Guidebook on Community and Tribal Broadband Planning

April 2024

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Office of Broadband Access & Expansion

Introduction

This guidebook is designed to introduce community planners to the life cycle of broadband network deployment, from planning to execution

It is the first in a series of resources developed by OBAE to prepare local and Tribal government leaders and their partners to apply for the state's Broadband Equity, Access, and Deployment (BEAD) grant funding

In line with the federal BEAD Program's focus on fiber optics as the preferred broadband technology, this guidebook covers the basics of fiber infrastructure, planning, deployment, and operations

Table of Contents

1. Introduction to Broadband

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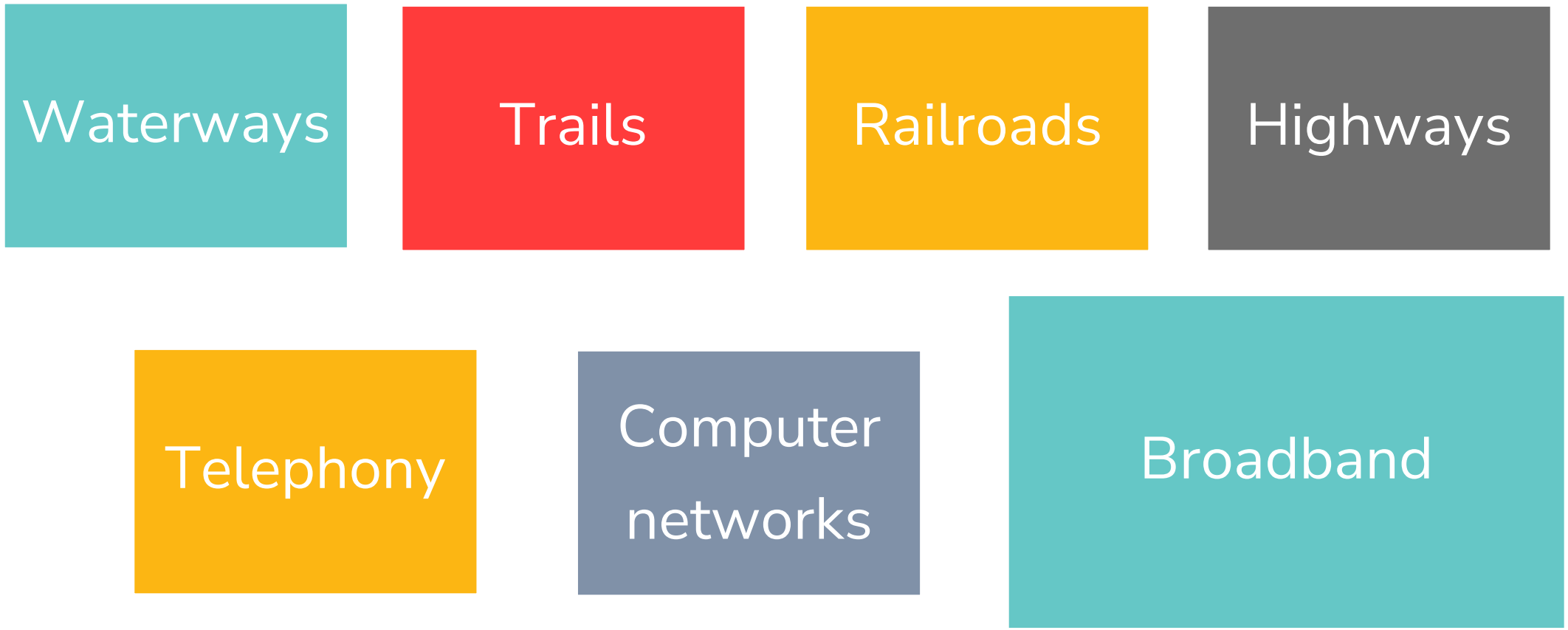
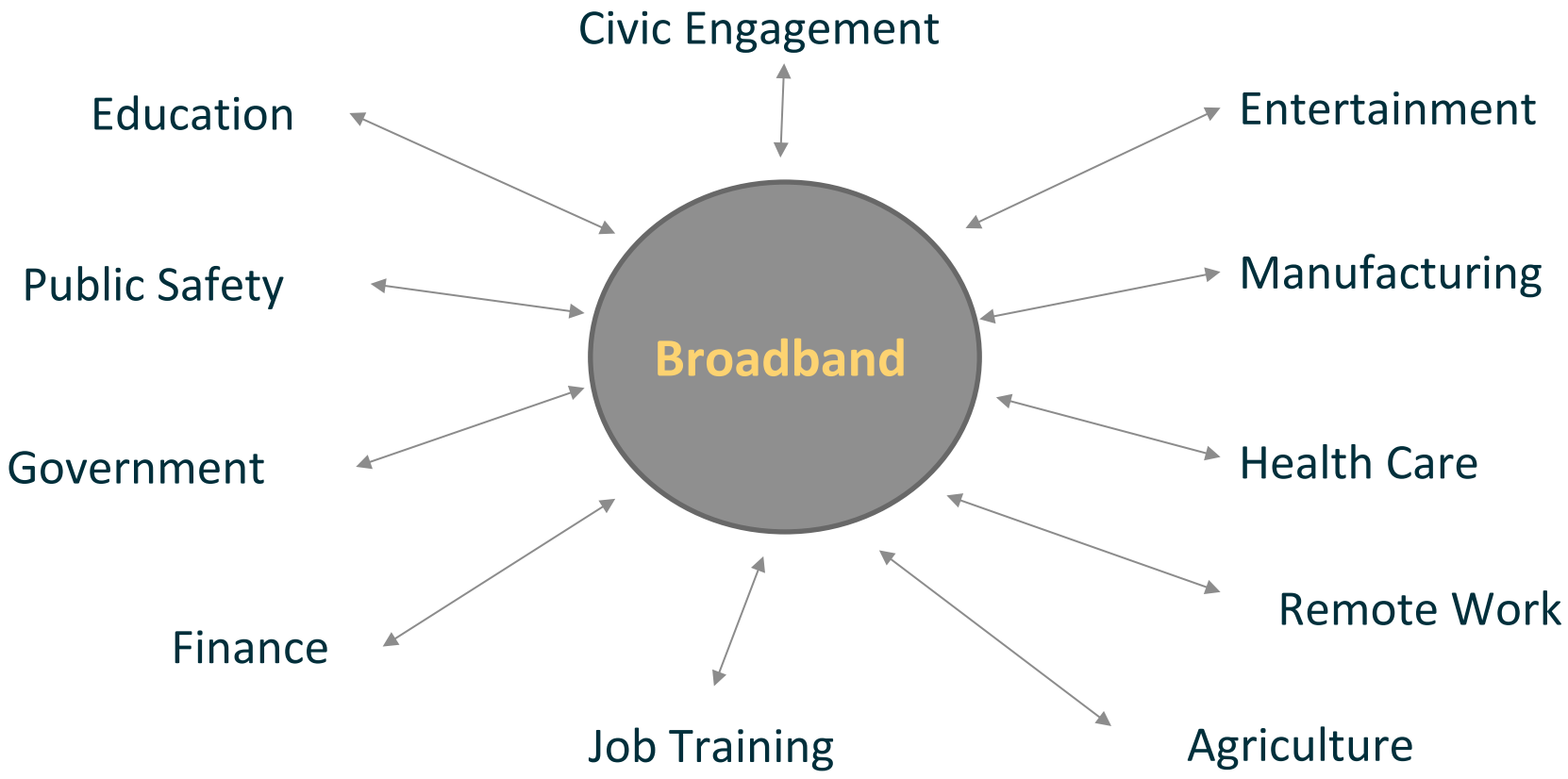
Broadband is the Connection at the Heart of the Digital Economy



Broadband Enables Society's Critical Functions and Services



The Federal Communications Commission's (FCC) Definition of Broadband

- Recently adopted FCC definition: 100/20 Mbps speed

- Evolving definition:
  - In 2015, it was 25/3 Mbps
  - In 2010, it was 4/1 Mbps
  - In 1996, it was 200/200 kbps

- These speeds reflect improving network technology and more demanding applications (e.g., video streaming and conferencing)

The Definition of Broadband for the Purpose of Federal and State Grant Programs

- Many federal and state grant programs (BEAD Program, Connect New Mexico program) consider locations with 100/20 Mbps “served”
- Locations with less than 100/20 Mbps but at least 25/3 Mbps are considered “underserved”
- Locations with less than 25/3 Mbps are considered “unserved”

New Mexico is Committed to Universal Broadband Availability for all Residents

Using federal and state funding, OBAE is leading the state's efforts to deliver broadband, and the opportunities that broadband provides, to all residents of New Mexico

New Mexico's BEAD Grant Program

A significant source of funding is the federal BEAD Program, which provides $42.45 billion to U.S. states and territories to support broadband infrastructure deployment and increase broadband adoption

OBAE is preparing a series of required BEAD plans, beginning with a Five-Year Action Plan
New Mexico was allocated approximately $675 million in BEAD funding

OBAE is developing a BEAD grant program that will enable the state to distribute funding to subgrantees to build new infrastructure

Broadband Challenges in New Mexico: Population Density and Geography

As noted in New Mexico's BEAD Five-Year Action Plan, New Mexico is the fifth-largest state in the U.S. and one of the most rural

The state's large area encompasses diverse geography, from deserts to forests to high altitudes

New Mexico's many remote and rural areas with low population density—combined with the state's topography—create expensive and challenging conditions for building and operating broadband networks

Broadband Challenges in New Mexico: Service Availability

According to the FCC's data (May 2023) and other data sources:

- 70,609 of the state's 873,797 addresses (8 percent) are unserved (no service of 25/3 Mbps or more)
- 72,384 (8 percent) are underserved (less than 100/20 Mbps)
- 730,804 (84 percent) are served, including addresses slated to receive 100/20 Mbps connectivity under enforceable commitments, such as federal or state grants

Broadband Challenges in New Mexico: Affordability

Internet subscription rates by household income in New Mexico and neighboring states

	New Mexico	Texas	Arizona	Colorado	Utah	U.S.
All households	84%	90%	91%	93%	94%	90%
Less than $20,000	66%	74%	76%	78%	78%	74%
$20,000 – $75,000	84%	89%	90%	91%	92%	88%
More than $75,000	94%	97%	97%	97%	97%	97%

Source: BEAD Five-Year Action Plan

2. Overview of Broadband Network Deployment

A. Infrastructure

B. Construction

C. Maintenance

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2A. Infrastructure

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Broadband Infrastructure Technologies

- Fiber optics are fundamental in a reliable, high-performance network – so fiber is prioritized for funding by the BEAD Program
- Hybrid fiber-coaxial (cable broadband) is currently the dominant broadband technology in the U.S. (Comcast, Charter, Cox)
    - “Hybrid” means fiber optic cables extend to a neighborhood, then coaxial cable connects to each house
    - Cable broadband providers are adding more fiber in their existing networks and frequently are building fiber all the way to the house in new service areas
- Wireless providers are not totally wireless: They use fiber to connect their antenna sites to the internet backbone

Broadband Infrastructure Building Blocks: Long-Haul (Backbone), Middle-Mile, & Last-Mile

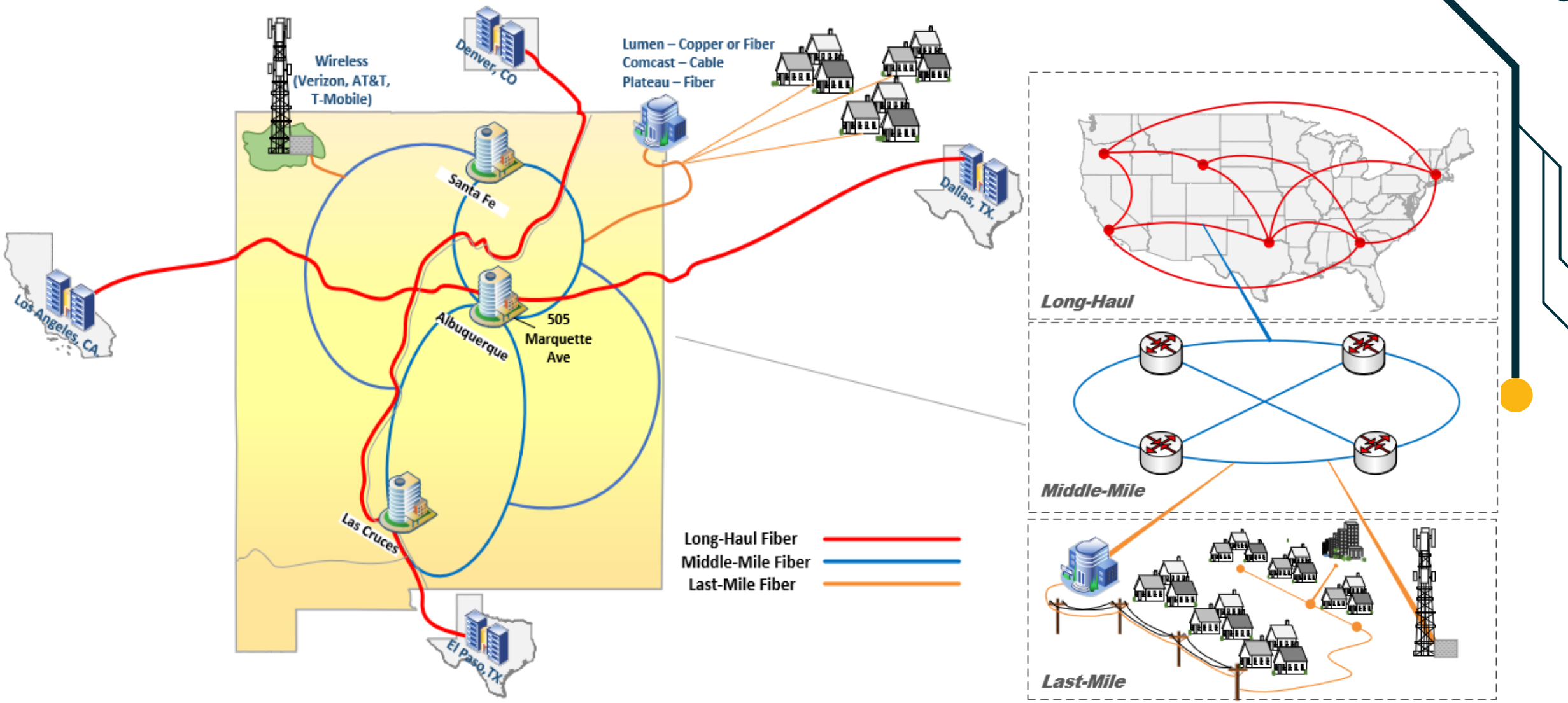
- **Long-haul connections**: High-capacity links interconnecting exchange points in major metro areas, often over distances of hundreds of miles
  - Backbone: High-capacity connections between exchange points and hubs
  - Exchange points and data centers: Meeting points for service providers to interconnect, where content (cloud, web services) is stored
  - Hubs: Traffic aggregation from last-mile and interconnection to middle-mile
- **Middle-mile connections**: Interconnect local service providers with hubs, data centers, and other carriers
- **Last-mile connections**: Connectivity to the end user over fiber, coaxial cable, or wireless

