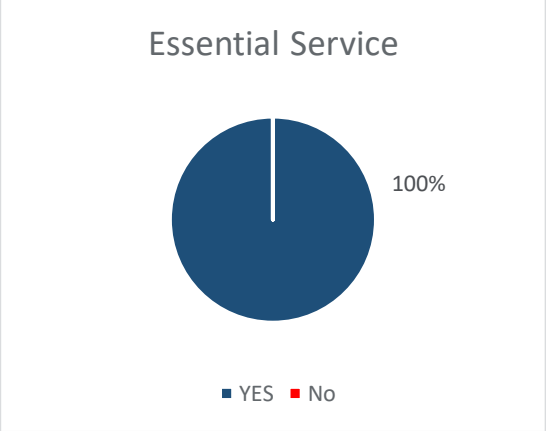


Figure 3-18. Broadband as Essential Service (n=59)



The organizations surveyed received their broadband access from several providers, using various technologies and experienced a wide range of speeds. The survey responses on internet providers are in line with the market study discussed earlier in this report. Almost half of respondents received their broadband connectivity from Cox, and other named providers included CenturyLink, Comcast and AT&T.

Performance & Bandwidth

While many of the providers appear to have coverage throughout several Pima County ZIP codes, the performance of the service appears to be consistently an issue across all areas. Figure 3-19 displays all survey responses, by ZIP code, in which an online test was taken to measure actual upload and download speeds[18]. As shown in the results, although the contracted (or offered) speeds in some cases exemplify robust bandwidth, the actual bandwidths experienced by users are considerably lower, in some cases falling well short of FCC speeds. The averages of these survey data indicate that this a trend throughout all areas of Pima County.[19]

Three small notes on the data. First, in the survey, "Average Contracted Upload" and "Average Contracted Download" speeds were manually entered by the respondent. Magellan did not curate the information in any way. Second, if no entries were made, Magellan reports "No Data," not zeroes. Third, these data only include responses in which actual speeds were tested through the

[18] Connection speeds were measured to the internet core via Measurement Lab's Network Diagnostic Tool (NDT) embedded in the survey instrument. For more information about this speed test, visit https://www.measurementlab.net/tests/ndt/

[19] While Magellan's survey did not receive enough responses to be statistically representative of Pima County, the responses received still provide important insights into the nature of broadband in the region. Therefore, we include them as a component of our analysis.

survey's built in speed test. Responses in which actual speeds were not captured are not included in the table below.

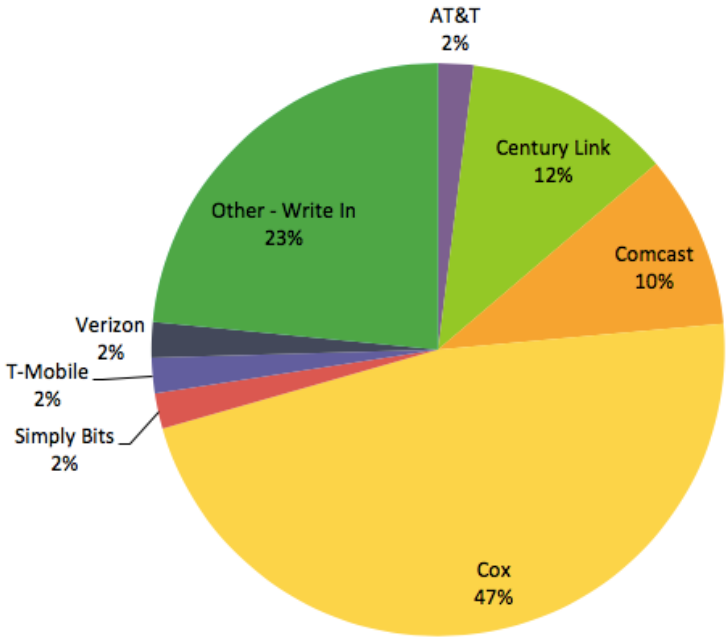
Figure 3-19. Speed Test Survey Results (Mbps) (n=14)[20]

ZIP Code	# of Responses	Average Contracted Download (entered)	Average Contracted Upload (entered)	Average Actual Download (electronic)	Average Actual Upload (electronic)
85622	1	22	10	2	11
85641	3	15	24	3	21
85653	1	79	36	49	8
85701 *	3	3767	3767	41	75
85705	1	10	50	10	41
85706	2	56	63	35	35
85710	1	15	70	31	67
85719	1	20	100	20	69
85721 *	2	5455	5435	162	220
85741	1	5	5	2	3
85747 *	1	No Data	No Data	91	58
85750	1	100	100	56	80
85757	1	250	250	4	0.5
85926 *	1	No Data	No Data	18	19
All (avg)	14	47	59	18	29

Averages are weighted, and exclude rows denoted by "*"

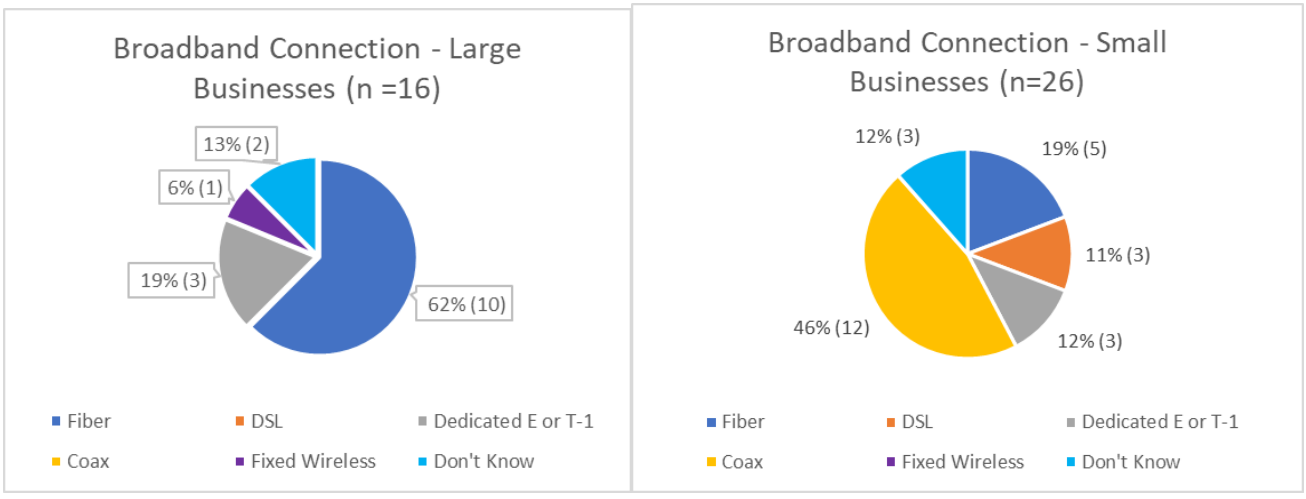
[20] The results of the speed test may be adversely affected by the respondents' connection type, especially if connected via WiFi.

Figure 3-20. Broadband Providers (n=51)



Nearly 35% (18) of organizations that responded to the question about type of connectivity (n=51) were receiving broadband connectivity over fiber-optics. This may be attributed to the types of organizations surveyed and the number of employees. Generally, larger enterprise organizations as well as public agencies like education and healthcare have greater abilities (larger budgets and access to government funding sources) to connect to fiber, and smaller businesses tend to rely on local cable and digital subscriber line (DSL) providers. Figure 3-21 below shows the surveyed PAG region organizations' employee counts vs. how they connect to broadband. For this analysis we considered any organization with fewer than 250 employees a small business.

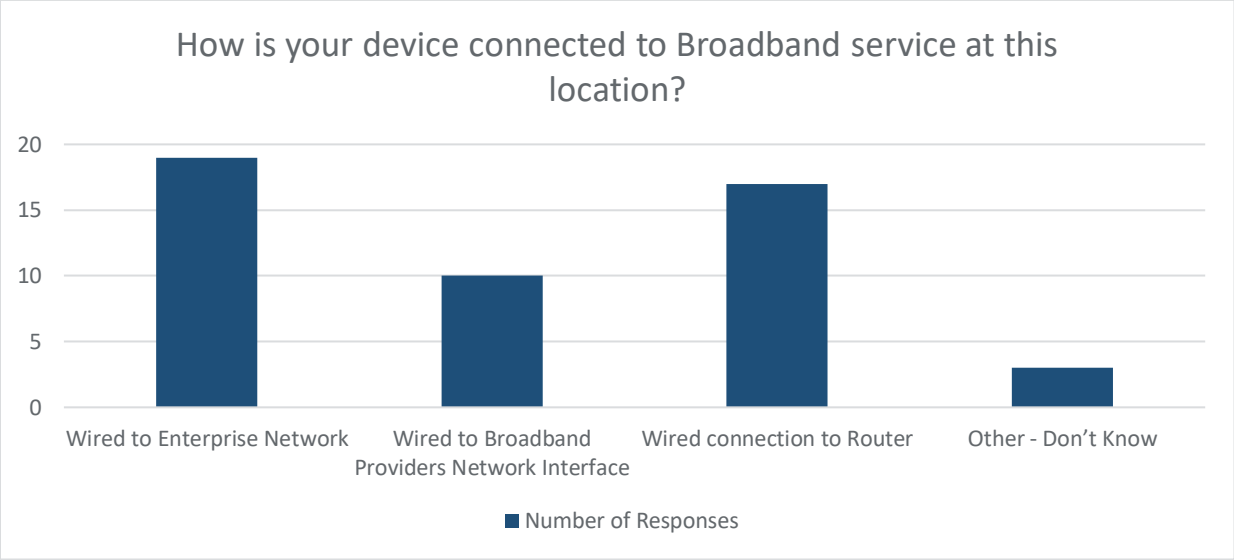
Figure 3-21. Broadband Connections by Business Size (n=42)



The proportion of businesses connected via fiber decreases as business size decreases. Smaller businesses in this survey tended to be more likely to have a connection over coax cable or, in some cases, less reliable and bandwidth-limiting technologies including DSL and fixed wireless. As bandwidth demands and connections increase so will the need for more speed and advanced communications infrastructure including availability of fiber optic broadband for all businesses in the PAG region.

To understand the actual speeds and connections PAG region's businesses were receiving, the survey contained a broadband speed test, which measures actual download and upload speeds, and questions on how the location was connected to the provider's infrastructure. As shown in Figure 3-22, most respondents (43) were connected by either a wired connection to the enterprise network, or a wired connection to a router.

Figure 3-22. Network Connections (n=51)



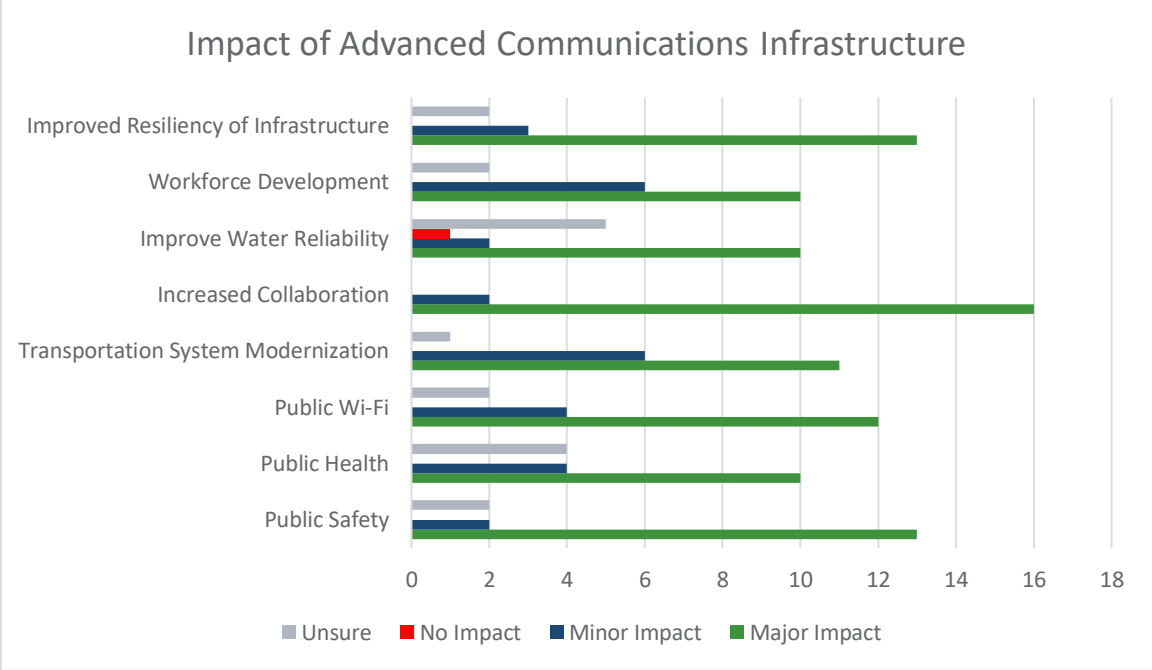
Speed test results varied depending on number and types of connections. The maximum actual speeds[21] were 331 Mbps download and 205 Mbps upload. Maximum total throughput—download plus upload—was 536 Mbps. Minimum actual speeds were 3.45 Mbps download and 2.33 Mbps upload, and lowest total throughput was 5.78 Mbps, well below the referenced FCC broadband definitions of 25/3 Mbps upload. The average speeds were 50 Mbps download and 37 Mbps upload. The highest throughput and speeds came from a fiber network with a wired connection to the enterprise network. The lowest throughput came from a coax cable connection wired to a router.