Long-haul connections are like the interstates that connect one state to another

Middle-mile connections are like the highways connecting one town to another

Last-mile connections are like streets to your house

Broadband Infrastructure at a Glance



Building Future-Proof Infrastructure is a Best Practice

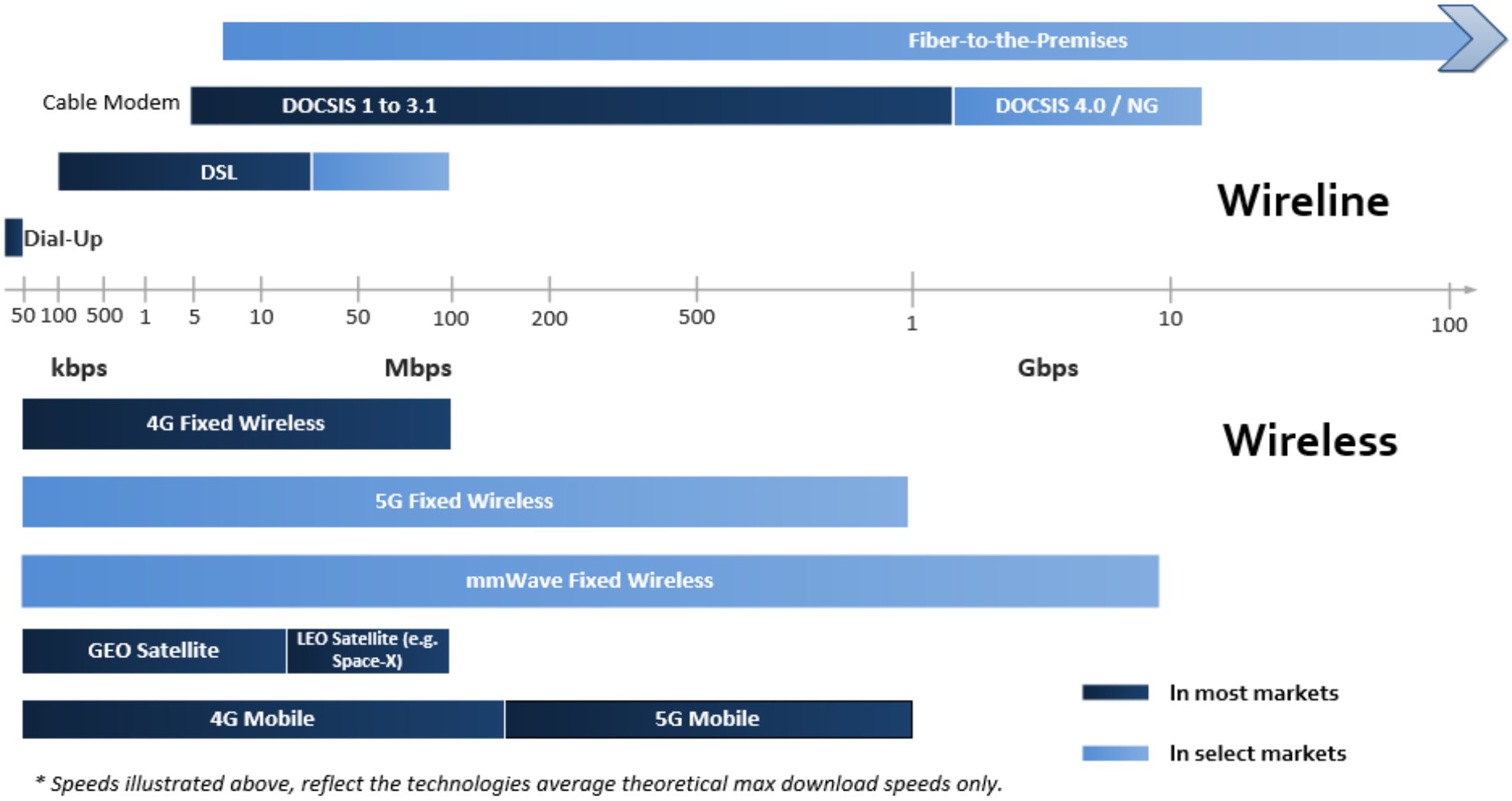
- A future-proof broadband network will maintain its value and usefulness even as demand and technology evolve
- Broadband networks should be scalable and adaptable to the demands of increasing speeds and bandwidth
- Investments that are future-proof mostly consist of components lasting decades, along with some components that can be upgraded seamlessly and cheaply for future increased capacity demand
- Underground conduit, fiber cables and towers typically last decades

Future-Proof Design Considers Current Needs and Assumes Substantial Future Growth

- Design a network to support current and future needs
- If foreseeable needs are 1 Gbps, design electronics and other short- and medium-term components (less than 10 years) for 1 to 10 Gbps
- But consider that cables and conduit will need to support more in coming decades (tens or hundreds of Gbps)
- Fiber optics accommodate decades of growth without having to construct new cables

	FUTURE PEAK BANDWIDTH UTILIZATION MULTI-GENERATIONAL FAMILY OF ELEVEN (EVENING)	TOTAL DOWNLOAD / UPLOAD
x2	Online video gaming (4 Mbps / 2 Mbps per user)	8 Mbps / 4 Mbps
x3	UHD streaming video applications (25 Mbps / 0.2 Mbps per user)	75 Mbps / 0.6 Mbps
x3	Surfing internet (2 Mbps / 0.7 Mbps per user)	6 Mbps / 2 Mbps
x1	Video chat (Zoom, etc.) (6 Mbps / 6 Mbps per user)	6 Mbps / 6 Mbps
x1	Home security (Ring, etc.) and other household smart devices (Alexa, Google Nest, etc.) (4 Mbps / 4 Mbps per home)	4 Mbps / 4 Mbps
X 3	Augmented/virtual reality HD advanced level (1200 Mbps / 1200 Mbps per user)	1,200 Mbps / 1,200 Mbps
	TOTAL BANDWIDTH USE (rounded)	**1,299 Mbps / 1,217 Mbps**

Fiber Leads Other Technologies in Speed



** Speeds illustrated above, reflect the technologies average theoretical max download speeds only.*

Fiber is a Future-Proof Technology

Functional

- Connects equipment over a vast range of distances (from a few feet up to thousands of miles)
- Can transport data at speeds from megabits per second (Mbps) to terabits per second (Tbps), based on equipment type
- Can withstand interference from weather, geography, and other communications technologies
- Fiber deployment construction costs are comparable to the cost of constructing cable or telephone wire, because the key cost is labor, not materials

Flexible

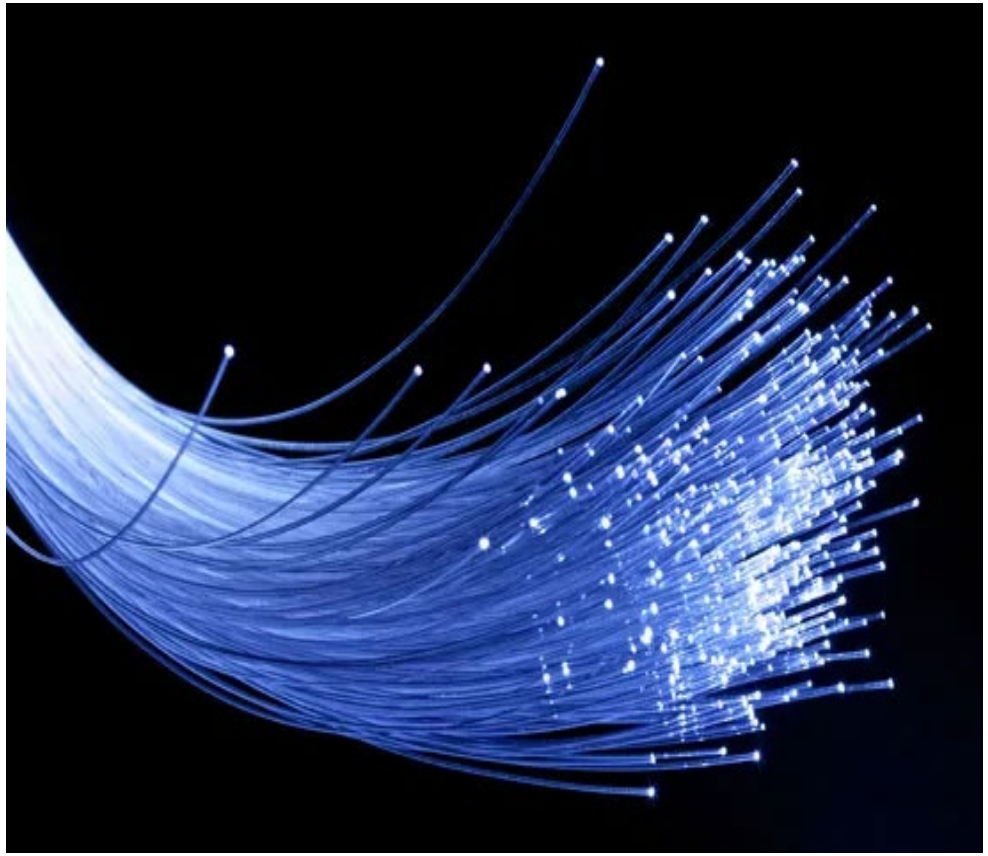
- Fiber optic capacity is virtually limitless (subject to equipment cost rather than technological limits)
- Industry standards ensure consistency and interoperability between fiber manufacturers
- Low manufacturing cost

Resilient

- Fiber optic strands are physically robust
- Life expectancy 40+ years
- Broken fiber strands can be respliced and function without deterioration
- Fiber strands do not corrode

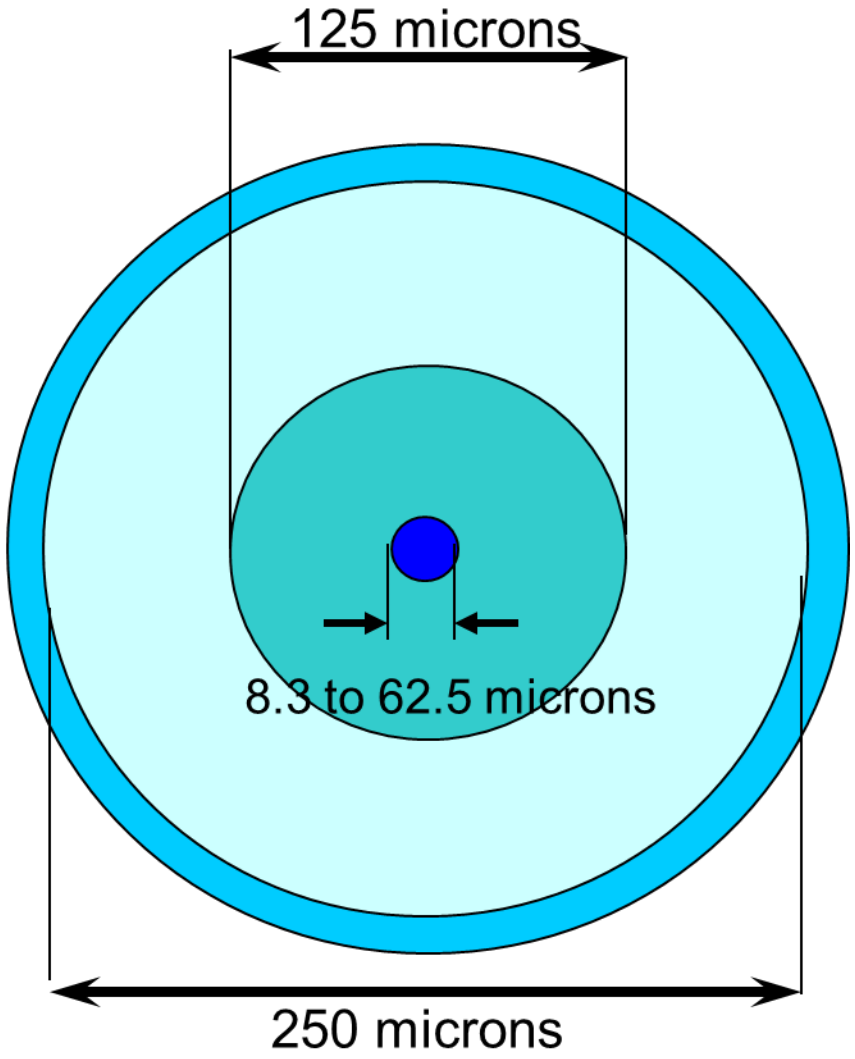
What are Fiber Optics?

- Fiber optic strands are an information transportation medium that carry light
- Made of chemical compounds similar to glass (silica-based)
- Able to transport a large amount of data securely over long distances
- Smaller than a hair (hundreds fit easily in a small cable)



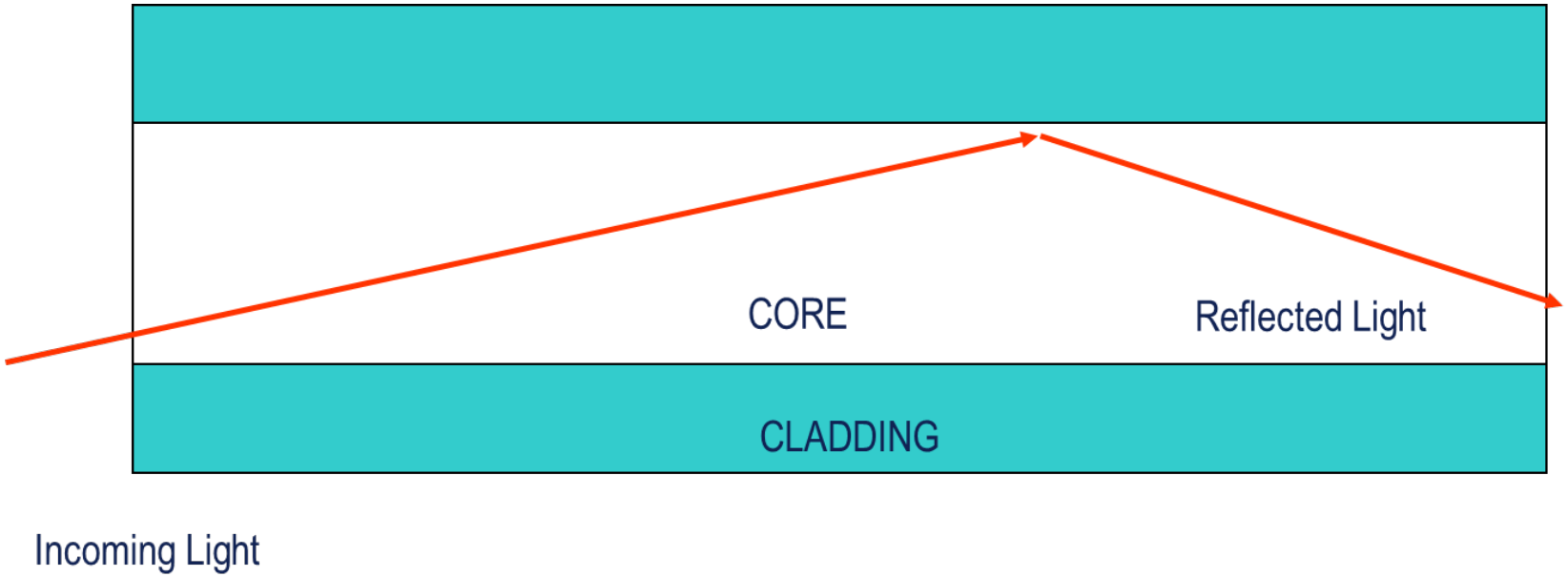
Fiber Cables Up Close

- Core – The center of an optical fiber
- Cladding – Outer layer of glass to contain light; different refractive index
- Coating – Cushions and protects fibers (primary buffer)



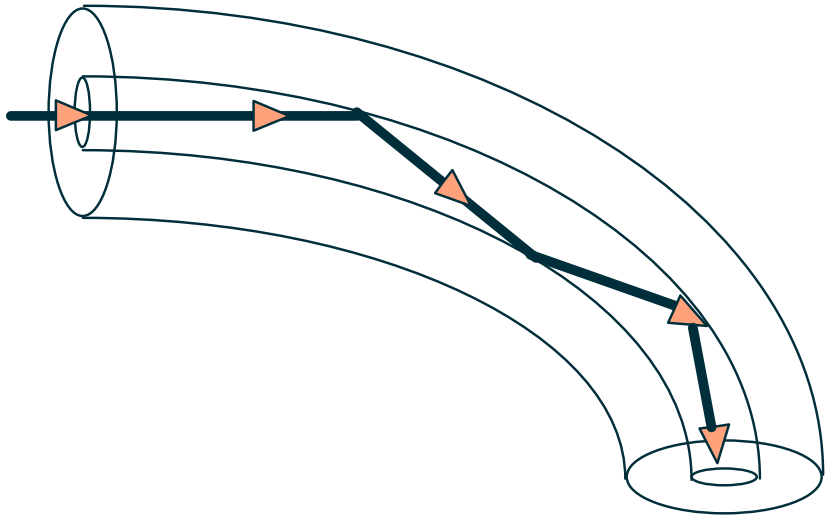
How Light (Carrying Data) Travels Through a Fiber

The fiber cladding “holds” the light inside the core and controls the direction in which a light signal is propagated (“total internal reflection”)

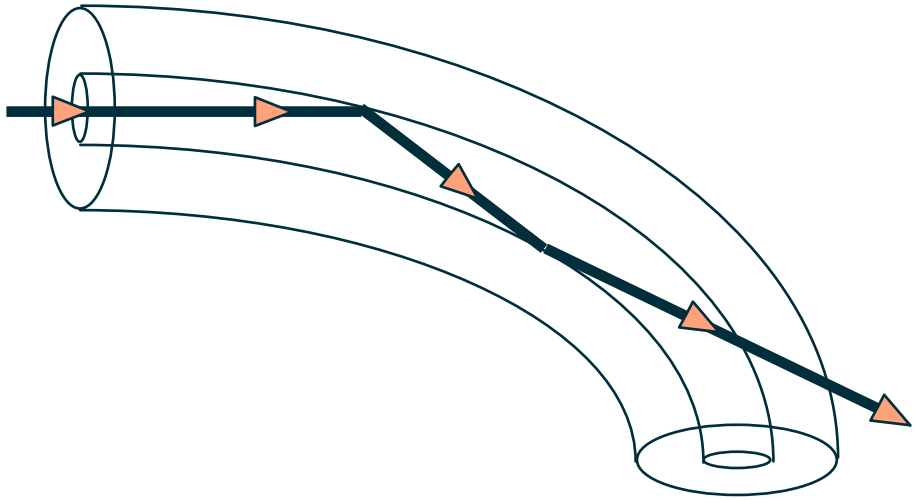


Light Can Bend in a Fiber Cable, Allowing Data to Travel Over Long Distances

- The cable's index of refraction keeps the signal inside and traveling from transmitter to receiver
- Light may exit a damaged cable, so construction practices are designed to protect the cables

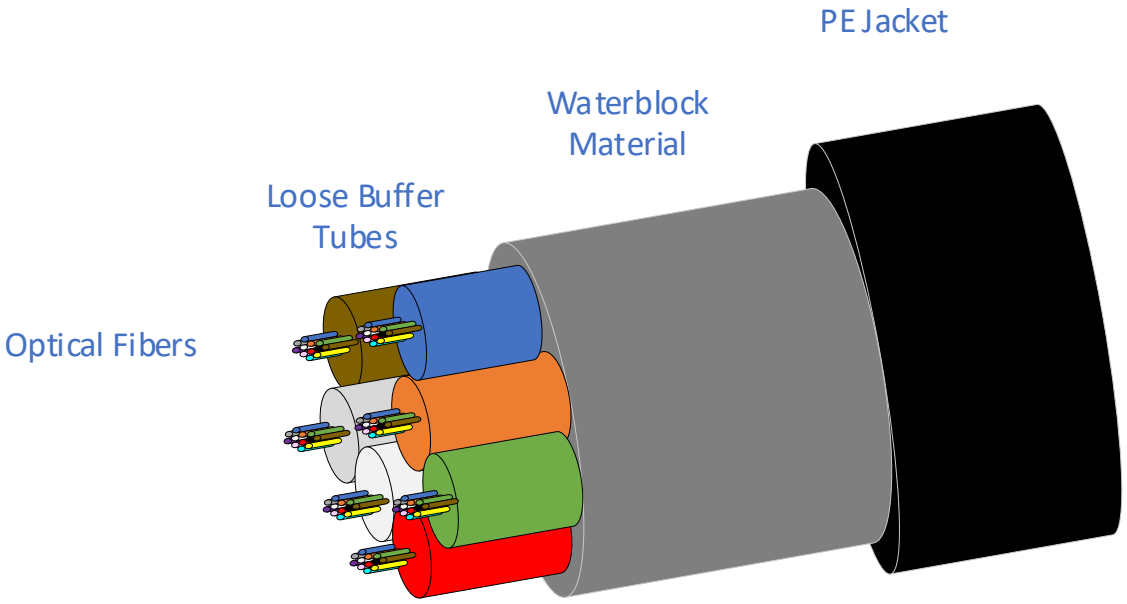


Light traveling in a fiber cable



Light leaving a damaged fiber cable

Fiber Optic Cable Manufacturing



Fibers are placed inside buffer tubes or put into a ribbon, then enclosed in an outer jacket

Depending on the requirements for the cable, the design could incorporate:

- A layer of aramid yarn as a strength element
- A metallic layer for grounding or protection purposes
- A central tube to house the fibers or multiple buffer tubes stranded together

2B. Construction

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Design Factors in Constructing a Fiber Network

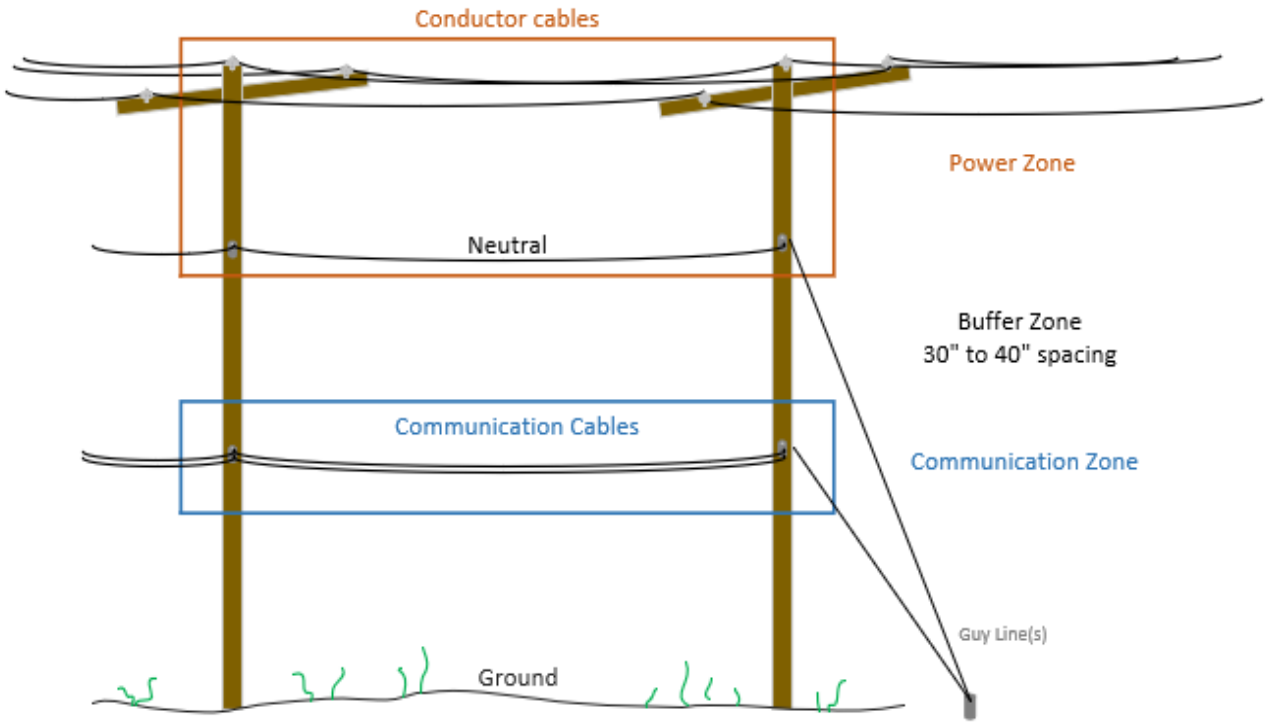
- Aerial or underground:
  - Placement is usually determined by the location of existing utilities on a route
  - Aerial placement is on utility poles, so it requires space on the poles and structurally sound poles
  - Underground placement is typically alongside a road, so it requires space in the right-of-way, permitting approval, and sometimes environmental approvals
- Underground construction is the most expensive construction method, but may deliver long-term cost and reliability benefits