Impact of Advanced Communications Infrastructure

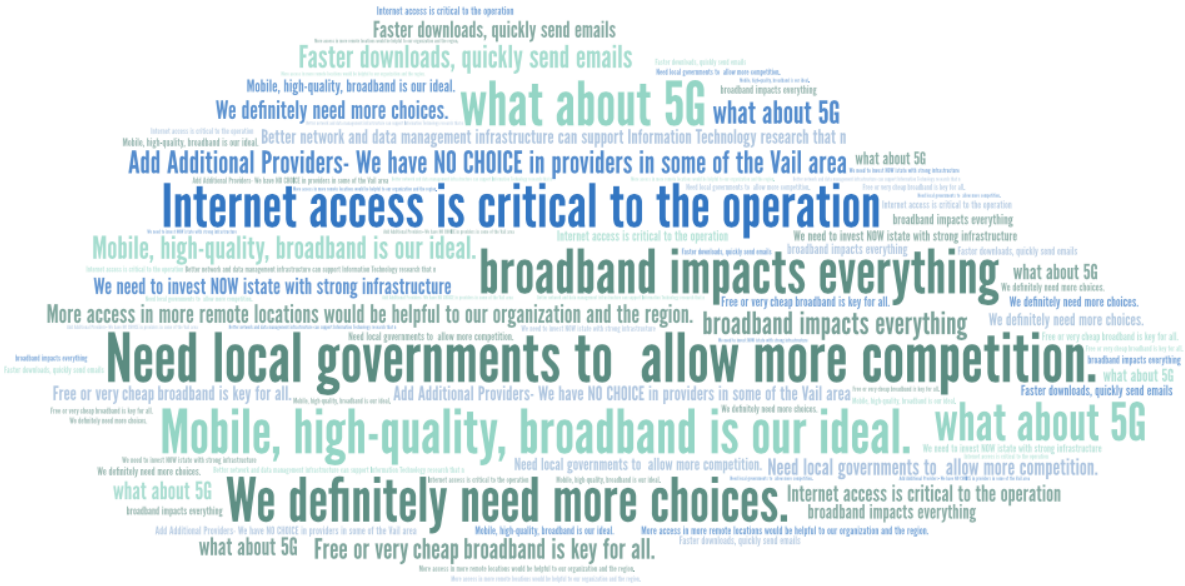
[21] Connection speeds were measured to the internet core via Measurement Lab's Network Diagnostic Tool (NDT) embedded in the survey instrument. For more information about this speed test, visit https://www.measurementlab.net/tests/ndt/

Perhaps the most insightful information for PAG can be gleaned from the respondents' beliefs about the benefits of increased advanced communications infrastructure in Pima County. Respondents indicated the areas in which advanced communications infrastructure would make the most impact for their organizations and the region. Respondents felt that the areas that would most benefit from advanced communications infrastructure included increased collaboration with internal departments and other organizations followed by public safety and improved resiliency of infrastructure. Over three quarters (13) of respondents to the question (n=18) believed that increased communication internally and with other organizations would be a major positive impact of implementing advanced communications infrastructure in Pima County. Respondents seemed least sure about the impacts that infrastructure would have on water reliability with over a quarter of respondents unsure if there would be any benefits at all. Overall, a majority of respondents believed that a major impact would be made to all areas, with greater than 50% of responses in every category indicating they believed implementation of advanced communications infrastructure in Pima County would make a *major positive impact*.

Figure 3-23. Impact of Advanced Communications Infrastructure (n=18)



Organizations that completed the survey were asked to leave additional comments or information. A few common themes emerged including a feeling that there was a lack of competition of ISPs in the area and a desire for faster speeds and reduced pricing. As one respondent wrote "I believe it is important to have more competition in the area of internet access to lower costs and promote innovation." While other respondents stated, "I would love to have faster access speeds for downloads" and "we would like to see more than one broadband service provider that is affordable."



Additional responses spoke to the importance of broadband and internet access for the region, its stakeholders and the future of its economy. The quotes include:

- "Arizona is poised to become a top five region in the Technology Industry. We need to invest NOW in becoming a state with strong infrastructure that enables our progress into the IT Services space."
- "Need local governments to allow more competition. Monopolies of broadband communication suppliers limit customer satisfaction. U.S (and Arizona) is behind compared to many advanced countries. Fiber optics is critical to advancing broadband to one Gigabit service for both download and upload at reasonable prices to customers, residential or business. Within Tucson, no competition between the two larger Internet Service Providers as regional areas are limited to one provider. Is this free market?"
- "Mobile, high-quality, broadband is our ideal. Right now, we rely on mobile tethering and consumer grade internet at home. We are a fully remote staff, so no offices."
- "Just about everything we do involves broadband. From water resource management to traffic signal coordination, to public safety, to economic development, broadband impacts everything."
- "Add Additional Providers- We have NO CHOICE in providers in some of the Vail area."
- "More access in more remote locations would be helpful to our organization and the region. Cost of adding broadband in areas where there currently isn't any, especially nearby, is a large barrier to growth for smaller companies or towns."

3.5 CONCLUSIONS ABOUT THE PAG REGION MARKET

As with most other regions in the country, and based on the analysis of the current broadband market in the PAG region and survey data collected by Magellan, the region struggles with unserved markets, gaps in coverage, a lack of competition, and insufficient bandwidth to meet the growing needs of business and organizations. To support a Smart Region, further investments in

advanced communications infrastructure are needed to ensure operational needs are met in all areas of the county.

Outside of its core metro areas, the PAG region faces the reality that portions of its region are still unserved by any wired internet service providers. These areas are limited in growth, economic development and a variety of negative social and educational impacts that accompany a lack of access to advanced communication infrastructure and can be categorized as internet deserts.

The PAG region is not alone in this as the majority of America is hindered with a choice of only one cable and one DSL provider leaving customers feeling "stuck" with their options. This is especially true in underserved and unserved areas. Regional planning organizations such as PAG have begun to take on the challenge of enhancing advanced communications infrastructure in their communities by making policy changes and deploying or leveraging infrastructure to assist providers in expanding their footprints. Such strategies, as appropriate to PAG, will be further expanded upon in the "Recommendations" section of this report.

4. Assessment of Current State of Broadband

4.1 INTERVIEWS AND QUESTIONNAIRES

Magellan conducted an extensive series of interviews with PAG personnel, and with some of the nine PAG members, and several important groups and individuals within the regions. These interviews discussed current state and immediate plans, and sought input for longer-term planning regarding advanced communications and broadband needs.

Among the groups and individuals interviewed were:

- Pima Association of Governments
- City of Tucson
- Pima County Economic Development
- Arizona Department of Transportation
- Arizona Commerce Authority Broadband Office
- Arizona Commerce Authority Smart State Office
- Arizona State University
- University of Arizona
- Pima Community College
- Town of Marana
- Town of Sahuarita
- Town of Oro Valley
- El Rio Health
- Pima County Wireless Information Network ("PCWIN")
- Banner Health
- Zayo
- GSW Telecom
- Tucson Electric Power

Magellan and PAG also collected written responses to a questionnaire from several of PAG's stakeholders including the Town of Marana, the Town of Oro Valley, the Town of Sahuarita, the City of Tucson, and the Pascua Yaqui Tribe. Unfortunately, Magellan was unable to schedule interviews with several PAG members, including the Tohono O'odham Nation, the Pascua Yaqui Tribe, and the City of South Tucson.

In addition, Magellan was also unable to schedule follow-up interviews with three important electric utilities, Tucson Electric Power ("TEP"), Trico Electric Cooperative ("Trico") and the Tohono O'odham Utility Authority ("TOUA"). Some information from TEP was collected during the kickoff meeting, but more depth of knowledge is required to adequately gauge partnership opportunities.

These utilities can likely play key roles in the delivery of broadband services to buildings in the PAG region.

PAG Member Agencies

During discussions with PAG's member agencies at the kickoff for this project, leadership from those present expressed a willingness to engage in best practices for the advancement of ACI for the PAG region, emphasizing that it should be a holistic approach with benefits for all, not just one community. The region consists of both urban and rural cities and towns, as well as tribal entities, and the interests and needs of each should be considered.

The Town of Marana, a suburban PAG member jurisdiction, emphasized the importance of recognizing the needs of non-metropolitan communities. Marana has many home-based businesses and telecommuters. The town's staff have heard that internet is an issue among these businesses. A particular pain spot is the remote northern parts of the town, where only one business internet options exists (CenturyLink). At the time of this project's kickoff in October 2019, Marana's staff indicated that they are currently in discussions with First Digital to expand fiber services in the community; as of the writing of this report, the status of these discussions is unclear.

Marana has a limited amount of fiber and conduit infrastructure, but exact specifications are unknown as the town does not currently track its assets in GIS. Although the town has not yet officially identified needs for Smart City applications, its Water Department is implementing smart meters and representatives from the town have indicated that "ideas and opportunities would more readily present themselves" if the necessary infrastructure was in place. None of the town's current capital improvement projects include advanced communications infrastructure, but staff recognizes the opportunities for regional collaboration, as long as its needs as a rural community are met. Marana has started planning for 5G by updating its permitting processes and would be open to regionalized approaches to planning for wireless small cell deployment as well.

The Town of Oro Valley, a similarly sized suburban community, has heard through discussions with its businesses that broadband is a need. Business owners and operators have expressed a need for more provider choices and faster speeds. According to town staff, no provider offers Gigabit service in Oro Valley. The town is currently seeking to bring several data centers to the area and has cited concerns among site selectors as an inhibitor of economic development. In addition to the needs of its businesses, Oro Valley has internal needs for ACI, including for the development of automated transportation technologies and increasing access to municipal services through Smart City applications. Overall, a representative from the town points out that there are a variety of existing, emerging, and unknown technologies that will require ACI in the future:

> "Society's reliance on access to large data will only continue to increase. Our ability to provide an infrastructure to support these needs will make the town more attractive to employers and citizens."[22]

The town's current broadband strategies include placing conduit in the ground during all street widening and reconstruction projects; a Broadband Infrastructure Plan to be submitted for Council's consideration by April of 2021; enhancing transportation such as connected traffic signals; improved reliability for accessing the internet, and expanding the footprint of broadband services for citizens. Oro Valley has already begun discussions with PAG on these initiatives and is in favor of a regional approach, especially for support of a regional plan, establishment of consistent design standards for ACI, the ability to cross-connect the various infrastructures in the region leveraging a more consistent and uniform broadband experience, and to provide a foundation for additional shared services in the region such as smart traffic signals.

The Town of Sahuarita, though slightly smaller than both Marana and Oro Valley, is also growing, as indicated by the town's wastewater treatment plant being upgraded from 1.5 million to 2.25 million gallons per day ("MGD"). Sahuarita partners with a number of telecommunications providers to fulfill the town's needs and already has fiber connectivity to its satellite locations both within and outside of the town, including a direct connection to the Pima County Sheriff's Office. Sahuarita has wireless mesh capacity by utilizing access points located on all traffic signals; however, this has not yet been implemented, and the equipment is aging, or has aged, out of service. The town is also working on distributing fiber availability throughout its boundaries.

Although Sahuarita has limited empty conduit and vertical assets, it has standardized installation of four-inch conduit when new roads are built or existing roads are expanded. The town also recognizes the need for ACI to support Smart City applications including intelligent transportation technology, public safety cameras, video, and traffic signals. The wastewater treatment plant has already implemented SCADA and Sahuarita Police Department uses an app called Nixile to engage with citizens on public safety information. Like Oro Valley and Marana, the Town of Sahuarita sees an opportunity to collaborate, especially for wireless permitting processes.

The City of Tucson, PAG's most metropolitan member, has over 500 miles of municipal fiber. As detailed in Section 2 of this report, Tucson has attracted and continues to draw a number of new businesses. Overall, the city feels its communications needs are being met. Most of the City's anchor institutions are already connected via fiber and staff was not aware of major development deals falling though due to a lack of connectivity. As seen in the market assessment, the city has

[22] Quoted from the Town of Oro Valley's written response.

the most private investment in fiber infrastructure in the region, enabling more options for businesses within Tucson than elsewhere.

Tucson uses intelligent inventorying to track its assets and participates in swaps with ADOT for conduit and fiber. It is also currently embarking on a pilot smart city program led by the Office of Economic Initiatives in collaboration with multiple private sector partners. The city's Transportation and IT departments are supporting this initiative and are pursuing a number of Smart City initiatives (no details were immediately available about what these were). The city expressed that school connectivity should be a key consideration for connectivity to ensure that they have a competitive advantage.

As of the writing of this report, all schools in the PAG region are connected or have applied for connections via the E-Rate program and have not expressed a need for additional connectivity. However, the school districts and Pima Community College have struggled to connect students who live in unserved or underserved areas, making remote learning challenging. Opportunities to collaborate with the schools to resolve these issues may certainly be pursued in the future.