Design Factors in Constructing a Fiber Network

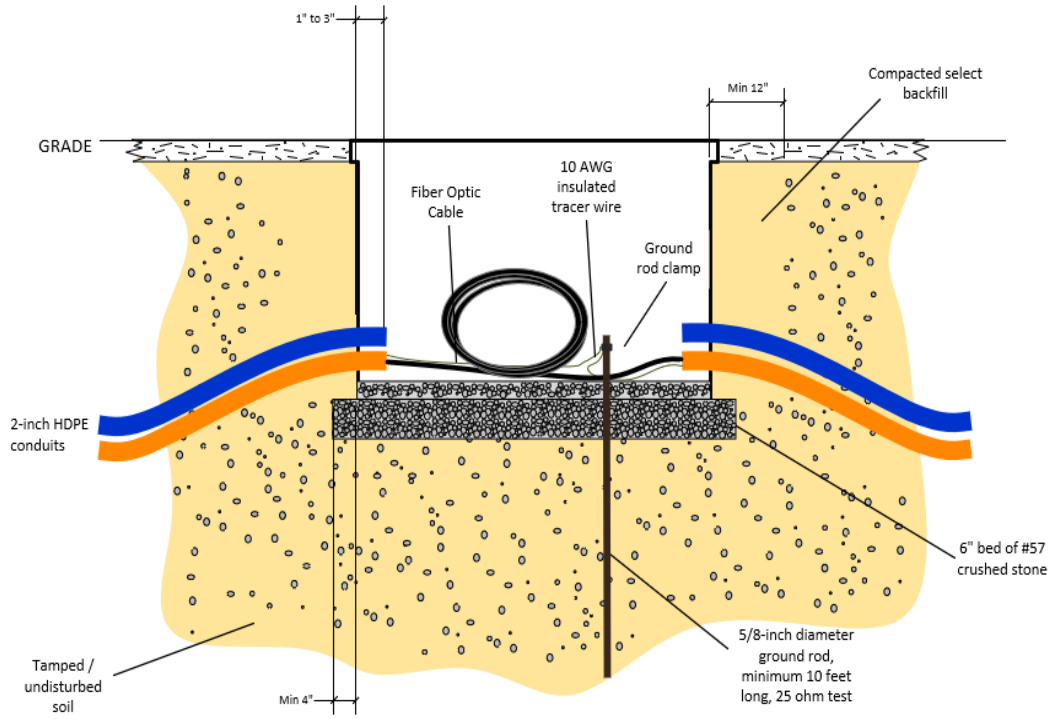
- If fiber cable is constructed underground, it will typically be:
  - Placed in a conduit (tube) to provide an additional layer of protection from damage
  - Run through a series of vaults or handholes to enable future access, splicing, repair, and replacement
- If cable is going to be placed on utility poles, it will need adequate clearance from other utilities, support structures (strand), and attachment hardware such as slack storage loops

Aerial and Underground Construction at a Glance

Aerial Fiber Cable (on a pole)

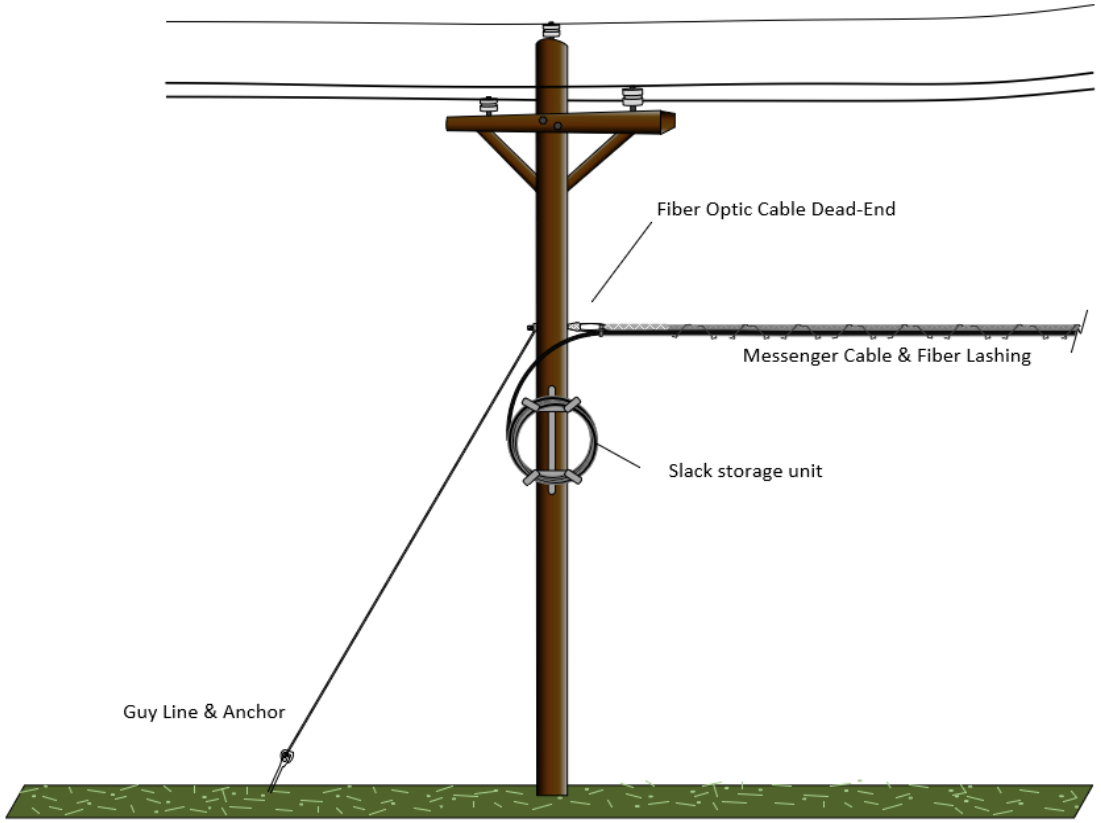


Underground Fiber Cable (in a conduit)



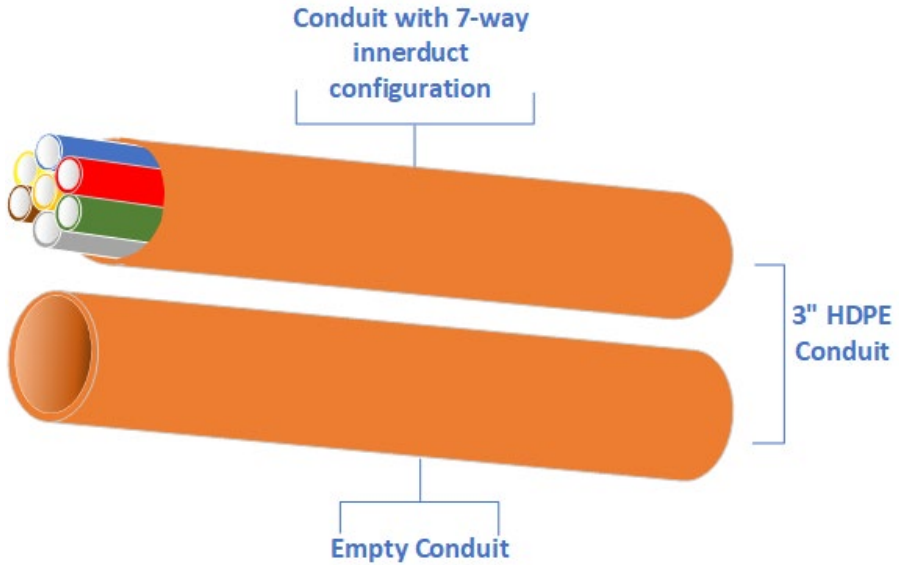
Infrastructure Needed for Aerial Construction

In aerial applications, each design will typically have suspensions, dead-ends, slack storage, and other accessories on the pole



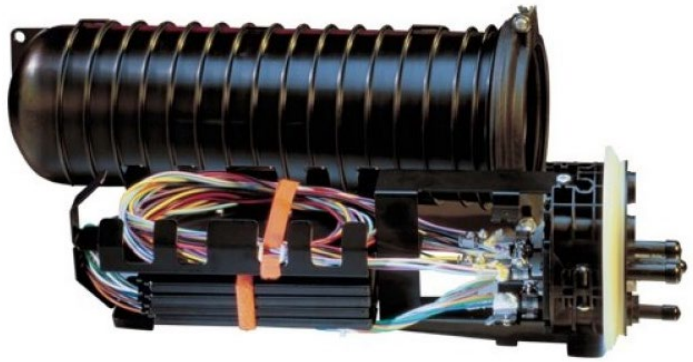
Infrastructure Needed for Underground Construction

Conduits can be empty or prefilled with inner ducts to provide more protection and better future-proofing

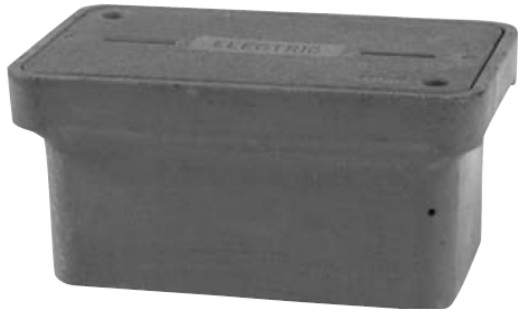


Infrastructure Needed in a Fiber Network: Access Points

- Splice enclosures



- Underground vaults



- Network Interface Devices (NID)

- Pedestals

Preconstruction and Construction Elements

1) Preconstruction

- Verification of project readiness
- Design
- Permitting and easement acquisitions
- Pole make-ready
- Survey of existing utilities

2) Construction

- Mobilization
- Traffic control
- Locates
- Aerial strand placement or underground conduit construction
- Placement of vaults
- Fiber placement
- Surface restoration
- Splicing
- Testing

Preconstruction Tasks: Permitting

- New Mexico has a patchwork of jurisdictions: local, state, federal, and Tribal
- “Use” permits required by public and private asset owners
    - Utility poles
    - Public right-of-way
- Encroachment permits for public and private properties
- Environmental clearance from relevant agencies
    - May be prerequisite for right-of-way use permit, but in most cases, broadband construction is in previously disturbed areas and has no significant impact
    - Project owner conducts environmental impact study and submits report to one or more environmental agencies for review and processing
        - New Mexico Environment Department
        - New Mexico Historic Preservation Division

Aerial Preconstruction Tasks: Pole Make-Ready

Insufficient Space

- Crowded poles may require re-arrangement of existing cables and pole attachments
- Pole replacement may be required if existing poles have insufficient space

Overloaded Poles

- Wind- or snow-loading specifications may be exceeded with added cables
- Deteriorating pole integrity may prevent added cables
- Pole reinforcement or replacement may be required, at ISP's expense

Aerial Preconstruction Tasks: Pole Make-Ready Process

Make-ready includes steps performed by the pole owner and the internet service provider (ISP)

New ISP: Submits pole use application and documentation on pole analysis findings and proposes new strand map

Pole owner:

- Owner may be power company or incumbent telephone company
- Reviews application and supporting documentation
- Verifies accuracy of analysis and strand map; may require walk-outs by existing and new attachers
- Provides permit decision
- Preplaces poles if necessary

New ISP: Initiates pole attachment modifications according to new strand map

Existing ISPs and power company: Move attachments according to new strand map

New ISP: Proceeds with fiber cable installation

Aerial Construction: Cable Placement

Steps taken by the new ISP:

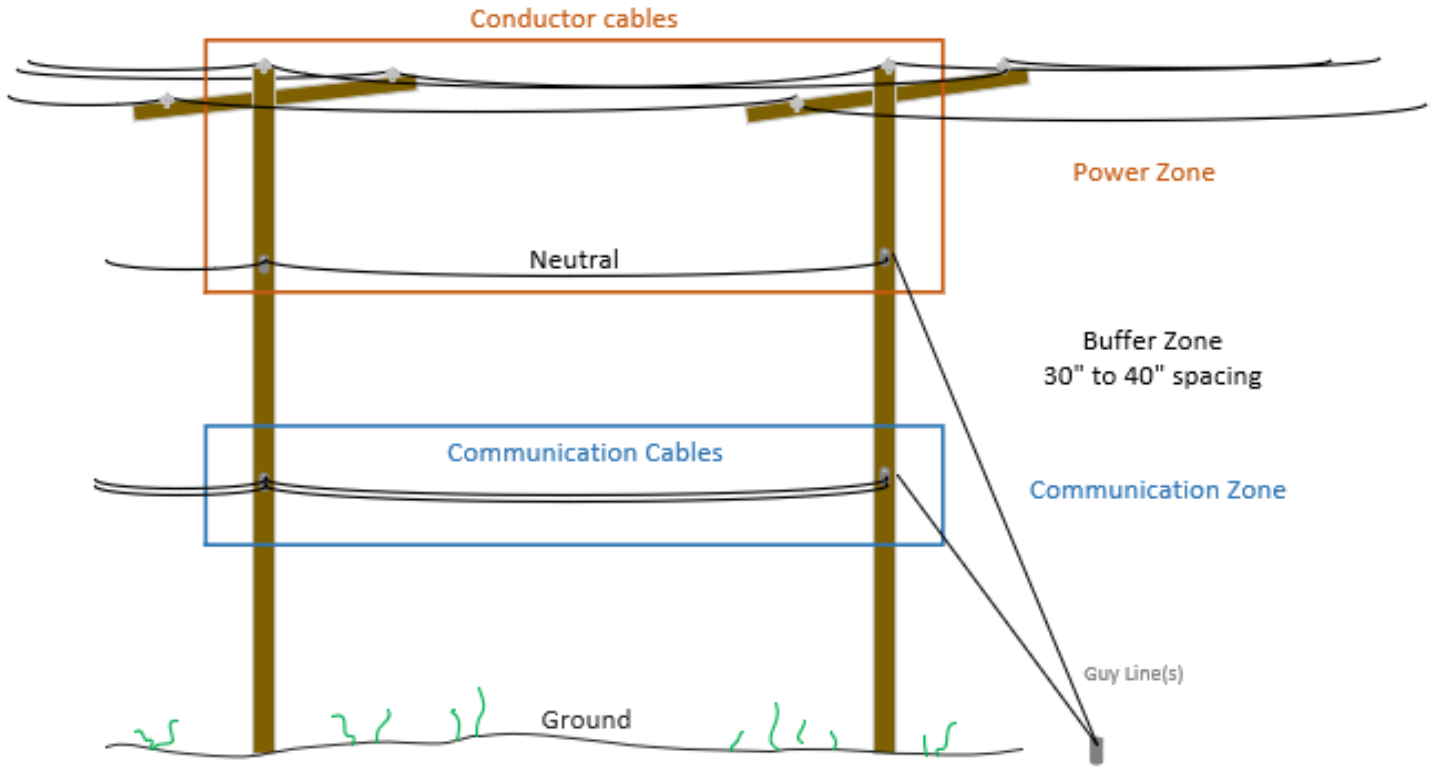
- Install hardware for messenger cable attachment on utility pole (a messenger cable is a supporting cable, usually made of steel)
- Mount messenger cable to pole
- Lash fiber cable onto messenger cable
- ISPs with existing infrastructure overlash new cable onto existing strand

Aerial Construction: Cable Placement

- NESC rules for separation and ground clearance
- Communication zone vs. power zone
- Qualified personnel in power zone
- Safe approach distances to live phases
- Separation rules for safety

Aerial Construction: Cable Placement

Power vs. Communications Zone



Pre-Construction Tasks: Underground Locates

- Existing underground facilities are located days before the start of construction
  - Construction contractors call NM811 and provide notification and information of an upcoming construction project
  - NM811 notifies owners of existing facilities in the project area
  - Utility owners are required to identify and mark the locations of their underground utilities using paint, flags, etc. This can be achieved through:
    - Internal asset management records of prior construction projects
    - Locating devices that detect metallic cable or tracer wire
    - Ground-penetrating radar (GPR)

Underground Construction: Construction in Urban Areas

Horizontal drilling and microtrenching are best-suited to paved public rights-of-way:

- Minimal surface restoration
- Less environmental impact
- Limited traffic disruption

Horizontal drilling

Microtrenching

Underground Construction:
Conduit Construction in Unpaved Public Right-of-Way

Plowing

- Plowing opens a narrow slit in unpaved right-of-way
- Combined conduit placement and plowing
- Fast construction run rate
- Suitable for soil and cobble ground composition
- Minimal surface restoration

Trenching

- Excavation of 6-foot to 24-foot-wide trenches (microtrenches can be less than 2 inches wide)
- Ideal for placement of large conduit banks
- Suitable for any ground composition
- May also be applied in paved right-of-way
- Substantial surface restoration required

Underground and Aerial Construction: Vault and Splice Placement

Underground construction

- Fiber placed in conduit (underground pipes)
- Vaults are spaced at intervals of 500 to 2,500 feet
- Vaults house fiber splice enclosures and slack cable to enable repair and maintenance

Aerial construction

- Splice enclosures may be strand-mounted

Construction: Fiber Splicing

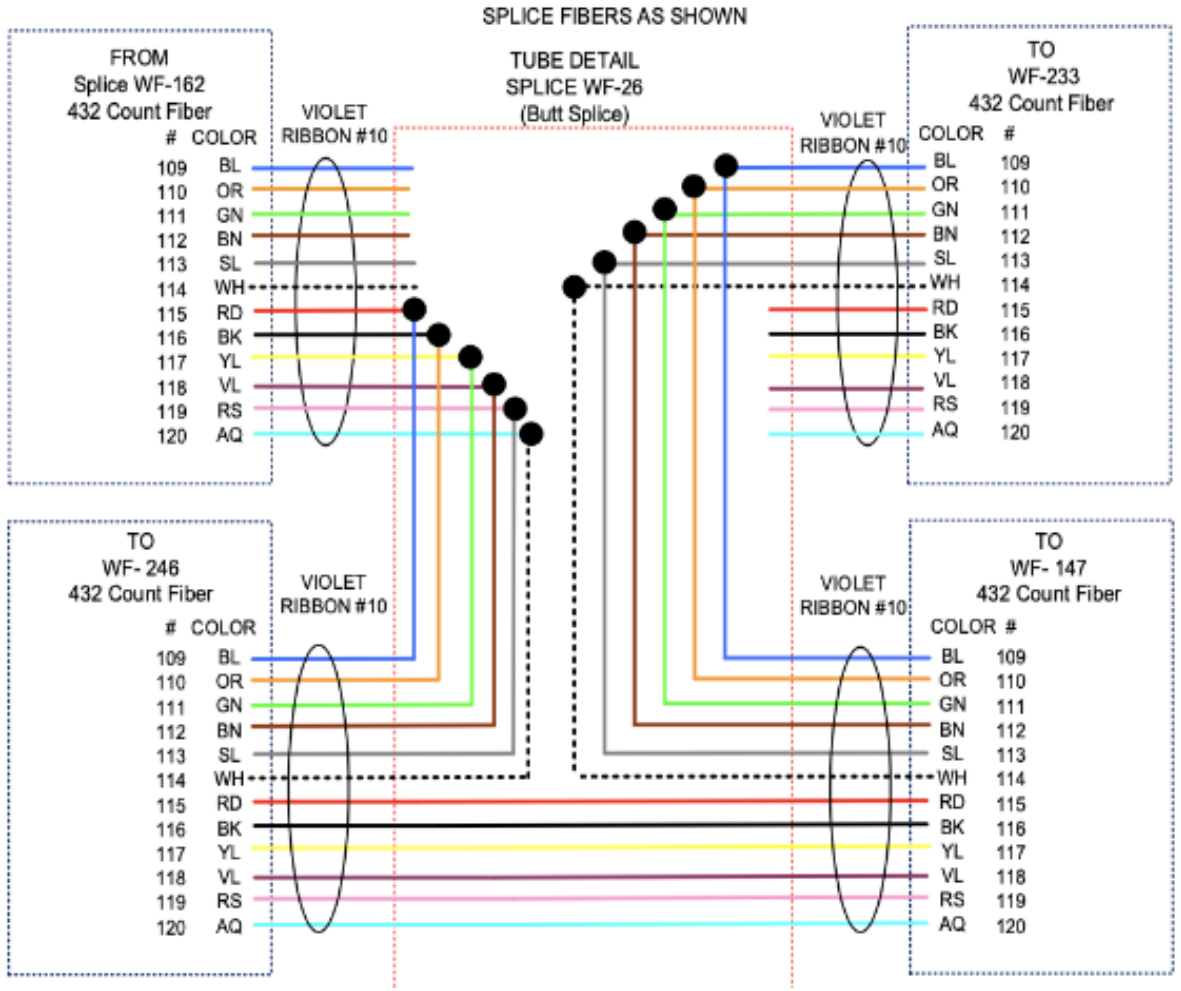
Fusion splicing required at:

- Cable segment meet points
- Fiber route intersections

Two methods of fiber splicing:

- Individual fiber strand splices
- Mass fusion splicing of ribbon cables

Splicing matrix for fiber cross-connects where fiber routes intersect



Testing: Optical Performance Verification

Optical power measurements of completed fiber segments

- Verify correct splicing
- Validate expected optical power loss

Bi-directional optical time domain reflectometer (OTDR) measurements

- Reveal splicing flaws
- Identify locations of optical path impairments, e.g.:
    - Air gaps in fiber connectors
    - Kinked fibers

OTDR measurement test set

Construction Roles

Construction generally performed by specialized contractors to the ISP

Construction oversight and verification performed by the ISP or a specialized consultant

For grant-funded projects, best practice is for additional construction oversight and verification to be performed by a representative of the funder (i.e., the state)

Oversight of Construction Contractor Performed by ISP/Infrastructure Owner

- Work completed in the previous week
- Labor expended per section (including fiber splicing)
- Materials expended per section
- Sections completed and service ready
- Status of permitting
- Construction practices in the field
- Compliance with build standards (i.e., cable depth, placement of vaults, restoration)
- Explain variances from plan of previous week
- Delays that have occurred or continue to occur, with detailed explanation
- Anticipated delays, with a detailed explanation
- Forecast of activities for upcoming week
- Proposed changes to the project
- Reports of addresses where construction has occurred and will be occurring in coming week
- Quality audits performed on segments under construction
- Conflict resolutions

Project Acceptance by ISP/Owner

Project or project components are accepted after ISP has completed construction:

- Field inspection of construction elements (cables, pole attachment, vaults, conduit seals, fiber terminations)
- Review of fiber installation records for accuracy (fiber splice matrices)
- Reconciliation of used versus billed materials
- Review of billed staff hours
- Review of as-built documentation accuracy
- Review of optical performance verification of installed fibers

Technical Oversight Performed by Funding Agency (State)

- Review high-level design for compliance with grant application and program rules
- Review project plan for compliance with grant schedule
- Identify program milestones and payment schedule
- Perform quarterly reporting
- Conduct field inspections on sample basis during construction and to confirm milestone completion
- Provide technical assistance to correct projects going off-track
- Review as-built and test results close-out

2C. Network Maintenance

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Maintenance

- Performed by network owner or dedicated contractor
- Dedicated contractor is required to respond to emergency and maintenance repairs including an on-call break-fix team
- Owner responsible for registering fiber with NM811 and responding to locate requests (i.e., paint on pavement)
- Owner responsible for moving aerial fiber if another provider attaches to poles (owner pays pole fees, right-of-way fees)
- Fiber maintenance is low-cost compared to other network technologies
- Must have spare material on hand to make repairs to infrastructure
- Maintenance contract and insurance usually required by owner/contractor

3. Providing Internet Service

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ISP’s Responsibilities

Broadly, a public or private ISP must provide:

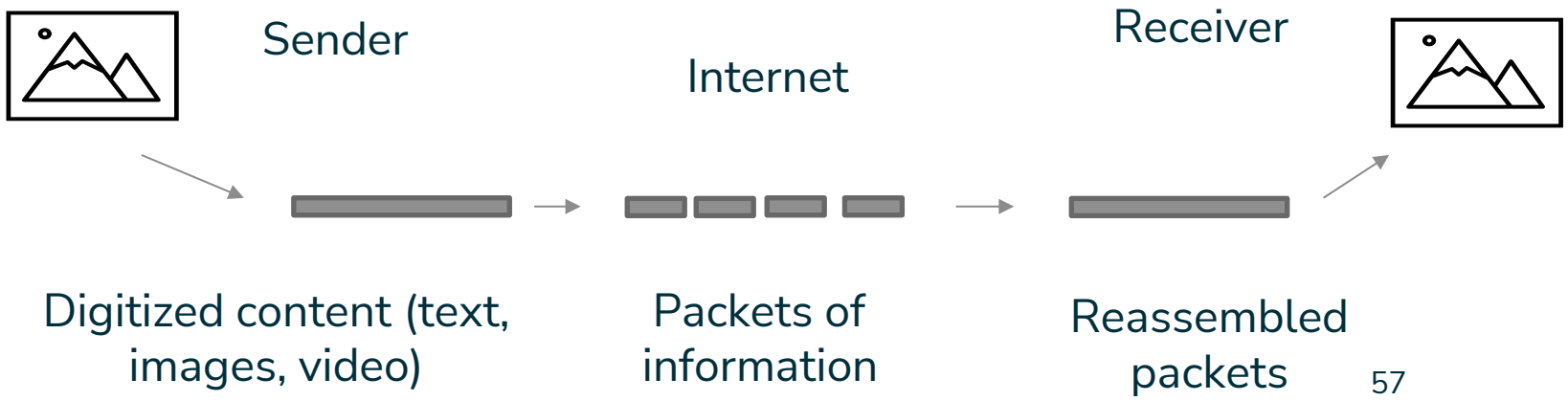
- Reliable broadband service
- Customer service (billing and technical)
- Network repairs
- Network cybersecurity and physical security
- Network monitoring
- Network technology and equipment upgrades

Services on a Fiber Network

- ISPs typically operate and sell “lit services” (internet, video) on the network they own
  - Residential broadband service
  - Small business broadband service
- ISPs sometimes also lease infrastructure (“dark fiber” strands, bulk internet capacity) and act as a wholesaler for other providers (such as wireless operators, educational institutions)

How Data Moves Through the Internet

Data travels in “packets”
Internet Protocol (IP) is the standard set of rules used worldwide by internet devices that ensure computers can send and receive data packets between each other and decode them properly
Packets include the destination address (or IP address) of the intended recipient and are “routed” along the internet through a series of hubs and data centers before arriving at the final router at the recipient’s premises



The ISP Connects its Network to the Internet Backbone

Direct internet access (DIA)

- Mostly used by enterprises, small ISPs
- A “big pipe” to an internet connection point (tens or hundreds of Gbps)
- Ideally ISP has multiple, diverse connections
- Typically includes block of internet (IP) addresses

Peering

- Best suited to large ISPs or institutions
- Interconnections among ISPs at meet-points without payment
- Interconnected parties receive mutual benefits from the connection

Estimating Internet Access Capacity Needed by an ISP

- Should be engineered to peak capacity demand
- ISPs often purchase “burstable” services to accommodate exceptionally high peak
- Residential demand peaks between 7:00 p.m. and 11:00 p.m.