While a formal interview with the Pascua Yaqui Tribe could not be arranged, the tribe provided some information about its current assets and needs. The tribe owns some fiber and wireless infrastructure and is in the process of replacing any outdated assets. They have several planned capital improvement projects, detailed below, and coordinate all approval processes involving the legal right-of-way with the County. The Pascua Yaqui Tribe indicated that it does not currently have any urgent need for ACI, but that it may be interested in a regional approach; participation from all Arizona Native American reservations would likely improve the tribe's willingness to participate.

Tucson Electric Power & Trico Electric Cooperative

Tucson Electric Power ("TEP") has both Advanced Metering Infrastructure ("AMI") and Automated Meter Reading ("AMR") in place in 100% of its service territory and is in the process of transitioning to AMI from AMR. AMI is more advanced, providing capabilities for managing flow and devices, in addition to AMR's ability to detect and record total usage without meter readers. TEP has a combination of fiber and licensed microwave, with a mix of approximately 70% fiber, 30% microwave. Almost all fiber is aerial, although there is some underground fiber in downtown Tucson. The fiber used for utility purposes goes across state land.

TEP states that its assets are challenging to monetize because of the complexity of land rights' issues. For instance, in one case, TEP has a line that runs 60 miles, across land which is owned by 30 different parties. The process to get land rights currently takes about 6 months to 3 years, making it challenging to develop a business plan.

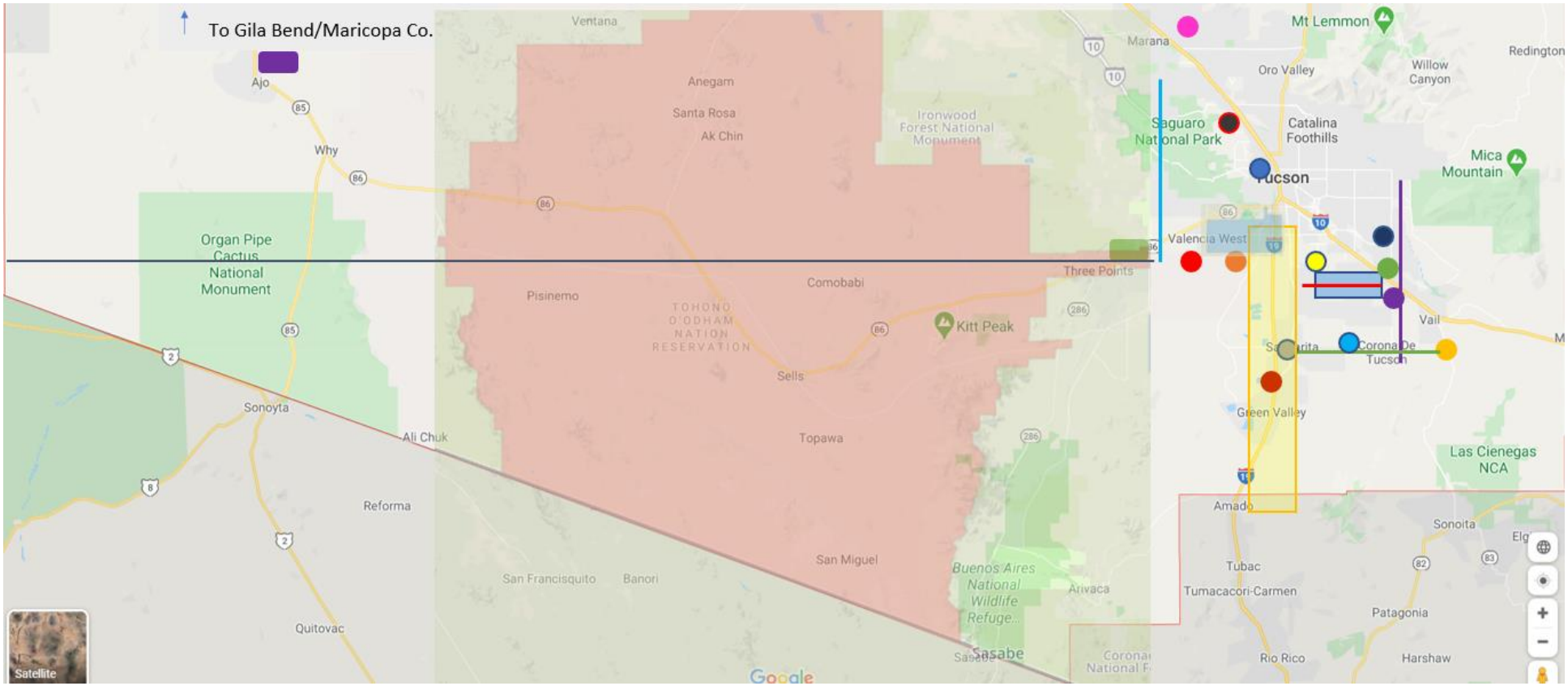
At the time of project kickoff, TEP had been approached by an unnamed large backhaul fiber provider that is well established in Phoenix but does not have a major presence in rural areas. Representatives from TEP expressed a willingness to continue discussions with PAG about the use of TEP assets to meet ACI needs across the region. Trico also has some fiber and microwave assets in the region, especially in the rural areas. They do a lot of backhaul from substations.

4.2 IDENTIFICATION OF FUTURE NEEDS

Magellan recommends that the RPC and PAG members leverage infrastructure and economic development plans already in place for Advanced Communications Infrastructure (ACI). When roads are being constructed or enhanced, Pima County, the cities and towns, and tribal nations can leverage the opportunities those initiatives provide by concurrently placing conduit and, if appropriate, fiber. Large business parks, new commercial expansion zones, new schools and other new community anchors offer similar opportunities for maximizing installation of ACI infrastructure, including conduit and fiber. These joint trenching opportunities provide tremendous opportunities for expansion with minimal marginal costs.

Based on the interviews, stakeholder questionnaires, review of existing reports, and other sources, Magellan has identified many of these locations as likely opportunities for broadband expansion in the county. These are consistent with known short-, medium- and long-term initiatives and planning underway. The following figure highlights the location of many projects.

Figure 4-1. Possible Focus Areas for Broadband Expansion



Legend for "Focus Areas for Broadband Expansion"

- Pascua Yaqui Property at Grant Rd at I-10 – To be developed
- Pascua Yaqui Property near Sewailo Golf Club – To be developed
- Diablo Village, Sonora Village, west along West Valencia and Highway 86 – Major developments to come
- Vail Crossings – 400-500 acres being developed. Looking at homes for half of it and industrial for the other half. All owned by one company. County is building sewer (start date late this year or early next year).
- Houghton Road at I-10 – Planned new ADOT interchange. 1,900 acres being planned for industrial. Auto manufacturer, supplier for Raytheon coming into this area. County is reserving for other major factories. Road improvements underway by county.
- Sahuarita to Vail (Sonoran Corridor) – Economic Impact Study estimates GDP of $31 billion per year. Needs water and sewer infrastructure in some locations. Water infrastructure around Tucson International Airport is underway.
- Southeast Employment and Logistics Center (Pima County Fairgrounds) – 2,000 acres planned for large industrial employment opportunities.
- Tucson International Airport/Space Port Tucson - Opening up 500-600 acres on Alvernon to the east of airport for development. Likely industrial development, not residential. This area also includes the already developed Aerospace Research Campus with 400+ acres and infrastructure (including conduit) for high technology and aerospace users.
- Huckelberry Loop bike trail to Houghton – Recently sold by state to home developers. 700-800 acres. City just rezoned and developers have recently purchased it. Quarter to third acre lots planned.
- Town of Sahuarita – Recently started developing 5,000 homes over the next 25 years per their master plan. Sahuarita has a master plan to grow over to Wilmot Rd. in the short term, and to Houghton Road in the long term.
- Between Sahuarita and Green Valley – Plans for an incubator for some industrial space down there on the west side of I-10 south of Sahuarita Road. This area may likely grow eastward. Tribal lands and mines are to the west.
- Town of Marana – Tangerine Corporate Center, at southwest corner of Interstate-10 and Tangerine. 45-acre Commerce park anchored by a distribution center.
- Sunset Innovation Campus – SWC of Sunset and Interstate-10. 100 acres planned for multi-building office complex with adjacent parks and access to The Chuck Huckelberry Loop. Also includes County/City/ADOT project for a new traffic intersection (TI) at Sunset and a new connection of Sunset Road to River Road.
- Sandario Road – Depending on final decisions made regarding Interstate 11, this could be a focus area for new fiber.
- Houghton Road – Major thoroughfare, used by people from Sahuarita to get to the UA Tech Park, miners to get to Vail.
- Old Vail Connection Alignment – Possible route for new Sonoran Corridor road between federal and state prisons. That area will open several thousand acres of land for industrial. Mostly state-owned.
- Sahuarita Road – Will connect to Highway 83. Seeing heavier densities moving that direction. Right now, larger 3-5 acre rural parcels.
- Garcia Strip – Runs east from map boundary to Sandario Road and the San Xavier District, south of Highway 86 and west of Nogales Highway, north of Pima Mine Road.[23]

[23] Approximate location based on information provided from County Economic Development and Pima County DOT's "Intermountain West Corridor in Pima County: A Preliminary GIS-Based Roadway Alignment and Impact Study," https://webcms.pima.gov/UserFiles/Servers/Server_6/File/Government/Transportation/Transportation%20Planning/Future%20Roadway%20Plans%20and%20Reports/Intermountain%20West%20Corridor%20Report%20no%20maps.pdf


Pascua Yaqui Reservation


Tohono O'odham Nation

County-owned Eric-Marcus Municipal Airport near Ajo. Potential for aerospace activity; 2-3 companies considering for horizontal launch site.

Ryan Airfield – City owns land to the west; County owns land to the north. Opportunity for a major aircraft pilot training facility, increased industrial development.

Potential location for a segment of the Sonoran Corridor – Home to Raytheon Missile Systems, Davis-Monthan Air Force Base, Tucson Int'l Airport, and UA Tech Park; approximately 50 square miles. Potential route goes south along Alvernon alignment to El Toro Road.

Arizona DOT Smart Highway Initiative (Interstate 19 from Tucson to Nogales) will provide opportunities for conduit sharing and new fiber.

4.3 REGULATORY ASSESSMENT – FEDERAL, STATE LAWS, POLICIES AND REGULATIONS

Magellan performed a detailed review of state and federal regulations that may have an impact on the future of advanced communications infrastructure within the PAG region. Local authorities around the country are adopting new policies to address the increasing demand for access to structures (e.g., streetlights, towers, utility poles, and buildings) owned by local authorities and public rights-of-way to accommodate "4G/4G+" and "5G" "small cell" deployments by wireless carriers such as AT&T, Verizon, T-Mobile, Sprint and their contracted providers. Current "4G/4G+" deployments are aimed at densification and increasing capacity in high-use areas while 5G small cell facilities also are being deployed in larger numbers to greatly increase speed and data capacity on a "fill-in" basis. Deployment of "5G" is distinguished from the present "4G" based wireless service by use of low power transmitters with coverage radius of approximately 400 feet, 5G thus requires closer spacing of antennas and more of them. Small cells bring the network "closer" to wireless service users to deliver greatly increased data capacity, faster connectivity speeds and an overall better wireless service. As stated by the FCC:

> *The wireless industry is currently deploying and planning for additional construction of large numbers of small cells – the number of these facilities is expected to grow rapidly over the next decade. S&P Global Market Intelligence estimates that between 100,000 and 150,000 small cells will be constructed by the end of 2018, and that small cell deployments are expected to reach 455,000 by 2020 and nearly 800,000 by 2026. AT&T has reported that a substantial majority of its infrastructure deployments over the next five years will be small cell sites. In addition, Verizon is deploying small cells in several urban areas, including New York, Chicago, Atlanta, and San Francisco. Sprint announced last year a goal of deploying 70,000 small cells within two years.*[24]

The growing multitude of applications for location of antennas by service providers is matched by efforts by large service providers, such as Verizon, AT&T, Sprint and T-Mobile, to change state and federal statutes and policies. The placement of wireless facilities (and telecommunications generally) is governed by a legal framework based on shared jurisdiction of state and federal authorities. However, the trend in the past two decades is for the Federal Communications Commission (and Congress) to preempt the authority of state and local jurisdictions. The FCC most recently attempted to preempt local authorities in its Small Cell Order (below).

The FCC states the "dilemma" of this shared jurisdictional legal framework, as well as its perspective regarding jurisdiction-supporting preemption of local authority, is as follows: [25]

[24] Streamlining Deployment of Small Cell Infrastructure by Improving Wireless Facilities Siting Policies; Mobilitie, LLC Petition for Declaratory Ruling, WT Docket No. 16-421, Public Notice, 31 FCC Rcd

[25] *Ibid*., at page 2.

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

Nonetheless, small cell deployments raise concerns which cities and counties must address in a multi-carrier (i.e., AT&T, Verizon, T-Mobile and Sprint) wireless competitive environment.

This includes increasing antenna and pole density with 5G, mitigating the visual and physical impacts of increased equipment to be used or mounted on municipal- and utility-owned structures, and addressing carrier preferences not to collocate[26] with another carrier on poles and structures in spite of the much greater density of small cell equipment. Many carriers consider streetlights and utility poles to be "ideal" supporting structures for placement of small cell antennas and equipment, which drives the cities' need for standards and guidelines on placement of antennas and other facilities on or near these structures. Cities and counties often prefer installation of small cell wireless facilities on streetlights owned by the local authority based on the positive visual qualities of these facilities when built in conformance with design standards, efficient use of assets and the public rights-of-way, as well as in support of Smart City initiatives as described throughout this Advanced Communications Infrastructure assessment.

Furthermore, there is a common misperception that wireless service means it is wireless all the way from the user's smartphone to the other end of the communication, whether a voice call to another person, browsing a website or streaming video. In fact, the wireless portion of the communication is typically relatively short, from the smartphone to the antenna which is supporting the communication. That antenna is either a "5G" small cell antenna on a pole or streetlight, a "4G" antenna on a taller tower, or a WiFi connection, depending on the location. The rest of the communication from the antenna or WiFi connection occurs over the landline network, typically via fiber.[27] The proliferation of 5G small cell antennas drives an equivalent need for fiber-optic cable connectivity to connect each antenna to the telecommunications network for backhaul and switching purposes.

[26] The general meaning of "collocation" is the mounting or installation of an antenna on an existing tower, building or structure for wireless communications purposes, which includes the circumstance of adding an antenna to a structure which already has another carrier's antenna on it.

[27] Verizon Wireless is beginning to explore use of wireless connections to link one tower via wireless to another fiber-linked tower to avoid the need for fiber-optic cable in some circumstances. "Verizon is looking to implement a fiber alternative to scale 5G deployments", https://www.businessinsider.com/verizon-plans-fiber-alternative-to-fuel-5g-rollout-2019-10?IR=T&itm_source=twitter&itm_medium=social&itm_content=briefings_post&itm_campaign=10-19-2019 , Business Insider, October 14, 2019.

The PAG region will see a corresponding trend of wireless service providers and their outsourced contractors (e.g., Crown Castle, Zayo, etc.) seeking permits to encroach in the public rights-of-way to place conduit and fiber for this purpose.

In this context, it is crucial for PAG's member jurisdictions to consider adoption of policies which enable and support ongoing development of municipal fiber as well as managing public rights-of-way and deployments of wireless communications facilities in the public interest.

Federal Policy[28]

The "Spectrum Act" was enacted by Congress in 2012[29]. The Spectrum Act added new requirements and directives to the Federal Communications Commission (FCC) for processing and approval of wireless deployments. On January 9, 2015, the FCC issued new regulations to interpret and implement these Section 6409(a) requirements and directives of the Spectrum Act related to processing applications for wireless communications facilities. In brief, Section 6409 requires local jurisdictions to approve certain collocations and modifications to existing wireless communications facilities, if it is an "eligible facilities request" (any request for modification of an existing tower or base station that does not substantially change the physical dimensions of such tower or base station, involving (1) collocation of new transmission equipment; (2) removal of transmission equipment; or (3) replacement of transmission equipment). The new FCC regulations established objective standards for what is considered to be "substantial change" and implemented "shot clock" regulations.

Federal law allows cities and counties to regulate the "placement, construction, and modification" of wireless communications facilities subject to certain limitations.[30] Those limitations include:

- City regulations may not "prohibit or have the effect of prohibiting the provision of personal wireless services"[31];
- City regulations may not "unreasonably discriminate among providers of functionally equivalent services"[32];
- Any denial of an application to place, construct, or modify a personal wireless facility must be based on "substantial evidence contained in a written record"[33]; and,

[28] The following discussion does not constitute a legal opinion and should not be construed as such. Questions about interpretation or applicability of these or other provisions of federal or Arizona law should be referred to legal counsel.

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

[30] 47 U.S.C. § 332(c)(7)(A).

[31] 47 U.S.C. § 332(c)(7)(B)(i)(I).

[32] 47 U.S.C. § 332(c)(7)(B)(i)(II).

[33] 47 U.S.C. § 332(c)(7)(B)(iii).

- City regulations may not "regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions.[34]"

Also, the FCC has regulatory jurisdiction over transmission of radio frequencies (RF), since the 1996 Telecommunications Act preempted local regulation of RF safety standards in favor of a uniform national RF safety standard under FCC jurisdiction.[35] "The FCC's limits for maximum permissible exposure (MPE) to RF emissions depend on the frequency or frequencies that a person is exposed to. Different frequencies may have different MPE levels."[36] Local authorities can require compliance with FCC RF standards be demonstrated in evaluating 5G siting applications. Applicants often make this demonstration part of the application package.

The FCC's Small Cell Order

On September 26, 2018, the FCC issued its "Small Cell Order,"[37] which is the subject of current, vigorous appeals. The Small Cell Order broadly interprets the "effective prohibition" provisions of the Telecommunications Act Sections 253(a) and 332(c)(7) to find that a state or local government need only "materially inhibit" placement of "small wireless facilities" to have an effect of prohibiting the provision of wireless service. The Order permits fees only to the extent they are non-discriminatory ("no higher than the fees charged to similarly-situated competitors in similar situations") and are a "reasonable approximation" of the government entity's "objectively reasonable costs" specifically related to the deployment.[38]

The Order sets out fee levels which are "presumptively reasonable" at $270 per small wireless facility per year, a $500 application fee for up to five facilities, plus $100 for each facility beyond five.[39] Higher fees can be charged if the state or local government entity can show the higher fees are a reasonable approximation of cost and the costs themselves are reasonable and being assessed in a non-discriminatory manner.[40] The FCC appears in a footnote to preclude "in-kind" services or contributions stating such services or contributions "are not cost-based" and "they inherently have 'the effect of prohibiting'

[34] 47 U.S.C. § 332(c)(7)(B)(iv).

[35] 47 U.S.C. § 332(c)(7).

[36] A Local Government Official's Guide to Transmitting Antenna RF Emission Safety: Rules, Procedures, and Practical Guidance; at page 3.

[37] Declaratory Ruling and Third Report and Order; In the Matter of Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment; WT Docket No. 17-79; In the Matter of Accelerating Wireline Broadband Deployment by Removing Barriers to infrastructure Investment; WC Docket No. 17-84; Released by the Federal Communications Commission, September 27, 2018. ("Small Cell Order" or "Order".)

[38] Small Cell Order, at paragraph 50.

[39] *Id*., at paragraphs 78-79.

[40] *Id*., at paragraph 80.

service."[41] The Order permits fees paid to consultants and third-party contractors to be passed through as long as they are reasonable.[42]

Additional provisions of the Small Cell Order include:

- Aesthetic requirements must be reasonable, non-discriminatory and published in advance, or they are subject to possible preemption;[43]
- Undergrounding requirements are subject to similar criteria;[44]
- Shortened shot clocks pertaining to small wireless facilities:
- 60 days for siting on preexisting structures (which is a new definition of collocation – a facility need not already have a wireless facility attached to it);
- 90 days for siting requests that involve construction of a new qualifying structure;
- Rejection of "deemed granted" remedy for failure to act within these time frames;
- Shot clocks are applied to all authorizations, e.g., zoning permits, building permits, electrical permits, road closure permits, and engineering permits;[45]
- Conflicting provisions of state small cell laws would evidently be preempted by the FCC;[46] and,
- Conflicting provisions of preexisting contracts could be preempted by the FCC, depending on facts and circumstances.[47]

The FCC's Small Cell Order became effective on October 15, 2018. However, provisions of the Small Cell Order are not self-effectuating – a service provider or other entity would have to prevail on the matter in court or before the Commission on a complaint. Beyond that, many parties filed appeals in various Courts of Appeal around the country as well as Motions for Stay of effectiveness of the FCC's Order. The appeals which have been consolidated before the Ninth Circuit Court of Appeals are:

- First Circuit: Puerto Rico Tel. Co. Inc. v. FCC
- Second Circuit: Verizon v. FCC
- Ninth Circuit:
    - City of San Jose, et. al v. FCC
    - City of Seattle, et al v. FCC
    - City of Huntington Beach v. FCC
    - Sprint Corp. v. FCC

[41] *Id*., at footnote 252. The footnote cites no evidence beyond comments of service providers.
[42] Id., at paragraph 70.
[43] Id., at paragraph 84-89.
[44] Id., at paragraph 90.
[45] Id., at paragraph 144.
[46] Id., at paragraph 6.
[47] Id., at paragraph 66.

Arguments have occurred before the Ninth Circuit in this case and a decision is pending. The appeals and pending decision casts a cloud of uncertainty over the FCC's Small Cell Order and it is not possible to predict the final status of the FCC's rulings in that Order.

Pending the outcome of the appeals, the FCC's Small Cell Order is enforceable. Whether any party would seek to enforce it, with all that would entail while it is under appeal, is another matter. Cities and counties are addressing the present uncertainty over what the rules will be according to their views on risk. Some cities and counties have chosen to accept the FCC's "presumptively reasonable" rental fee of $270 per small wireless facility per year as a "safe harbor rate." which will not be challenged.

Other cities and counties have chosen to recognize that the FCC's Small Cell Order is under appeal and not in effect, and either set fees/terms and conditions as they would have otherwise, and/or incorporated provisions in ordinances and agreements that have "change of law provisions" with the current appeal in mind. Such "change of law provisions" allow changes to fees, agreements and other regulations in the event the FCC Order is substantially upheld.

Federal Wireline Broadband Policy

Over the past several years the Federal Communications Commission has undertaken a number of investigations regarding promotion of deployment of broadband facilities and services, for both wireless and wireline infrastructure. In 2017, the FCC opened a new proceeding regarding wireline infrastructure seeking "to accelerate the deployment of next-generation networks and services by removing regulatory barriers to infrastructure investment; to speed the transition from legacy copper networks and services to next-generation fiber-based networks and services; and to eliminate Commission regulations that raise costs and slow broadband deployment."[48] One primary objective stated in the FCC's First Report and Order is to "reform" pole attachment policies to address certain industry issues including:

- Codifying a rule excluding capital costs recovered via make-ready fees from pole attachment rates;
- Establishing a 180-day shot clock for resolution of pole attachment access complaints; and
- Allowing incumbent local exchange carriers (LECs) access to infrastructure owned by other LECs.

The FCC's Third Report and Order extended the Commission's new rules regarding pole attachment issues by establishing a new "one touch make ready" pole attachment process and making other changes to the Commissions existing pole attachment regulations addressing the treatment of over lashing, stating that new attachers (sic) to a pole are not

[48] *Accelerating Wireline Broadband Deployment by Removing Barriers to Infrastructure Investment*, 25WC Docket No. 17-84, Report and Order, Declaratory Ruling, and Further Notice of Proposed Rulemaking, FCC 17-154 (rel. Nov. 29, 2017)

responsible for preexisting violations and addressing rate and other pole attachment issues.[49]

Arizona State and Local Policy

Wireless Services

Along with pushing for reexamination of FCC rules, the wireless service providers have embarked on a nationwide push for state legislation to limit what local authorities can do regarding placement of "small wireless facilities." The state legislative push is strategic on the part of the wireless providers looking forward to the deployment of "5G," given the vastly increased number of antennas that will be required. The state legislative framework advanced by the wireless providers generally truncates timelines, limits review and fees or payments. Such legislation has passed in some states and has been introduced but not passed in other states. Arizona was an early state for passage of such legislation, with the passage in 2017 of HB 2365. HB 2365 amends Title 9, Chapter 5 of the Arizona Revised Statutes by adding Article 8 pertaining to cities, and Title 11 by adding Chapter 13 pertaining to counties, the provisions of which significantly limit local authority over placement of small wireless facilities in public rights of way and public easements. The provisions of HB 2365 limits a local authority in 1) the types of review which may be conducted; 2) the time frames for review of applications; 3) requires approval of applications except in limited cases; 4) requires consideration of consolidated applications of up to 25 small wireless facility antennas; 5) limits rates and fees to "direct and actual costs" in addition to other prescribed limitations; and, 6) limits application and monthly fees to very low levels, e.g., $50 per pole per year. A city may apply "reasonable" spacing requirements for new poles. HB 2365 includes mandatory time frames for the City or county to adopt conforming ordinances.

It should be noted that the term "small cell" is relative in that some equipment service providers seek to install is the size of a household refrigerator on a pole. At present the industry preference is not to collocate antennas on the same support structure (e.g., a streetlight pole). The close spacing and multiple service providers mean that PAG member agencies need improved ordinance provisions and internal departmental workflows to deal with large numbers of applications for antenna placement. There are also concerns regarding inspections to ensure that the selected pole can support the weight of the equipment, and also to ensure the actual installation does not deviate from the approved plan and permit.

Master License Agreement

Use of MLAs has emerged as a key practice for cities and counties to deal with the large number of pole attachments that are associated with 5G deployment. An MLA establishes the procedures, terms and conditions under which licensees may request individual pole licenses. The MLA is a comprehensive document that contains uniform terms and

[49] *Accelerating Wireline Broadband Deployment by Removing Barriers to Infrastructure Investment*, 26WC Docket No. 17-84, Third Report and Order and Declaratory Ruling, FCC 17-154 (rel. Aug. 3, 2018)

conditions applicable to all wireless facilities installed on county- or city-owned poles. Individual pole licenses identify the licensed pole and contain detailed exhibits for the site plans, permits, fee schedules, insurance documentation, and other materials that are unique to each site. When the county or city grants a pole license, that pole license (together with all the plans, equipment specifications and fee schedules) become integrated with the MLA.