Aggregate capacity $C = N^* T_{av} + k^* S_{top}$

N= Number of active subscribers at peak (typically 85% - 95%)
T_{av} =average bitrate per active subscriber
S_{top}= top speed tier
k= adjustment factor, range 1.2 – 1.4

Example:

- 10,000 passings, 50 percent take-rate
- Top speed tier: 1 Gbps
- Average subscriber data rate: 6 Mbps
- Aggregate capacity: 30 to 35 Gbps

Broadband Service Metrics

Four performance parameters characterize an ISP's broadband service:

Download speed: Rate at which user receives information
Upload speed: Rate at which user can transmit information

- Download and upload speeds are measured in megabits per second (Mbps) or gigabits per second (Gbps) (25 Mbps/3 Mbps, 100 Mbps/20 Mbps, 1 Gbps/1 Gbps)

Latency: Time delay between the sender and recipient devices

- Typical range of 10 milliseconds to hundreds of milliseconds

Jitter: Time variations in arrival of information packets (variation of latency)

- Measured in milliseconds
- Most relevant for real-time applications (e.g., teleconferencing, video streaming)

Broadband Service Tiers

Speed and amount of data are subject to contracts with last-mile provider

Tiered speed service model:

- Most operators offer various speed tiers (such as 100/20 Mbps, 400/50 Mbps, 1/1 Gbps)
- Flat rate, with price varying by speed offered
- Most residential providers do not guarantee the speeds (best effort)— BEAD grants require 80% or more of measurements to meet 80% or more of the required speed (100/20 Mbps)

Unlimited data at flat rate:

- Typically offered by default (except mobile data)
- At times of congestion, heavy users may be deprioritized (fair share concept)

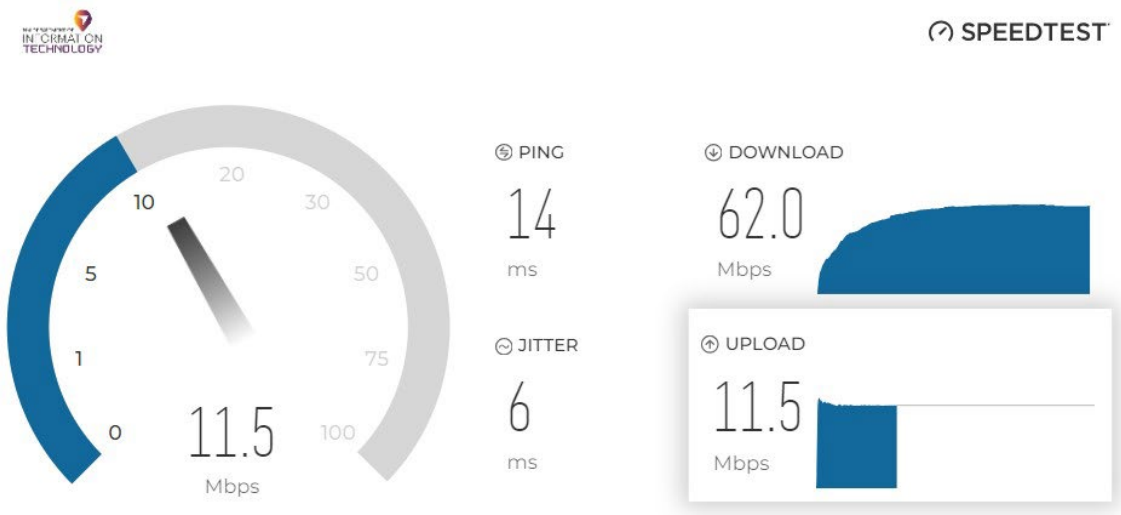
Metered data:

- Subscriber selects a monthly data package with a data cap (typical for mobile providers)
- Exceeding the data ceiling may result in added usage fees and substantially diminished data throughput, thus encouraging customer to change data plan or moderate future usage

Typical data traffic per household per month: 600 to 1,000 Gigabytes (GB)

Speed Test

- One means of testing your internet connection
- Packets travel from your computer to a computer in a data center
- Quick burst of data in both directions measures connection speed, travel time (ping)
- Not perfect: May be hard to determine whether problems are caused by your computer, Wi-Fi, or service provider



Run your own internet speed test: [NM Broadband Speed Test Survey](https://nmbbmapping.org/survey/) (https://nmbbmapping.org/survey/)

ISP Staffing Requirements

- **Sales and marketing**
  - Defines products and sales strategies, actively engages with enterprise customer prospects
- **Field service team**
  - New installations, repair, plant and equipment maintenance
- **Core network engineering**
  - Facility-based network design; moves, adds, and changes; turn-ups; upgrades; troubleshooting
- **Customer service representatives**
- **Billing**
- **Sales engineering**
  - Engineering support on complex customer service requests
- **Network operations**
  - Surveillance of network health, performance reporting, coordination of plant upgrade and troubleshooting procedures, communication with customer service
- **Facilities management**

Customer Service: Elements of Billing Support

- Answer questions related to billing statements and explain charges and fees
- Handle the processing of payments
- Assist with resolving billing disputes and issue credits where necessary
- Handle service changes, including changing billing rates and terms
- Handle requests for past bills, payment receipts, and other documents related to the customer's account

Customer Service: Elements of Technical Support

Installation and setup

- Provide guidance on setting up new services or adding new devices to the network

Troubleshooting

- Assist with connectivity issues such as slow speeds, intermittent connectivity, or total loss of service

Equipment support

- Assist with the provider's equipment such as routers, modems, and Wi-Fi extenders

In a Small Network, Operations Can Be Outsourced

Building in-house staff takes time, is initially inefficient, and requires an investment that likely exceeds the operating budget

Consider alternatives:

- **Hire a contracted turnkey operator:**
  - Contracted organization has economies of scale as they offer same services to other clients
- **Outsource by operational function**:
  - Customer help desk with shared 24/7 call center
  - Field service retainer for installation and repair, billed on a per event basis
  - Network surveillance services by third parties
  - Core network engineering contracted with vendor's VAR or system integrator

Cost Elements of Operating an ISP

Fixed cost	Variable cost

• Staffing
• Maintenance and fees
  ○ Equipment maintenance fees, fiber locates, utility pole use fees
• Leases
  ○ Facilities, hub locations, conduit leases, dark fiber
• Depreciation
  ○ Funding pool for replacement of aging infrastructure
• Insurance
• Interest
	• Contractors, consultants, outsourced services
	• Utilities
	• Internet access (DIA, IP transit, peering)
	• Interconnect services
	• Equipment repair/replacements

Cost Model for ISP Operations

- Example small FTTP PON network
- 365 fiber route miles
- 19 percent underground
- 81 percent aerial
- 9,800 addresses
- 60 percent take-rate

Estimated yearly cost of operations:

$2,544,000 ($212,000 per month)

Category	Component	Yearly cost
Fiber maintenance	Underground utility locates	Contracted at 1 percent of fiber plant capex or $800 to $1,800 per fiber route mile per year
	Fiber repairs and relocations	$600 per mile per year
Equipment maintenance	Vendor contracts for firmware updates, engineering, and operations support	12 percent to 18 percent of purchase price per year
Depreciation of network electronics	Funding equipment replacement	10 years for core electronics, 5 to 7 years for customer premises equipment (CPE)
Pole attachment fees	Lease of pole space	$12 to $18 per pole
Internet access		$9 to $18 per Mbps per year
Staffing	Manager Marketing and sales Customer service rep Core network engineer Broadband engineer Service technician Fiber plant technician	1 FTE 2 FTE 4 FTE (1 per 2,500 subscribers x 1.5 shifts) 2 FTE 1 FTE 4 FTE 2 FTE (1 per 100 to 200 miles of plant)
Business expenses	Billing support Churn (costs of new subscribers) Office expenses Accounting and human resources Insurance Leases Carrier interconnection charges Utilities Marketing	$1.50 per subscriber 1.5 percent of new customers or $200 per event $15,000 $25,000 $20,000 $10,000 $12,000 $16,000 $25,000

4. Public-Private Partnership Models

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Three Models of Public-Private Partnership (P3)

Facilitation model

- **Public facilitation** of **private investment**
- **Strategy**: Providing streamlined permitting, tax benefits, or access to public assets

Grant model

- **Public financing** of **private infrastructure**
- **Strategy**: Using federal or state grant programs to partially fund privately owned broadband infrastructure

Investment model

- **Public financing** of **public infrastructure** to be **operated by the private sector**
- **Strategy**: A locality funding fiber itself, then leasing it to a private partner for operations (other strategies also possible)

Facilitation Model

- **Summary:** Facilitate private investment by seeking to make it attractive, streamlined, and profitable

- **Strategy:** Several options—develop local infrastructure, offer tax benefits, increase access to information, streamline government processes like permitting and inspections, decrease fees, implement Dig Once or one-touch make-ready

- **Risks:** May not fundamentally change underlying business case; private sector may still only deploy capital in profitable areas (which they may have served anyway)

Facilitation Model: Case Study

- The **City of Memphis, TN,** passed an ordinance amendment that streamlines permitting and right-of-way processes (including fee exemptions) for service providers that commit to deploying fiber to low-income households and significant percentages of the city

- Resulted in a partnership with Meridiam, Blue Suede Networks, and Ting to build and operate a fiber network they say will pass at least 85 percent of premises in the city, including 85 percent of low-income premises

Grant Model

Summary: Award a grant (and/or assist with an application for a state or federal grant) to provide funding to a private partner that will construct, own, and operate broadband infrastructure

- The private partner commits to deployment and service requirements in exchange for the public partner's assistance

Strategy: Can conduct a competitive grant process centered on a community's needs and priorities and select the applicant that will deliver the best value

Risks: Ensure that applicants' proposals are viable and that applicants are financially and operationally capable

Grant Model: Case Study

New Mexico Office of Broadband Access and Expansion (OBAE) awarded $66.8 million in grants in 2023 for 11 projects to expand broadband to over 10,300 unserved locations in 23 communities

- Diverse communities, geographic locations, and business models
- Mostly fiber-to-the-premises projects
- Awardees provided cash and in-kind matching contributions of $39.5 million

Investment Model

Summary: Make a capital investment to construct and own fiber infrastructure, then lease it to a private partner for operations

Strategy: Can pursue community-wide fiber or focus on a targeted area where the business case is insufficient for privately funded broadband; ownership and leasing can follow different approaches

Risks: Could require significant funds to build and (if pursuing community-wide network) could end up paying to build in areas that private sector would have been willing to deploy independently

Investment Model: Case Study

The **City of Jacksonville, IL,** paid for part of an ISP's infrastructure cost to bridge the business case in likely low-return areas of the city

- The city's investment resulted in ubiquitous fiber
- Investing in only those areas was four to eight times cheaper than paying for a complete citywide fiber network, according to city leadership

Jemez Pueblo funded the Tribally owned Jemez Pueblo Tribal Network in New Mexico using federal and state grants and partnering with BigByte and i9 for engineering, distribution, and deployment

- Now provides service to government offices and 500 homes

Overall P3 Best Practices

- Design the partnership to serve your community's policy priorities and best-in-class goals
- Ensure both risks and opportunities are shared evenly
- Be conscious of dependencies and control
- Insist on qualifications, best practices, and standards
- Include workforce opportunities and training requirements
- Avoid unenforceable promises and unrealistic projections

Cautions Regarding P3s

Beware of:

- Overly optimistic projections (e.g., for revenue or timeline)
- Overstated capabilities of technology
- Business plans that claim there is no risk (as they may be obscuring the risks)
- Assumptions not backed by evidence (e.g., for costs, revenue, take-rate)

5. Grant Funding Opportunities (State and Federal)

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Introduction to Federal Funding

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Federal Funding Opportunities by Source

Department of Agriculture

- Rural Broadband Access Loan & Loan Guarantee Program
- ReConnect rural broadband grant/loan program
- Distance Learning & Telemedicine equipment grant program
- Telecommunications Infrastructure Loan program

National Telecommunications & Information Administration

- Broadband Equity, Access, and Deployment (BEAD) Grant Program
- Digital Equity Act grant programs
- Tribal Broadband Connectivity Program

Economic Development Administration

- Economic Adjustment Assistance
- Planning and Local Technical Assistance Program

Federal Communications Commission

- Affordable Connectivity Program – subsidized service for low-income households *(set to expire)*
- E-Rate – subsidized service for schools and libraries
- Healthcare Connect and Rural Healthcare programs – subsidized service for hospitals and clinics

What is the BEAD (Broadband Equity, Access, and Deployment) Opportunity?