Use of an MLA framework provides for a level playing field since the MLA format remains essentially the same regardless of licensees. Each wireless service provider executes a separate MLA with the county or city that entitles them to obtain pole licenses on a first come, first- served basis for a specific time period. Thus, one set of rules is used for all wireless service providers which in turn reduces the administrative burden on the PAG member jurisdiction and promotes a level playing field among competitive licensees.

The wireless service providers benefit from use of an MLA to license existing city- or county–owned infrastructure to install small cell facilities rather than bearing the time and cost of negotiating individual pole licenses. This more streamlined process accelerates the deployment of advanced wireless facilities. The PAG member jurisdiction benefits from use of an MLA as well by establishing more robust wireless broadband networks available to the PAG region's residents and businesses, maintaining greater control over aesthetics and potential liability from wireless facilities on city- and county-owned poles, and earning license revenues.

Magellan recommends consideration of developing a Master License Agreement or similar document for a member jurisdiction's use in managing what could be many requests for small cell attachments to city or county property. The volume of these attachment requests will depend on the number of streetlights, utility poles or other suitable structures PAG member jurisdictions own, and the suitability of other property for antenna attachment.

Dig Once

"Dig Once" or the similar concept of joint trench, can be defined as policies and/or practices that foster cooperation among entities (especially utilities) that occupy public rights-of-way, to minimize the number and scale of excavations when installing infrastructure (especially telecommunications[50]) in public rights-of-way. Dig Once has numerous substantial benefits, including promoting and supporting the placement of broadband infrastructure (e.g., fiber-optic cable and conduit), reducing the consequences and disruptions of repeated excavations (traffic disruption, road deterioration, service outages, and wasted resources), and enhancing service reliability and aesthetics.

Dig Once accomplishes the goal of minimizing costs of constructing separate trenches and facilities – via shared costs of construction. The cost savings are significant. The Federal Highway Administration estimates it is ten times more expensive to dig up and then repair

[50] Many utilities are "monopolistic" providers (such as gas, water/sewer and electric) but there are a number of telecommunications providers that seek permission to encroach on public rights-of-way, including cable TV companies, competitive telecommunications companies, and wireless communications companies.

an existing road to lay fiber, than to dig support structure for fiber (e.g., conduit) when the road is being fixed or built. According to a study by the Government Accountability Office, "dig once" policies can save from 25%-33% in construction costs in urban areas and approximately 16% in rural areas.[51] In addition, development of Dig Once standards and guidelines for deployment of conduit and fiber will facilitate economic development and growth, as it enables cost-effective staged or gradual deployment of broadband infrastructure by local authorities.

Dig Once implementation requires revision to the planning and coordination process for construction projects in the public rights-of-way. When subsurface utility work occurs, it presents opportunities for PAG member jurisdictions to install new fiber in the right-of-way at reduced costs via coordination of work. Dig once and joint trench policies allow PAG member jurisdictions to take advantage of other subsurface utility projects for the installation of fiber. This enables the member jurisdictions to expand their ownership of fiber anytime subsurface utility work occurs, at preferential costs to new construction.

The concept can also extend to required placement of conduit for fiber optics whenever the ground is opened, as expressed in recent Congressional legislation. This concept was embodied in the Broadband Conduit Deployment Act of 2018, which required the inclusion of broadband conduit during construction of any road receiving federal funding.[52]

As an example, the State of Virginia recently clearly studied the concept and benefits of "Dig Once" and enumerated several benefits from a Dig Once policy:

- Dig Once "can *potentially lower the cost of broadband deployment* by coordinating with internet service providers (ISP), *facilitating access to public rights of way (ROW)* and *minimizing the number of excavations* required to install telecommunications infrastructure. This can prevent unnecessary digging within a ROW after construction is complete.
- Allowing ISPs access to an open trench can *promote coordination among multiple providers* related to broadband infrastructure placement, as opposed to locating in multiple trenches. A dig once policy can *provide consistent guidelines* under which conduit would be installed and utilized.
- As conduit is added under a dig once policy, it *could be mapped* for better understanding of broadband infrastructure placement, which would facilitate more effective broadband planning to better reach unserved areas of the Commonwealth.
- By reducing the number of excavations, a dig once policy can *reduce environmental impacts* such as soil disruption, diminished water quality resulting from sediment, and potential habitat disruption.

[51] https://eshoo.house.gov/issues/economy/eshoo-walden-introduce-dig-once-broadband-deployment-bill
[52] The Broadband Conduit Deployment Act of 2018, H.R. 4800, January 16, 2018.

- From an administrative standpoint, a dig once policy could prove beneficial by *potentially reducing the number of broadband infrastructure permits needed*, if multiple entities take advantage of an open trench."

Directly analogous benefits from Dig Once also will accrue to the PAG region and its member jurisdictions. Arizona enacted Dig Once policies for the state Department of Transportation for rural areas in 2012. These policies are found at A.R.S. § 28-7381 targeting broadband expansion in rural areas. The policy states that during road construction projects along rural highways, the DOT can coordinate with telecommunications companies to install conduit, and enables DOT to lease the conduit to other telecommunications providers at a cost-based rate. These practices can be expanded outside DOT, and in urban areas as well to achieve significant benefits and cost-savings as outlined above. For example, the City of Mesa was an early adopter of "dig once" and use of non-traditional existing infrastructure (e.g., other abandoned utility pipes or conduit) and has achieved substantial benefits.[53]

Magellan recommends further exploration by member jurisdictions of implementation of "dig once" policies and practices which could include processes for noticing the jurisdiction's intent to work on streets, practices for coordination of work in public rights of way when any occupant plans to open the ground for their purposes, regular (e.g., quarterly) mandatory meetings of occupants of the public rights-of-way to share plans and coordinate work, and implementation of moratoria on street work (e.g., 3-5 years after street work) to incent and enforce coordination among occupants of the rights of way, and to protect investments in paving the streets.

Small Cell Design Standards and Guidelines

An emerging best practice for management of small cell deployments by cities and counties is the use of small cell design standards and guidelines. These Standards and Guidelines are administered by the relevant member agency departments (e.g., Public Works) in PAG member jurisdictions under authority included in its wireless ordinance or other adopted policy. This best practice avoids embedding specific terms, guidelines and procedures in ordinances and allows PAG's member jurisdictions to be more flexible over time in how it administers wireless facilities' placement requirements and adapts to rapid changes in technology. However, it should be noted that Standards and Guidelines provisions would be limited by HB 2365, e.g., size of equipment, etc.

Policy and Regulatory Framework

A policy and regulatory framework specifies governance structure and processes to ensure maximum public benefit from network infrastructure, whether by fostering competition, meeting public sector requirements, or minimizing negative impacts of development. Governance ensures investments are aligned with goals and priorities. Policy guides development, laying out what can be built and how. Political will is the starting point for the

[53] https://muninetworks.org/content/transcript-community-broadband-bits-episode-139

governance and policies simply because, without it, there is nothing to govern and no possibility for policy. PAG and its member agencies have demonstrated strong political will already by undertaking this planning effort.

Political Will

Political will can be defined as the determination to build support for and achieve an outcome via one's personal influence. Most public sector undertakings require some political will, and new undertakings can be especially demanding. Generally, public innovations require more support and stronger rationales to succeed politically than common practices, programs, projects, or procedures. As described elsewhere in this report, broadband infrastructure is becoming more important for municipal operations and local economies.

Therefore, it is important for PAG and its member agencies to assess and build political will, which means providing a strong rationale for the importance of advanced communications infrastructure to influential people, including appointed and elected officials, executives with major employers and prospective investors, and those citizens who are well-connected to others. Rationale for broadband can be based on risk of loss—such as poor economic competitiveness—but the strongest rationale is built on the potential benefits. As summarized in the Needs Assessment, broadband can be used to improve operations, increase impacts, reduce costs, and transform economies.

The process of building political will is as important as the individuals involved and the rationale for action. Indeed, all three work together: the process must be tailored to the individuals and rationale. For broadband, the rationale revolves around uses and impacts as well as availability, costs, and performance. Support from business executives and technologists reinforces this rationale. These stakeholders are most likely to respond to peers, particularly personal outreach from top public officials. Generally, the process involves:

- Clearly articulate project goals and objectives in public documents
- Identify, educate, and mobilize internal champions to garner support from stakeholders
- Reach out to and inform councils, commissions, and community stakeholders
- Organize a task force of diverse advocates

Governance and Ownership

Owners incur the cost of building or buying, maintaining, and operating an asset. They also control how it is used and, depending on business arrangements and economic circumstances, get the bulk of benefits or profits from those uses. These facts apply to fiber-optic cables in much the same way as to real estate. An optical fiber is simply a real asset that can be used for moving information between two or more locations. To-date, most fiber network assets have been privately owned and developed for private interests.

If PAG and its member agencies are to enhance advanced communications infrastructure across the region by using publicly owned network assets, built with taxpayer funds, governance must ensure the network meets the interests of its owners - the public. The only way to accomplish this is by directly involving members of the public. We recommend beginning early by creating a broadband task force to provide input and to engage and inform other members of the public. As the infrastructure is deployed, the task force should be transformed into a governance board.

The governance board can oversee the initiation and ongoing performance of public-private partnerships.

Internal and External Policy Development

Appoint a range of local leaders, reflecting the community's diversity, to the task force. The Regional Partnering Center, which already represents such a collection of representatives from across the region, would be an excellent place to start. Ensure that the task force meets regularly. The task force should establish policies and procedures for the governing board, including for situations in which those policies and procedures are not followed. This report identifies a variety of internal and external policies, including a "Dig Once" or joint-trench policy, right-of-way ordinance, and a wireless ordinance. The task force should have a role in reviewing these policies, and the governance board should ensure the policies are consistently applied.

Internal Cooperation, Communication, and Alignment

A key function of governance is to reduce internal "silos." Currently, government agencies across the PAG region are operating several separate networks for an array of local initiatives including traffic management and the needs of internal operations. The schools and public safety agencies also have networks that are totally separate from each of these. Such duplicative systems drive up complexity and costs, impede flexibility and resilience, and reduce overall efficacy.

By including top level representatives from all agencies along with community representatives, a governance board breaks down silos and ensures that every dollar spent on technology benefits as many municipal functions as possible. Indeed, we recommend the governance board establish partnerships between communities on a department-to-department level to achieve particular goals. Specifically, the board should ensure value for each member agency's Economic Development, Emergency Services, Fire, Police, Planning, Public Works, and IT departments, as well as ADOT and utilities such as TEP.

PAG already coordinates transportation capital projects and development processes that involve all member agencies. We recommend that such collaboration be extended to IT infrastructure and projects, specifically for advanced communications infrastructure. Network infrastructure should also be integrated into approval practices for right-of-way projects, public and private, and development agreements. The governance board provides a formal mechanism for such alignment.

Internal best practices and workflow for these purposes include:

- Document and share information about municipal, state, utility, and private sector assets
- Invite private sector participation in public works projects
- Trade and lease public and private assets for network expansion
- Utilize region-wide GIS asset tracking for management and expansion
- Streamline excavation and pole permitting processes
- Streamline wireless permitting processes
- Combine public works schedules for lowering construction costs
- Build on demand and for savings
- Bid multi-year infrastructure design and construction contracts

5. Detailed Recommendations

Magellan makes the following recommendations in this assessment.

5.1 ESTABLISH MASTER AGREEMENT AMONG ENTITIES TO PLAN ACI EXPANSION

Pima Association of Governments ("PAG") should work to establish a Master Agreement ("Agreement") to govern coordination, communication and outreach initiatives for the Advanced Communications Infrastructure ("ACI") initiative. The most likely candidate for the lead coordination role is PAG.

Parties to the Agreement would include the nine PAG member entities, including: Pima County, the Cities of Tucson and South Tucson, the Towns of Oro Valley, Sahuarita, and Marana, the Tohono O'odham Nation and Pascua Yaqui Tribe, and the Arizona Department of Transportation.

The scope of the Agreement would frame collection and sharing of information to:

- Plan conduit expansion – along highways; in new commercial, residential and mixed-use developments, along water and sewer routes (subject to appropriate guidance and regulations specified by Arizona Department of Water Resources, local municipalities, others); etc.
- Plan fiber expansion – underground fiber within new and existing conduit, and aerial fiber, if and as appropriate.

- Communicate – to provide program and project status to Pima County, PAG members, constituents and residents.
- Outreach – to possible commercial, utility, and academic partners to plan network and service expansion.
    - Commercial partners may include internet service providers such as CenturyLink, Cox Communications, Comcast, and others. In addition, dark fiber network providers such as Crown Castle and Zayo.
    - Utility providers would include Tucson Electric Power ("TEP"), Tohono O'odham Utility Authority ("TOUA"), Trico Electric Cooperative ("Trico"), Tucson Water, Southwest Gas, and wastewater utilities.
    - Academic partners may include the University of Arizona, Arizona State University, Pima Community College, Tucson Unified School District ("TUSD"), and other Tucson area school districts in coordination with the Pima County School Superintendent's Office.
- Monitor – using publicly available data, to actively track regional broadband competition, plans, pricing, access, and adoption.

- Collect Regional GIS Data - collect regional asset and mapping data, including municipal fiber and other assets from partners.

5.2 COORDINATE COUNTY-WIDE ORDINANCES AND POLICIES TO SUPPORT BROADBAND

PAG should work to define and standardize key broadband governance and policy frameworks for the County and the PAG municipalities. Once defined and agreed upon, these can be submitted through the several City and Town Councils and the Tribal Councils. These Ordinances and Policies include Dig Once with Joint Trenching and MLAs, and Wireless Ordinances.

Dig Once and Joint Trenching policies control right-of-way management and coordination while reducing construction, installation, and road resurfacing costs when installing conduit, fiber and other utilities. These policies will lead to future opportunities for partnerships and reduce costs of new fiber network extensions and new connection laterals.

The State of Arizona has had a Dig Once policy in place since 2012 to support rural broadband. The policy guides that "…during road construction projects along rural highways, ADOT can coordinate with telecom companies to install conduit, and enables the agency to lease the conduit to telecom providers at a cost-based rate."[54]

PAG members also should provide wireless lease agreements for 5G pole attachments, supporting 5G networks, WiFi, and Smart City applications that will promote economic development and enhance county and cities' services.

Typically, review, development and implementation of these policies will require the participation of many groups within each jurisdiction. These include the Public Works Departments, Right-of-Way groups, Information Technology, Attorney and Finance, and perhaps others. PAG/RPC can consider sponsoring a regional forum to inform and educate the cities, towns, tribal nations, and county of the benefits of alignment and consistency of these broadband enabling policies across the PAG region. The forum can address many policies, including Dig Once, Joint Trench, Wireless Agreements, MLAs, and Dark Fiber Lease Agreements.

Several PAG members have Franchise Agreements ("FA") which reserve geographic territories for offering cable services. While these FAs are most likely non-exclusive, the existence of the Agreement marginally diminishes competition in the communications space. This reduced competition is likely resulting in higher prices than would exist in a truly competitive market. Magellan recommends negotiating MLAs instead of FAs, to provide greater flexibility for cities, towns, the Tohono O'odham Nation and the Pascua Yaqui Tribe.

[54] https://www.azleg.gov/viewdocument/?docName=https%3A%2F%2Fwww.azleg.gov%2Fars%2F28%2F07381.htm

PAG should work with Arizona Department of Transportation ("ADOT") to provide leadership on these policies to enhance the likelihood of adoption. ADOT's Smart Highway program down Interstate 19 south of Tucson, planned for Fiscal Year 2021, will be proving ground for these policies, likely starting in Tucson.

Finally, PAG should advocate on the value of including terms for conduit expansion and fiber expansion into cities' and towns' Development Agreements. The City of Baltimore, MD, for example, requires installation of new conduit into Development Agreements. This could include sponsoring a forum to educate members on the specifics of policy and governance issues, and to work toward a common set of policies.

5.3 PLAN EXPANSION OF FIBER NETWORKS

Based on the Master Agreement in recommendation 5.1, PAG/RPC should begin working with PAG municipal members, utilities, ADOT, local telecommunications providers, the Tohono O'odham Nation and Pascua Yaqui Tribe, and other interested parties, to plan the vision of a regional or county-wide fiber network. This network should plan for extended backbone fiber throughout the greater Tucson region, passing along major highways, including the I-19 Smart Highway. The RTA also will play a critical role in influencing a plan for backbone fiber network along major highways and main roads in the county, and will be able to provide advice on rights-of-way, permitting, and transportation technologies.

The fiber network expansion plan can utilize the planned projects outlined in Section 4.2, leveraging current initiatives and plans.

Entities involved in the fiber network expansion plan include, at least:

- Existing Cities and Towns – there may be opportunities to extend fiber by interconnecting with the Cities of Tucson and South Tucson, and Towns of Marana, Oro Valley and Sahuarita.
- Commercial Dark Fiber Providers – Entities like Crown Castle, Zayo, and others may have, or may be expanding, their fiber networks in Pima County.
- Tribal Nations - there may be opportunities to extend fiber by interconnecting with fiber in Tohono O'odham and Pascua Yaqui.
- Sun Corridor Network (including University of Arizona, Arizona State University)
- Pima Community College
- Utilities such as TOUA and TEP.
- Southern Area of County – to support expansion of mining efforts.

In addition, the regional backbone network plan should include connections to a minimum of two Internet Points of Presence ("PoPs"). The resulting fiber backbone will enable the delivery of wholesale bandwidth to municipalities, tribes, businesses, consumers, providing lower-cost open access for ISPs, and offering redundancy for backup and network resilience.

5.4 PLAN EXPANSION OF CONDUIT NETWORKS

Starting from Tucson, other cities and towns, and overlaying conduit from universities, PAG/RPC can plan extensions to create county-wide conduit network. Ensuring that this conduit is large enough to contain innerduct will be key, allowing multiple providers to occupy the same conduit and providing additional capacity for other utilities. ADOT will play a key role as its Smart Highways program and support for a Dig Once and Joint Trench policy will accelerate conduit placement and create incentives for other municipalities to follow suit. Utilities such as TEP, Trico and TOUA can also play a critical role in conduit networks.

Owners of available conduit space can lease entire conduit ducts, or parts of ducts, to utility providers, commercial entities, and other municipalities, for additional revenue.

5.5 LEVERAGE ARIZONA COMMERCE AUTHORITY INITIATIVES

The Arizona Commerce Authority ("ACA") has several programs and projects underway which can support and accelerate the Advanced Communications Infrastructure strategy. These ACA programs are sponsored by the ACA Broadband Office and the ACA Smart State Office.

ACA's Broadband Office is focused on bringing broadband services to rural areas of Arizona, which includes significant parts of Pima County. Recently established, the Broadband Office offers grant programs in two categories. First, for planning efforts on expanding broadband with grant awards of up to $50,000; and second, for shovel-ready construction projects with grants of up to $1 million. The initial grant program provided $3 million. For the coming fiscal year, Arizona Gov. Ducey has more than tripled the funding, to $10 million. As part of PAG's ACI initiative, PAG should apply for one or two grants to fund detailed planning and high-level design for broadband expansion.

ACA's Smart State Office has begun work on the Smart Highway Corridors initiative. The program is reserved to 514 miles of three rural interstate highways, one of which is Interstate 19 heading south from Tucson to Nogales. The primary goal of the initiative is to install new traffic safety technologies, including infrared wrong-way detection systems, road temperature sensors, dynamic message signs, and traffic cameras to improve highway safety and support first responders. As part of the infrastructure, this Smart Highway program will also install conduit and fiber along with the safety technologies. While conduit will be owned by the State, and Arizona Department of Transportation governs the right-of-way, there will likely be opportunities to lease fiber, or install new fiber, for Pima County along parts of I-19, including in Tucson and South Tucson. (Due to the COVID-19 crisis, funding for the Smart Highways Corridors program has been repurposed for the coming fiscal year. Funding will likely be considered later. In addition, some federal grants may be available under the CARES act to support rural broadband. However, State of Arizona grants may well be limited without significant contributions of matching funds.)

5.6 IDENTIFY OPPORTUNISTIC EXPANSIONS

Significantly based on conversations with representatives from member agency economic development offices, Magellan recommends that the RPC and PAG members leverage current infrastructure and economic development plans already in place to develop ACI, including aerial fiber and underground conduit. When roads are being constructed or enhanced, county, cities and towns, and tribal entities can leverage the opportunities those initiatives provide by concurrently placing conduit and backbone or aerial fiber either along or adjacent to the road alignment.

Large business parks, new commercial expansion zones, new schools and other new community anchors offer similar opportunities for maximizing installation of ACI, including conduit and fiber. These joint trenching opportunities provide tremendous opportunities for expansion with minimal marginal costs.

As listed in Figure 4.1, this includes such projects as:

1. The Smart Highway project's plans to install conduit, fiber, and transportation safety technologies along I-19
2. Roadway projects including:
    a. The new, planned I-10 ADOT interchange at Houghton Road
    b. A potential new roadway along the Old Vail Connection alignment
    c. The potential I-11 alternative along Sandario Road
    d. Additional connections along Sahuarita Road from Vail to Sahuarita
3. Regional development projects including:
    a. The Town of Sahuarita's planned expansion
    b. The Pascua Yaqui Tribe's planned developments near Grant Road and I-10 and near Sewailo Golf Club
    c. Commercial developments at Eric-Marcus Municipal Airport near Ajo
    d. Commercial developments near Ryan Airfield
    e. Developments to the east of Tucson International Airport/Spaceport Tucson
    f. Planned incubator space between Sahuarita and Green Valley
    g. The 1900-acre industrial developments near Houghton Road and I-10
    h. The 700-800 acres of residential developments on Houghton Road near Huckelberry Loop bike trail
    i. The 400-500 acres of residential development at Vail Crossings

Both roadway projects and development projects, whether commercial or residential, provide opportunities for laying conduit and/or fiber. Many of the areas seeing the biggest boom in development activity will need improvements not only to roadways, but also to water and sewer infrastructure; likewise, ACI should be considered a pre-requisite to new construction, supporting the broadband as a new and necessary utility.

Magellan has identified many of these locations as likely opportunities for broadband expansion in the county. These are consistent with known short-, medium- and long-term initiatives and planning underway. A detailed list of the projects is enumerated in Section 4.2

5.7 CREATE OUTREACH PROGRAM TO POSSIBLE PARTNERS

At the ACI Kickoff meeting in October, several parties showed interest in participating in the planning of broadband expansion in the PAG region to support economic development, to enhance quality of life, and to make the region more competitive in attracting and retaining businesses. PAG/RPC should develop an outreach program to work with each of these entities to define what contributions might be made by Pima County and by the entities to improve advanced communications infrastructure and broadband services.

These entities included:

- Tucson Electric Power – As the private electric utility serving the county, TEP is well positioned to deliver broadband to premises. Electric utilities around the country are expanding their natural markets to provide broadband services. Using its existing assets, specifically, utility poles and entry into all buildings in the PAG region, TEP is a natural ally in developing strategies to offer broadband services. TEP's poles can be utilized for new fiber distribution network, creating a possible revenue stream for TEP while keeping costs for fiber installation at a minimum. TEP's utility customer billing system could be expanded to support broadband subscription services billing. Alternatively, TEP could position itself as the data transport and distribution utility, with one or several ISP partners offering broadband utility services.
- Trico Electric Cooperative – As a local cooperative electric utility, Trico can offer similar infrastructure and asset use opportunities as TEP.
- Commercial Internet Service Providers – These include Cox, CenturyLink, Comcast and others. Commercial providers have an operational and sales infrastructure and are always seeking additional subscribers. PAG could explore how these providers could directly market to new customers, how to engage them in joint trench opportunities to place conduit and fiber for new developments and along road expansions. Working with PAG, the providers can learn where new developments are anticipated. PAG could also work to plan open access to conduit to encourage competition among providers.

5.8 EXPLORE OTHER FUNDING OPPORTUNITIES

There are many other grant and loan programs available which the PAG region can utilize to expand broadband services.

Department of Commerce Economic Development Agency ("EDA"), Economic Adjustment Assistance Program, CARES Act - The CARES Act was passed in 2020 to assist communities with the COVID-19 crisis and appropriated additional funding to the tune of $1.5B for the Federal Economic Development Agencies Economic Adjustment Assistance Program, distributed by region. No funding deadline exists, and the funding will be highly competitive to local and tribal governments as well as universities. To further explore this opportunity, PAG should thoroughly read the Notice of Funding Availability (NOFA) and contact its regional representative for next steps in developing an application. More information can be found at: https://eda.gov/coronavirus/.

USDA ReConnect – The U.S. Department of Agriculture ("USDA") offers the Broadband ReConnect Program. ReConnect provides loans and grants to provide funds for costs of construction, improvement, and/or acquisition of equipment and facilities needed to provide broadband service in eligible rural areas. ReConnect offers three possible programs. States, Counties, Tribal Nations, not-for-profits, and eligible for-profit corporations may apply. While this year's funding window closed in April 2020, rural broadband is expected to remain a critical infrastructure enhancement for the nation and will almost certainly be funded in coming years.

There are three ReConnect programs for which an entity may apply: 100% grant; 50/50 grant / loan (in equal amounts); or 100% loan. Each of the three programs is funded up to $200 million in aggregate. These programs are designed to stimulate private sector investment to provide broadband to as many rural premises as possible, including homes, community facilities for healthcare and public safety, schools, libraries, farms, factories and ranches. As with most federal funding programs, there are matching obligations required for the grant portions. Currently, the interest rate on loans is 2%. Details on the program may be found at https://www.usda.gov/reconnect.

USDA Distance Learning and Telemedicine – USDA also offers Distance Learning and Telemedicine ("DLT") Grants. These grants can be provided to eligible entities to provide equipment to support synchronous, real-time, interactive use of broadband to link teachers and medical service providers with students and doctors and patients, respectively. With appropriate design, these facilities can effectively extend distance learning from universities, colleges and high schools to students, wherever they may be. This can help eliminate much of the need for long-distance travel to learning and medical institutions, along with the significant direct and indirect costs associated with that travel (time, fuel, foregone income through time off, etc.). This year's grant window closed in April 2020, but funding is expected again next year. Details on the program may be found at https://www.rd.usda.gov/programs-services/distance-learning-telemedicine-grants.