Access

Increases access for unserved and underserved households to ensure that all Americans have access to high-speed internet

Ensures Americans have access to **high-quality broadband services** to support full participation in the 21st century economy and beyond

Affordability

Supports **affordability** of broadband services, especially in low-income households

Fosters a system that **promotes long-term, sustainable, affordable solutions**

Adoption and equity

Enables investment in digital skills training to increase the number of households adopting high-speed internet and narrow adoption disparities

Makes investments to ensure Americans can **participate in economy and society, reducing inequities** across sectors including health care, workforce, and education

SOURCE: National Telecommunications & Information Administration

BEAD to Prioritize Complete Coverage of Unserved Locations and Underserved Locations (where funding permits)

Complete coverage of **unserved locations** (including by deploying Wi-Fi to multi-family buildings)

Complete coverage of **underserved locations** (where funding permits)

NTIA urges use of remaining funds for **Community Anchor Institutions (CAI)** before other eligible uses

SOURCE: National Telecommunications & Information Administration

New Mexico's BEAD Grant Program

- New Mexico was allocated approximately $675 million in BEAD funding
- OBAE must submit a series of planning documents to NTIA for approval (Five-Year Action Plan, Initial Proposal, Final Proposal)
- Volume 2 of the state's Initial Proposal, submitted to NTIA in December 2023, outlines the proposed requirements for the state's grant program
- OBAE will administer the grant program in 2024 and 2025 to award funding to subgrantees
- Prior to opening the application window, OBAE will conduct a Challenge Process (outlined in the Initial Proposal Volume 1) to determine the locations eligible for BEAD funding
    - Permissible challengers—including local governments and Tribal nations—can dispute the initial eligibility determinations made based on the FCC National Broadband Map using their local data

Digital Equity Act Grant Programs

NTIA also administers three grant programs to promote digital equity and digital inclusion:

- Digital Equity Planning Grants ($60 million)
  - Funding for states, territories, and Tribal governments to create Digital Equity Plans
- Digital Equity Capacity Grants ($1.44 billion)
  - Funding for states, territories, and Tribal governments to implement their Digital Equity Plans
  - Allocations are based on population, broadband availability and adoption, number of members of “covered populations”
  - NTIA must approve applications
- Digital Equity Competitive Grants ($1.25 billion over five years)
  - Grants directly through NTIA
  - Eligible entities include political subdivisions, local educational agencies, nonprofits, Tribes
  - NTIA to release guidance

What is Digital Equity?

Broadband access:

- Affordable, accessible, and reliable high-speed home internet service is available for all individuals

Accessible and inclusive content:

- Public online content is inclusive and accessible by all individuals

Devices and tech support:

- Individuals have access to a computer or tablet and technical support

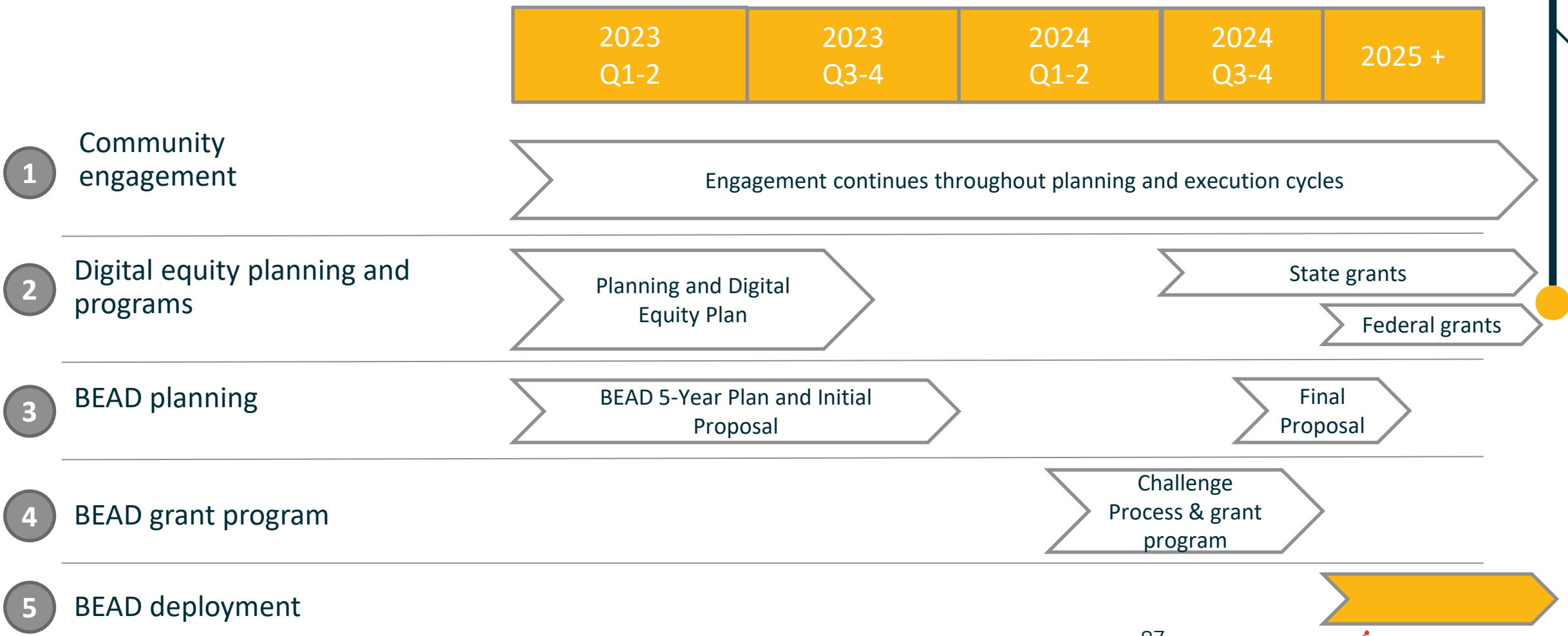
Privacy and security:

- Individuals can protect their data privacy and online security

Digital literacy and skills:

- Individuals have digital skills to support their ability to meaningfully use the internet in their daily lives

Summary of BEAD and Digital Equity Timelines



How to Participate in BEAD & Digital Equity Planning

Community outreach and engagement are critical steps to ensure you have the information and participation that you need

Ensure the FCC map shows your community's reality

- Check the FCC map and challenge if necessary
- Provide data on unserved and underserved locations to OBAE

Review digital equity data for your community

- Understand how many households lack access to broadband because of affordability, language, or other issues—even where it is available
- Use existing data and collect new data to understand challenges
- Provide data to the state planning effort

Prioritize areas of concern

- Using your digital equity data, prioritize areas of effort for your community
- Using your data on unserved and underserved locations—as well as OBAE-designated priority areas—build a prioritization of infrastructure projects

Prepare for funding opportunities

- Identify existing digital equity programs that work and can be expanded, and needs for new programs
- Build partnerships with nonprofits or companies that have track records

Tribal Broadband Connectivity Program Rounds 1 & 2 (Applications Closed)

Approximately $3 billion for Tribal governments to support broadband deployment on Tribal lands, as well as efforts related to digital inclusion and broadband affordability, telehealth, and distance learning

For infrastructure project proposals, applicants were directed to prioritize coverage of unserved locations; funding can be used for middle-mile and last-mile network construction

Available funding is distributed over two rounds:

- In New Mexico, 16 Tribal entities received awards through Round 1 totaling $187 million
- Application window for Round 2 closed in March 2024

Introduction to State Funding and Resources

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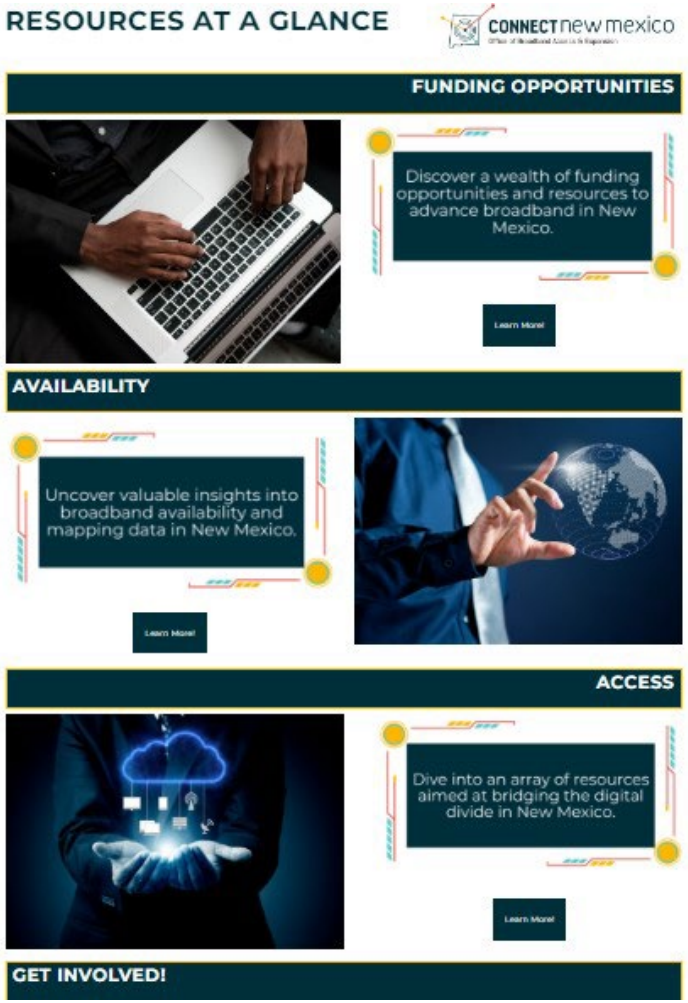
Office of Broadband Access and Expansion (OBAE)

OBAE's website, with resources and program information:
https://connect.nm.gov/

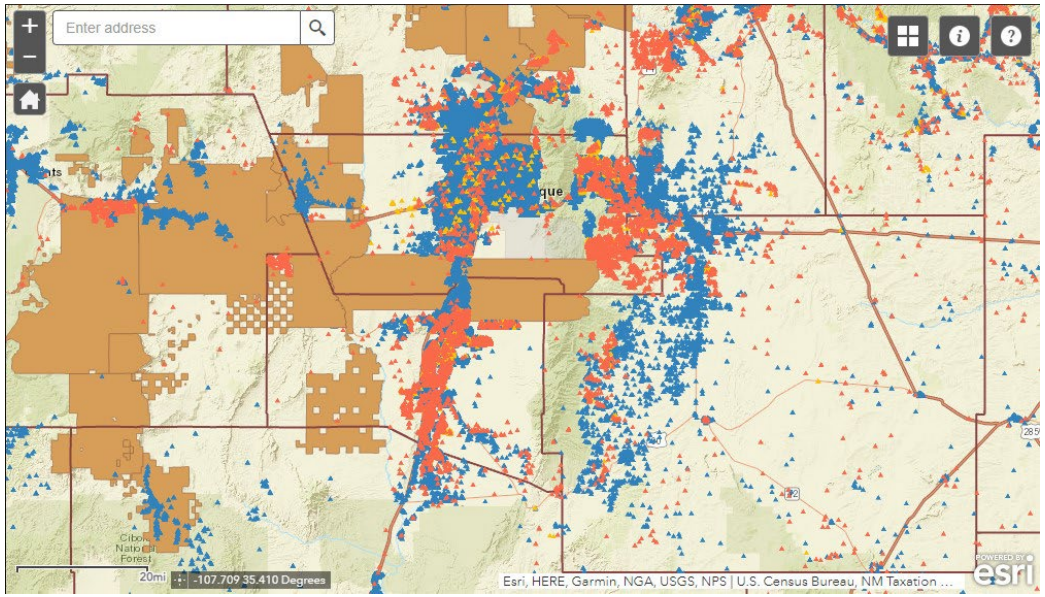
OBAE's mapping and data hub:
https://maps.connect.nm.gov/

New Mexico County Profiles:
https://connect.nm.gov/counties-a-c.html



New Mexico Broadband Map

Interactive online map of broadband availability by technology based on data from the FCC and ISPs
Shows served, underserved, and unserved residence and business locations, and community anchor institutions lacking 1 Gbps service
Determines eligible locations for the Connect New Mexico Fund grant program
See: https://nmbbmapping.org/mapping/



New Mexico Grant Writing, Engineering, & Planning Program (GWEP)

OBAE will award financial assistance grants to aid local and Tribal governments in procuring grant writing, engineering, and/or planning assistance to help identify community broadband needs and to support applying for other funding sources for broadband-related projects

Applications will remain open until available funds ($5 million) are obligated
Award maximum is $100,000
See: https://connect.nm.gov/gwep-program.html

Connect New Mexico Fund

OBAE will award grants to local and Tribal governments, private entities, and consortia to subsidize network deployment for unserved and underserved areas, aiming to provide broadband access to residents, businesses, and institutions. The program promotes sustainable networks offering reliable, affordable high-speed solutions for comprehensive community coverage and digital inclusion

$70 million in funding available

Applications closed March 2024, but NOFO includes contingency to apply any unused funds in a subsequent funding round

See: https://connect.nm.gov/obae-funding.html

Connect New Mexico Pilot Program (Closed)

A forerunner to the Connect New Mexico Fund grant program, the Pilot Program provided infrastructure grants for broadband deployment to unserved and underserved communities across New Mexico

Final set of awards were announced in September 2023

Over three waves of funding, OBAE awarded a total of $117 million to deploy 1,400 miles of fiber and connect 26,000 premises

See: https://connect.nm.gov/obae-funding.html

Other state funding: New Mexico Public Regulation Commission (NMPRC) Annual Broadband Program

Open to eligible telecommunications carriers

Grants for construction and maintenance of facilities to serve unserved and underserved rural areas, funded by the State Rural Universal Service Fund (SRUSF)

Proposals are considered on a technologically neutral basis (per the SRUSF rule) and must provide minimum 25/3 Mbps service to all households and businesses in the proposed project area

Approximately $11.8 million in awards announced in October 2023

See: https://www.prc.nm.gov/utilities/telecommunications/nmprc-annual-broadband-program/

Preparing for Funding Opportunities: Key Points to Consider

- What, if any, broadband funding does your community have (e.g., USDA or U.S. Economic Development Administration programs)?
- Have you reviewed the FCC's National Broadband Map, and does it accurately portray broadband in your community?
- How can your community engage in the BEAD and digital equity planning processes?
- What data does your community already have that would be helpful for digital equity or infrastructure projects?
- What potential private sector partners does your community already have that could support your efforts?