FCC's Universal Service Programs – Federal Communications Commission's Universal Service Administrative Company ("USAC") administers four separate funding programs which support expansion and subsidy of broadband in, especially, rural areas.

Two of the USAC funding programs, "Rural Health Care" and "E-Rate," enable communities to connect more cost effectively to provide better health care services and better education

services, respectively. USAC's Rural Health Care provides funding to help facilities provide world class medical care through increased broadband capabilities. USAC's E-Rate program provides annual subsidies for qualified broadband equipment and subscriptions exclusively to schools and libraries. One specific E-Rate program can support the self-provisioning of new fiber to schools and libraries, covering construction costs, equipment and program management (but not ongoing operations).

USAC's Lifeline program provides subsidies to households and individuals helping to keep broadband subscription costs at a minimum. USAC's High Cost program provides funding for companies to expand infrastructure in unserved or underserved areas.

Many service providers already have USAC accounts, as the USAC program is funded by fees paid into the Universal Services Fund (USF). (Your telephone bill has some of these charges, which are collected on behalf of, and remitted to, USF.) Details of the programs may be found at: https://www.usac.org/.

Arizona Office of Grants and Federal Resources ("GFR") - GFR offers training and technical assistance programs for public entities in Arizona. As a central location for funding opportunities, GFR is available to support PAG/RPC with grant application training, streamlining the application process and improving the likelihood of securing grants. For example, as part of GFR, Arizona Public Safety Broadband Network ("PSBN") grants can be secured to enable the expansion of the PCWIN network. Details of the programs may be found at: https://doa.az.gov/grants-and-federal-resources-gfr.

FCC Rural Digital Opportunity Fund - Auction 904 - To follow up with the FCC's Connect America Fund, the FCC has launched a new opportunity to bridge the digital divide. The reverse auction 904 or Rural Digital Opportunity Fund (RDOF) is a $20B fund aimed at servicing unserved and underserved census blocks with less than 25Mbps/3Mbps broadband services available. Census blocks and groups have been identified by the FCC. Funding is done by two phases a short form and long form. Short forms are expected to be submitted summer of 2020 and long form deadline will be completed by the deadline of October 22, 2020.

PAG should review all funding guidelines and action items detailed in the FOA and complete the following tasks prior to an application. Details of the program can be accessed at: https://www.fcc.gov/auction/904.

Municipal Debt Financing – For several reasons, it is premature to consider debt financing, whether general obligation or revenue bonds. Municipalities, whether cities, towns, or Pima County, would have to issue the debt, not PAG. Second, there are neither specific routes, technical details, construction designs, business and operating plans, nor any entity designated to lead any project. Debt financing is certainly an option for broadband expansion in later phases once specific designs and plans are completed.

5.9 TRIBAL CONSIDERATIONS

The Tohono O'odham Nation and the Pascua Yaqui Tribe offer development and possible partnership opportunities, as well. Tribal areas are often given priority for federal funding opportunities including the CARES act and the Indian Energy and Economic Development National Tribal Broadband Grant. As these communities are often harder hit by economic inequities, bridging the digital divide by connecting the tribal areas should be a key consideration for PAG.

Tohono O'odham was the indirect recipient of Broadband Technology Opportunities Program (BTOP) grant funding in the early 2010s which resulted in an extensive underground and aerial fiber network being constructed on its lands. Pascua Yaqui is currently planning developments around the Tucson area that open dig once and joint trench opportunities to the Tribe, which can result in additional fiber to serve its needs.

Outreach - PAG/RPC should continue engagement efforts and work to jointly develop a plan to support the two tribal entities and their broadband plans.

Tohono O'odham Utility Authority - as the electric utility serving the Tohono O'odham Nation, TOUA is well positioned to deliver broadband to premises. Using its existing assets, specifically, utility poles and entry into all buildings in the nation, TOUA is a natural ally in developing strategies to offer broadband services. TOUA's poles can be utilized for new fiber distribution, creating a possible revenue stream for TOUA while keeping costs for fiber installation at a minimum. TOUA's customer billing system could be expanded to support broadband subscription services billing. (This is similar to the TEP outreach recommendation.)

FCC Spectrum Offer to Tribal Nations - Second, in December 2019, the Federal Communications Commission announced a six-month head start window for tribal nations in rural areas to apply for unassigned wireless bands on the 2.5 GHZ spectrum. This is a unique opportunity for tribes, like Tohono O'odham and Pascua Yaqui, as tribal nations have an advance window where they can apply ahead of general applicants.

This band is suitable for both mobile coverage and fixed point-to-point communications. Where available, spectrum in three different channels (49.5 Mhz, 50.5 MHz, and 17.5 MHz) within the band. If available spectrum is applied for, once obtained, it can be used to provide wireless broadband and communications capabilities on the tribal lands. There are specific definitions of "rural" based on population density in specific areas. There are certain conditions on the license; for example, two years after the license has been granted, tribes must demonstrate that at least 50% of the targeted area has access to the services (this is not a 50% adoption rate). Details of the programs may be found at: https://www.fcc.gov/25-ghz-rural-tribal-window.

5.10 ISSUE RFI FOR NETWORK EXPANSION OPPORTUNITIES

PAG/RPC should consider developing and issuing an open-ended Request for Information ("RFI") seeking ideas for how to expand the broadband and fiber network in the greater

Tucson region. Much work must be done prior to issuance, including securing engagement and commitment with potential partners which would evaluate, help select, and support the efforts of preparing a complete Request for Proposal ("RFP") for construction and/or services.

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Appendix A: Construction Cost Estimates in Pima County

Findings of this report indicate that a robust fiber backbone throughout the region is necessary for regional plans for tomorrow's Advanced Communications Infrastructure. Fiber transmits information at lightning speed, and transmission rates are limited only by the electronics at each end to encode and decode transmissions. As such, an augmented fiber network can provide 10 gigabits (10 Gbps) of service and up to 100 Gbps or more.

Fiber networks are essential to Smart Cities activities and supporting 5G wireless attachments. While many 5G devices (sensors, for example) receive and collect data wirelessly, the need to both transmit collected data back to data centers for analysis and to provide device control from those data centers depends on fiber backhaul.

Later design of the network will require imposing design constraints to ensure future networks are redundant, scalable and ubiquitous enough to support the density required for 5G attachments, controls for autonomous vehicles, and for providing broadband services.

Magellan's scope for this engagement did not include a detailed conceptual route design. However, Magellan provides the following unit cost estimates for installation of new underground fiber and conduit, for new aerial fiber, and laterals from fiber backbones into buildings.

Interconnections with other fiber networks (Sun Corridor, Smart Highways on I-19) will cost less but will depend on well-defined Memoranda of Understanding ("MOU") between and among parties.

A.1 CONSTRUCTION COST ASSUMPTIONS

Magellan provides these estimates of fiber and conduit construction and installation costs in Pima County. Cost estimates are for new backbone underground fiber and conduit installation, and for new backbone aerial fiber. Lateral connection costs are per unit.

Underground Fiber and Conduit

- Costs for underground fiber and conduit for any backbone runs are quoted per ten-mile run and per foot.
- Per-foot costs are accurate for minimum five-mile distances. Shorter runs will likely have higher per-foot costs.
- Once routes are specified, per foot costs should be used for cost estimation longer than five miles.
- Backbone is 144-strand fiber, includes tracer wire, and marking posts.
- Conduit includes two (2x) 4" ducts. No inner duct assumed.

- Directional boring.
- Handholes every 600'.
- Straight splice every 5000'.
- Pricing includes all costs for design, permit fees, construction labor, splicing, and materials.
- Pricing includes soft surface restoration and traffic maintenance.
- Design costs may be funded by municipality leading design work.
- Construction contractor will pay permit fees, construction labor, splicing, and materials.
    - Prevailing wage costs are used for designated construction labor categories, as specified for year ending June 2021, for Pima County, at https://ebacon.com/prevailing-wage-info/wage-determination-rates/
- No lateral costs are included to connect backbone to premises.
- For a minimum five-mile backbone run, all-in, fully loaded costs per foot are estimated at $36.57.

Aerial Fiber

- Costs for aerial fiber for any backbone runs are quoted per ten-mile run and per foot.
- Per-foot costs are accurate for minimum five-mile distances. Shorter runs will likely have higher per-foot costs.
- Once routes are specified, per foot costs should be used for cost estimation longer that five miles.
- Backbone is 144-strand fiber.
- Lashing for fiber is in communications space on pole, not in power space.
- Pricing includes all costs for design, permit fees, construction labor, splicing, and materials.
- Aerial pricing also includes costs for pole-loading analysis, Professional Engineer ("PE") review and stamp, and make-ready costs on poles.
- Design costs may be funded by municipality leading design work.
- Construction contractor will pay permit fees, construction labor, splicing, and materials.
- Construction contractor will pay for pole-loading analysis, PE stamp, and pole make-ready costs.
    - Prevailing wage costs are used for designated construction labor categories, as specified for year ending June 2021, for Pima County, at https://ebacon.com/prevailing-wage-info/wage-determination-rates/
- For a minimum five-mile backbone run, all-in, fully loaded costs per foot are estimated at $7.50.

Lateral Connections (Backbone to Premises)

- Per-foot costs for laterals are estimated for 500’ lateral. Shorter laterals may have higher per-foot costs.
- Lateral fiber is 24-strand fiber.
- Pricing includes all costs for design, permit fees, construction labor, splicing, and materials.
- Directional boring, with tracer wire.
- Construction contractor will pay permit fees, construction labor, splicing, and materials.
    - Prevailing wage costs are used for designated construction labor categories, as specified for year ending June 2021, for Pima County, at https://ebacon.com/prevailing-wage-info/wage-determination-rates/
- Per-foot costs for a 500’ foot underground lateral into a building is $32.80.

A.2 CONSTRUCTION UNIT COST SUMMARY

Based on assumptions above, Magellan's Engineering Team constructed detailed unit costs for underground and aerial backbone fiber, and for laterals connecting subscribing entities.

Following is a table summarizing costs for 144-strand Underground Backbone with conduit (2" x 4" tubes); 144-strand aerial fiber; tracer wire; handholes every 600'; straight splice every 5,000'; and soft surface restoration; all on a minimum 10-mile run. (Shorter runs may have larger proportional labor costs.). 500' underground laterals into buildings.

Figure A-1. Summary of Unit Construction Costs

Estimate Summary **Pima County, AZ** 10-Mar-20

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Backbone Underground Build Estimate

Description	Ft	Labor	Material	Contingency	Composite Cost per Ft.	Notes
Backbone - full build out (2) 4" ducts & 144 cable	52,800.00	$1,293,697.20	$637,226.56	0	$36.57	Total all in composite price per ft includes UG backbone construction, design, and permitting, and splicing.

Backbone Aerial Build Estimate

Description	Ft	Labor	Material	Contingency	Composite Cost per Ft.	Notes
Backbone - All aerial 144 cable, strand & Lashing in comspace	52,800.00	$174,654.56	$221,233.43	0	$7.50	Total all in composite price per ft includes Aerial backbone construction, design, and permitting, and splicing, pole attachments and make ready work.

Lateral Estimate

Description	Ft	Labor	Material	Contingency	Composite Cost per Ft.	Notes
Backbone - All aerial 144 cable, strand & Lashing in comspace	500.00	$12,740.00	$3,659.00	0	$32.80	Total all in composite price per ft includes 500' lateral into building

Appendix B: Service Provider Coverage by ZIP Code

The following information contains details about advertised speeds from internet service providers throughout the PAG region by ZIP code. Much of this data is reported by the ISPs themselves and is available at www.broadbandnow.com[55].

ZIP Code	Provider	Coverage	Speeds (Up To)
85321	Mediacom	5.30%	
85341	None Available	N/A	N/A
85601	CenturyLink	100%	20 Mbps
	Cox	52%	987 Mbps
85614	CenturyLink	100%	140 Mbps
	Cox	91%	300 Mbps
85619	CenturyLink	100%	140 Mbps
	Cox	87%	300 Mbps
85622	CenturyLink	100%	140 Mbps
	Cox	48%	300 Mbps
85633	Comcast	65%	987 Mbps
85634	Tohono O'odham Utility Authority	52%	100 Mbps
85639	None Available	N/A	N/A
85641	CenturyLink	92%	140 Mbps
	Cox	17%	300 Mbps
85645	CenturyLink	100%	100 Mbps
85652	None Available	N/A	N/A
85653	CenturyLink	92%	140 Mbps
	Comcast	54%	987 Mbps
85654	None Available	N/A	N/A
85658	CenturyLink	100%	140 Mbps
	Comcast	96%	987 Mbps
85701	CenturyLink	100%	140 Mbps
	Cox	75%	300 Mbps
85702	CenturyLink	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85703	CenturyLink	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps

[55] Data accessed November 2019.

85704	**CenturyLink**	100%	140 Mbps
	Cox	16%	300 Mbps
	Comcast	99%	987 Mbps
85705	**CenturyLink**	100%	140 Mbps
	Cox	69%	300 Mbps
	Comcast	33%	987 Mbps
85706	**CenturyLink**	100%	140 Mbps
	Cox	78%	300 Mbps
85707	**CenturyLink**	100%	140 Mbps
	Cox	87%	300 Mbps
85708	**CenturyLink**	100%	140 Mbps
	Cox	79%	300 Mbps
85709	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85710	**CenturyLink**	100%	140 Mbps
	Cox	76%	300 Mbps
85711	**CenturyLink**	100%	140 Mbps
	Cox	69%	300 Mbps
	MegaPath	10%	12 Mbps
85712	**CenturyLink**	100%	140 Mbps
	Cox	78%	300 Mbps
	Comcast	19%	987 Mbps
85713	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	26%	987 Mbps
85714	**CenturyLink**	100%	140 Mbps
	Cox	89%	300 Mbps
85715	**CenturyLink**	100%	140 Mbps
	Cox	53%	300 Mbps
	Comcast	61%	987 Mbps
85716	**CenturyLink**	100%	140 Mbps
	Cox	73%	300 Mbps
85717	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85718	**CenturyLink**	100%	140 Mbps
	Cox	12%	300 Mbps
	Comcast	99%	987 Mbps
85719	**CenturyLink**	100%	140 Mbps
	Cox	67%	300 Mbps
85720	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps

	Comcast	31%	987 Mbps
85721	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85722	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85723	**CenturyLink**	100%	140 Mbps
	Cox	100%	300 Mbps
85724	**CenturyLink**	100%	20 Mbps
	Cox	75%	300 Mbps
85725	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85726	**CenturyLink**	100%	4 Mbps
	Cox	100%	300 Mbps
85728	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85730	**CenturyLink**	100%	140 Mbps
	Cox	23%	300 Mbps
85731	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85732	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85733	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85734	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85735	**CenturyLink**	100%	140 Mbps
	Comcast	14%	987 Mbps
85736	**CenturyLink**	100%	100 Mbps
85737	**CenturyLink**	100%	140 Mbps
	Comcast	99%	987 Mbps
85738	**None Available**	N/A	N/A
85739	**CenturyLink**	100%	140 Mbps
	Comcast	20%	987 Mbps
85740	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps

	Comcast	31%	987 Mbps
85741	**CenturyLink**	100%	140 Mbps
	Cox	19%	300 Mbps
	Comcast	98%	987 Mbps
85742	**CenturyLink**	100%	140 Mbps
	Comcast	82%	987 Mbps
85743	**CenturyLink**	100%	140 Mbps
	Comcast	64%	987 Mbps
85744	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85745	**CenturyLink**	100%	140 Mbps
	Cox	38%	300 Mbps
	Comcast	22%	987 Mbps
85746	**CenturyLink**	100%	140 Mbps
	Cox	57%	300 Mbps
	Comcast	30%	987 Mbps
85747	**CenturyLink**	100%	140 Mbps
	Cox	75%	300 Mbps
85748	**CenturyLink**	100%	140 Mbps
	Cox	68%	300 Mbps
85749	**CenturyLink**	100%	140 Mbps
	Cox	42%	300 Mbps
	Comcast	49%	987 Mbps
85750	**CenturyLink**	100%	140 Mbps
	Comcast	97%	987 Mbps
85751	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85752	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85754	**CenturyLink**	100%	140 Mbps
	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps
85755	**CenturyLink**	100%	140 Mbps
	Comcast	71%	987 Mbps
85756	**CenturyLink**	100%	140 Mbps
	Cox	41%	300 Mbps
85757	**CenturyLink**	100%	140 Mbps
	Cox	22%	300 Mbps
	Comcast	93%	987 Mbps
85775	**CenturyLink**	100%	140 Mbps

	Cox	54%	300 Mbps
	Comcast	31%	987 Mbps

Appendix C: Advanced Communications Infrastructure (ACI) Survey for PAG

Welcome to the Regional Broadband Survey

Pima Association of Governments (PAG), the region's metropolitan planning organization, is assessing the Tucson metro area's advanced communication infrastructure, in collaboration with Magellan Advisors. This assessment is the first step in a broader Smart

Region initiative (https://www.pagregion.com/Default.aspx?tabid=1356) that will involve coordination with public and private stakeholders to plan for meeting the future needs and opportunities in advanced communications for transportation, business, education, health and safety, and many other sectors.

Feedback from information technology (IT) professionals and leaders across the region is critical to this process.

The following 19-question survey should take you three to five minutes and will provide valuable input into the future of communications infrastructure in Pima County.

In compliance with the Americans with Disabilities Act (ADA), those requiring special assistance, such as large-type face print, or other reasonable accommodations, may request those through the administrative offices at: 1 E. Broadway Blvd., Suite 401, Tucson, AZ 85701 or by calling (520) 792-1093. Si necesita ayuda con traducción, llame por favor al 792-1093 y comuníquese con Nathan Barrett.

Please complete the survey by Dec 6, 2019.

Who should complete the survey?
The survey should be completed by the person responsible for paying for and/or selecting the internet services for your organization. We request your assistance to gain a better understanding of how your organization or home-based business currently accesses the internet. Please share this survey with others in your organization if necessary.

Location?
If your location has broadband, please complete the survey from a computer directly connected to the service. Avoid using a WiFi connection, if possible. If your organization has multiple locations within Pima County, please submit one survey response for each location, for purposes of receiving information from a broad spectrum of locations.
Feedback?
Please answer all questions to the best of your knowledge, but don't worry about getting answers exactly right. If you're unsure about an answer, please estimate. A good guess is better than a blank answer.

If you have any questions or difficulties with the survey, please email Melanie Downing at mdowning@magellan-advisors.com .

Your input is greatly appreciated!

Key/Legend
*: Denotes required questions

- Advanced Communications: Includes technologies such as internet that provide users with high-speed connections.
- Broadband: Broadband is defined as 25 Mbps or greater download speeds and 3 Mbps or greater upload speeds, as defined by the Federal Communications Commission (FCC).

- Internet: A means of connecting a computer to any other computer anywhere in the world via dedicated routers and servers.
- WiFi: WiFi is the wireless version of a wired ethernet network, and it is commonly deployed alongside it.
- Satellite Service: Satellite internet access refers to internet access provided through satellites. In other words, it is a telecommunications network provided by orbital communication stations and constellations. Signals from these satellites allow a user with a dish to have a high-speed internet connection.
- Dial-Up: Dial-up refers to an internet connection that is established using a modem. When a user initiates a dial-up connection, the modem dials a phone number of an internet service provider (ISP) that is designated to receive dial-up calls.

1) What is the name of your organization?*

_____

2) What is the address of the location for which you are completing this survey?*

We request your location's address to identify where broadband is and is not available.

Street Address: _____

Apartment or Suite: _____

City: _____

State: _____

ZIP Code: _____

3) Which of the following best describes this location?*

( ) This location is a private business

( ) This location is a satellite office of a private business

( ) This location is a public agency

( ) This location is a satellite office of a public agency

( ) This location is a non-profit

( ) This location is a satellite office of a non-profit

( ) This location is a home-based business

4) Does the location for which you are completing this survey have broadband internet access?*

Broadband is always-on, high-speed internet access service. Cell phone, dial-up via modem, and satellite internet connections are not considered broadband.

( ) Yes, this location has broadband.

( ) This location only has internet access via cell phone, dial-up, or satellite.

( ) No, this location does not have internet access.

Your opinions about broadband

5) Do you consider internet access to be an essential service to your organization, much like water and electricity?

( ) Yes

( ) No

( ) Unsure

6) How important are these aspects of broadband service to your organization?

Please, rate the importance of each of the following.

	No opinion/Don't care	Not important	Somewhat important	Very important	Critical
Internet access overall	( )	( )	( )	( )	( )
Performance/speed	( )	( )	( )	( )	( )
Price	( )	( )	( )	( )	( )
Reliability	( )	( )	( )	( )	( )
Technical support and customer service	( )	( )	( )	( )	( )

About your broadband service

7) What company provides broadband to your location?*

If you have multiple broadband providers at this location, please select your primary provider.

( ) AT&T

( ) Bluespan

( ) Century Link

( ) Comcast

( ) Cox

( ) GTT

( ) HughesNet

( ) MegaPath

( ) Simply Bits

( ) Sprint

( ) T-Mobile

( ) Viasat/Exede

( ) Wi-Power

( ) Verizon

( ) Zayo

( ) City of Tucson

( ) Other - Write In: _____

8) How is this location connected to the internet?*

Select the technology your provider uses for broadband. If you have more than one connection, select the primary one. Answer to the best of your knowledge. If you are not familiar with a connection type, you probably don't have it.

( ) Coaxial cable (also used for cable TV services)

( ) Dedicated line or enterprise network (T-1 or similar, Metro Ethernet, etc.)

( ) DSL (digital subscriber line) twisted pair wire (also used for plain-old telephone service)

( ) Fiber-optic cable ("fiber")

( ) Fixed wireless antenna

( ) Don't know or not sure

( ) Other - Write In: _____

9) How is this device connected to broadband service at the location?*

( ) Wired directly to broadband provider's network interface

( ) Wired connection to router connected to broadband

( ) Wired to enterprise network with broadband internet access

( ) Other - Write In: _____

10) How fast is your broadband supposed to be? What contracted download and upload speeds are delivered to this location?*

Enter numbers only, including decimals. Please do not write "Mbps" or other label. Estimates are fine. Your best guess is better than no answer.

	Contracted speed in megabits per second (Mbps)
Download speed (from the internet to your computer)	_____
Upload speed (to the internet from your computer)	_____

11) Approximately how many internet-connected devices are at this location?

Please estimate the total number of computers, laptops, tablets, smartphones, e-readers, media players, smart speakers or TVs, appliances, security devices, and other device that is on the internet via your broadband connection. An approximate number is fine.

_____

No broadband?

Broadband is always-on, high-speed internet access that is at least 25 megabits per second (Mbps) downstream to your device and 3 Mbps upstream from your device.

12) Why does the location for which you are completing this survey not have broadband?

Rank the importance of each of the following reasons from 1 = "Most Important" to 7 = "Least Important."

_____Access internet elsewhere (work, school, library, public/free WiFi, etc.)

_____Available services are too expensive

_____Available services are too slow or unreliable

_____Broadband is not available to this location

_____Do not need internet services

_____Smartphone meets internet access needs

_____Other reason not listed here

About Your Organization

13) What is your organization's primary line of business or economic sector?

( ) Accommodation and Food Services

( ) Administrative and Support and Waste

( ) Agriculture, Forestry, Fishing and Hunting

( ) Arts, Entertainment, and Recreation

( ) Construction

( ) Educational Services

( ) Finance and Insurance

( ) Health Care and Social Assistance

( ) Information

( ) Management of Companies and Enterprises

( ) Manufacturing

( ) Mining, Quarrying, and Oil and Gas Extraction

( ) Other Services (except Public Administration)

( ) Professional, Scientific, and Technical Services

( ) Public Administration

( ) Real Estate and Rental and Leasing

( ) Retail Trade

( ) Transportation and Warehousing

( ) Utilities

( ) Wholesale Trade

14) How many people does your organization employ?

Enter the number of full-time equivalent employees, counting part-time and volunteer positions as partial, and round to the nearest whole number. An average or estimate is fine.

In Pima County: _____

Total: _____

15) How important are advanced communications technologies for the following functions?

	Not important at all	Helpful but not really important	Somewhat important	Very important	Absolutely essential
Administration or management	( )	( )	( )	( )	( )
Buying materials, etc., and finding and hiring employees	( )	( )	( )	( )	( )
Inbound logistics: bringing materials in for use in production	( )	( )	( )	( )	( )
Production of goods for and providing services to customers	( )	( )	( )	( )	( )
Outbound logistics: getting goods and services to customers	( )	( )	( )	( )	( )
Sales and marketing	( )	( )	( )	( )	( )

Support and maintenance	( )	( )	( )	( )	( )

16) Please indicate how improved data and communications infrastructure would impact your organization's plans in the following areas:

	Major Impact	Minor Impact	No Impact	Unsure
Public Safety	( )	( )	( )	( )
Public Health	( )	( )	( )	( )
Public WiFi	( )	( )	( )	( )
Transportation System Modernization	( )	( )	( )	( )
Increased Collaboration Between Departments and Other Organizations	( )	( )	( )	( )
Improve Water Reliability	( )	( )	( )	( )
Workforce Development/Strategic Talent Alignment	( )	( )	( )	( )
Improve Resiliency of Infrastructure	( )	( )	( )	( )

Speed Test

17) What are your actual speeds? Click the "Start Test" button below. The indicators should immediately show activity. If not, you may move to the next page. The speed test represents a snapshot in time and may not be indicative of typical performance.

Start Test

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Final Thoughts and Follow-up

18) What would improved advanced communications mean to you, your organization, and the region? Is there anything you would like to know about broadband in the area?

Please share your thoughts with us. Don't worry about grammar and punctuation. Phrases are fine.

_____

_____

_____

_____

19) Would you like to receive future updates from PAG?

First Name: _____

Last Name: _____

Organization Name, if appropriate: _____

Title, if appropriate: _____

Email Address: _____

Phone Number: _____

URL, if appropriate: _____

Thank you for responding to PAG's Advanced Communications Survey!

Your survey responses have been recorded.

Thank you for responding to PAG's Advanced Communications Survey!