6. Writing a Request for Proposal (RFP) and a Scope of Work (SOW)

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RFP Development: What Goes into an RFP?

A competitive process is required by the rules for most grants

A request for proposal (RFP) is a solicitation document that lays out a strategic approach for procurement and allows multiple contractors to submit a proposal

An RFP should include:

- Scope of work (SOW)
- Proposal submission requirements
- Project timelines
- Contractual terms and conditions
- Performance bonding requirements
- Technical specifications for material and labor procurement

Optimize your processes and know your assets

Proper planning, research, and coordination are key to a successful RFP

- Understand your permitting process and how it impacts broadband deployment
    - Understand the patchwork of local land ownership and identify rights holders and property owners (Tribal, state, federal, railway, public and private utilities, waterways)
    - Identify and secure proper easements and rights-of-way along your path
- Conduct asset mapping exercise to identify and leverage assets that can be utilized in the development of the network route
- Develop a preliminary system-level design to assist in all phases of procurement
- Secure or identify pole attachment agreements, requirements, and cost for poles owned by other parties
- Identify opportunities for economic and workforce development that may multiply the benefits of broadband deployment

Engage potential partners

Including these partners and participants in the planning process can help prepare you for grant applications and broadband deployment:

- **County and municipal government**
  - Planning and public works
  - County administrative offices
  - Information technology
  - Finance
  - Public safety
- **Broadband community task force**
- **Internet service provider partners**
- **Power utility**
- **Regional planning groups**
  - Chambers of commerce
  - Economic development
  - Transportation
  - Council of government/association of governments
- **Tribal Nations**
- **Quasi-governmental**
  - School districts, library, utility districts

RFP Development: Scope of Work

The scope of work (SOW) explains to the applicant the criteria for completing the project

The SOW will generally specify:

- Functional objectives, performance requirements, and general work guidelines
- Requirements for adherence to workmanship and professional product delivery
- Reporting requirements

Executing Procurement: Planning and Project Management Role

- Onboarded early in the planning cycle, regardless of procurement approach
- Role typically overseen by grantee/public entity, executed by contractor/consultant
- Should be independent of the other contractors
- Acts as public entity's engineering and management "right hand"
- Assists with grant application, contract management, compliance review, field verification
- Activities continue through construction and quality assurance
- Develop scope and assist in preparing and evaluating bids for design and construction RFP(s)

Selecting Construction Contractors: Essential Qualification Criteria

- **Experience with project tasks of same type and similar scope**
  - Crew sizes, ability to mobilize subcontractors, expertise in managing project plan
- **Familiarity with locality or region**
  - Local contractors have knowledge of terrain, regulations, and building codes, and they have experience interacting with relevant jurisdictions (permit approvals, change orders)
- **Performance track record**
  - Adherence to time schedule, budget, quality of workmanship
- **Accident history**
  - Accidents may be indicators of poor work procedure and safety standards
  - Accidents cost time and money
- **References**

*** Important: *Limit contract term with option to extend***

Procurement Strategies

The approach to procurement will depend on project considerations such as grant funding timelines and material lead times

Two common methods are:

Design-Build

Single firm is contracted for both design and construction

Pros and cons

Pros

- Quicker start; the project can begin before all designs are complete
- Single contractor to coordinate project details

Cons

- May require additional oversight to ensure that both the design and construction are properly installed

Design-Bid-Build

Designer and builder are contracted separately

Pros and cons

Pros

- Contracting separate entities allows for a more specialized approach for each responsibility
- Project is bid after the design is finalized, which could yield more accurate cost estimation

Cons

- Slower start; builder cannot be selected until full design is completed and request for bid (RFB) released
- Possibility of change orders that arise from the design
- Multiple contractors to coordinate project details

Appendix A: Definitions

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A-C

Always on – a continuous internet connection that is delivered by an internet service provider; this type of connection has been the norm since the early 2000s, but it was preceded by a dial-up connection that required calling the internet service provider using a telephone modem

Backbone – a network of high-capacity fiber connections between exchange points and hubs, typically covering a large geographic area

Backhaul – a high-capacity connection between a communications network's central backbone and local network nodes; one common example is the connection from a cellular tower to network backbone

Bandwidth – the maximum amount of digital data that can be sent over a wired or wireless network in a period of time, often measured in terms of "megabits per second" or "Mbps"; also describes the frequency width of a channel on a wireless network or wired network, in which case it would be measured in "megahertz" or "MHz"

Bit – the smallest unit of data transferred over a network, typically referenced in binary computer code as "1" or "0"; data transfer speed measurements are given in "bits per second" (bps), "megabits per second" (Mbps), or "gigabits per second" (Gbps)

Broadband – high-speed internet access that is always on and is faster than dial-up access; the definition is always evolving: in 2024, the Federal Communications Commission (FCC) updated the legal definition of broadband to refer to services providing at least 100 Mbps download and 20 Mbps upload, also referred to as "100/20 Mbps" service. (In 2015, the FCC set its definition at 25/3 Mbps)

Byte – a unit of data consisting of 8 bits; bytes, megabytes (MB), or gigabytes (GB) are units used to measure the size of a data file or the amount of storage available on a computer device

Churn – the rate at which customers cancel or do not renew a subscription over a given period of time

Coaxial – a type of insulated cable with a copper core and copper or aluminum outer conductor; primarily used by cable TV companies to transport both TV and data signals

Competitive local exchange carrier (CLEC) – a telecommunications service provider that competes with the incumbent local exchange carrier through a local network interconnection and providing its own equipment

Conduit – a pipe, duct, or tubing that houses fiber optic or other cables, usually buried underground

Customer premises equipment (CPE) – electronic equipment installed at a subscriber's home or business

D-E

Dark fiber – fiber optic strands that are not “lit” by network electronics, often used as spare capacity or leased to customers.

Dark fiber lease – a contract to lease dark fiber, typically for a few years or less (a shorter term than that in an IRU agreement), paid on a month-to-month or annual basis. Leased dark fiber does not connect to the ISP’s electronics, allowing the customer to make all electronics and network choices.

Dial-up – internet access using a standard copper telephone line and modem at slow data transfer rates; the user’s modem dials an internet service provider over the telephone line—and while the dial-up connection is engaged, the telephone line cannot be used for voice

Digital subscriber line (DSL) – internet access using a standard copper telephone line and special electronic equipment to transfer data; in contrast to dial-up, DSL is always on and uses higher frequencies (so the line can be used for voice and data at the same time)

Distribution fiber – fiber optics in a fiber-to-the-premises network that connects the hub sites to neighborhood fiber distribution cabinets

DOCSIS – a communications network standard (Data Over Cable Service Interface Specification) that enables a cable modem to deliver high-speed data over coaxial cable networks; the standard enables the same technology to be used nationally and internationally and makes cable data networks interoperable

Download – the speed at which an internet service provider can deliver data from the internet to a user’s computer; measured in Mbps or Gbps; a network’s download speed generally is faster than its upload speed

Drop – the connection from the right-of-way to the customer’s premises

Enterprise service – high-speed broadband connections to mid-size and large companies and institutions, sufficient to perform large data transfers and provide enhanced security, may include a service level agreement where the ISP pays the customer a penalty for failures

Exchange point – a meeting point for internet service providers to interconnect and exchange traffic, often in larger cities or at universities

F-G

Facilities-based – service providers that own the physical infrastructure (wired or wireless) used to transmit data and make broadband connections between the network and the end user location; this is in contrast to a provider that does not own wires or spectrum and instead leases capacity on another network

Fiber optic – hair-thin glass strands that can be used for the transmission of light signals over fiber strands. Fiber can transmit data at high speeds; a single cable may contain hundreds of fiber strands

Fiber-to-the-premises (FTTP) – a network architecture in which fiber optics provide broadband services all the way to each subscriber's premises

Fixed wireless – a type of communications service that uses radio signals to connect fixed locations (such as homes and businesses) to the internet

Geographic Information System (GIS) – computer-based geographic information service that analyzes and displays datasets via mapping and other forms of visual presentations, and is a central tool in planning, designing, and operating networks

Geostationary Earth Orbit (GEO) – a type of satellite that appears to be fixed in the sky as it orbits at 22,369 miles above the Earth in synchronization with the Earth's rotation; GEO satellites transmit signals to a satellite dish at a customer premises to provide internet access

Gigabit passive optical network (GPON) – a commonly used passive optical network architecture using gigabit-capable passive electronics at hubs and customer locations to split the optical signal for end-user connectivity

Gigabit per second (Gbps) – a measure of network speed equivalent to 1,000 Mbps

H-I

Hub – a facility that houses the core electronics of a network and typically interconnects last-mile and middle-mile networks

Hybrid fiber/coaxial (HFC) – a network architecture used by cable TV operators to deliver data (internet access) to end users; HFC includes both fiber optic and coaxial cables

Incumbent local exchange carrier (ILEC) – i.e., "the phone company," a company that was offering local telephone service in an area prior to the introduction of competitive local exchange carriers in 1996; an ILEC typically offers telephone (voice, long-distance) and internet services

Indefeasible right of use (IRU) – an agreement, typically covering 10 to 20 years, under which the customer has the right to use dark fiber strands on a network. Unlike a lease, an IRU is a one-time payment classified as a capital expense

Infrastructure – the wireline and wireless equipment and facilities used to provide broadband service, including fiber, coaxial, and copper cable, as well as conduit, poles, towers, antennas, routers, and a network's electronic equipment

Interconnection – a connection between two or more networks used to exchange data for transport to an end user; interconnection can be a physical connection or performed through software

Internet – the global interconnected network of computers that users access when they type a web address into a browser application on their computer or smartphone

I-L

Internet protocol (IP) – a set of standard rules and addressing formats that computer networks use to exchange data on the internet

Internet service provider (ISP) – a company or nonprofit entity that provides services enabling customers to connect to the internet

Jitter – variances in the delay or lag of the arrival of each packet of data to a user's computer which could cause poor service quality

Last-mile – network infrastructure used by ISPs to connect directly to business or residential end users using fiber, cable, wireless, or a combination of these technologies

Latency – a measure of the time it takes signals or packets of data to reach a user over a link, such as from a data center to a user device; very long latency, such as over 0.1 seconds, can result in noticeable problems such as poor quality in voice or video calls or streaming

Local exchange carrier (LEC) – a telephone company that provides voice and/or broadband service to a local or regional area

Long-haul – high-capacity network infrastructure interconnecting national and regional exchange points, typically over distances of hundreds of miles or more

Low Earth orbit (LEO) – communications satellites that circle Earth from approximately 300 miles to 1,500 miles above the Earth's surface; these satellites orbit the Earth at a relatively low altitude and provide faster and more reliable connectivity than high-altitude geostationary satellites, because they connect to fewer devices (due to a smaller footprint) and because the shorter distance delivers lower latency connections

M-O

Make-ready – preparing existing utility pole for additional communications cable attachments, which may entail moving existing cables or replacing the pole

Megabits per second (Mbps) – a measure of network speed equivalent to 1,000 bits per second

Middle-mile – high-capacity network infrastructure interconnecting wireline and wireless local (last-mile) internet service providers with national and regional networks including hubs, exchange points, data centers, and long-haul carriers

Mobile virtual network operator (MVNO) – a reseller of wireless communications services that leases wireless capacity and spectrum offered by facilities-based wireless providers to offer service to end users under a different brand; some MVNOs are corporate affiliates of facilities-based wireless providers, some are cable operators bundling mobile services with their other services

Multi-dwelling unit (MDU) – a building with multiple residences, such as an apartment building

Multiple-tenant unit (MTU) — a term that encompasses MDUs as well as office buildings that contain multiple tenants

Open-access – physical networks that offer the same terms of infrastructure use to any internet service provider

Operational support systems (OSS) – computer systems used by facilities-based wireline and wireless service providers to monitor and control their networks

Outside plant (OSP) – the physical portion of a network (also called “layer 1”) that is constructed on utility poles (aerial) or in conduit (underground) or in a wireless network includes the antennas and transmission of signals over the air

Overbuild – constructing communications infrastructure in a geographic area that already has similar infrastructure; often refers to an internet service provider that builds a new fiber optic network with the intent to compete with an existing internet service provider

Over-the-top (OTT) – content and services that are delivered over a data connection owned by a different entity; voice over IP (VoIP) telephone service and video streaming services such as Hulu are examples of OTT content

P-R

Passing – a potential customer location (e.g., a house) that is near enough to a broadband network's infrastructure (e.g., a fiber cable strung on a utility pole near the house) that the customer can be connected and receive service in a reasonable amount of time (days, not weeks)

Passive optical network (PON) – a last-mile fiber optic architecture connecting an internet service provider's network equipment to an end-user's premises without any active electronic components in outdoor cabinets or vaults between the network equipment and the user

Plain old telephone service (POTS) – the type of voice-only service delivered to a landline analog telephone over a copper wire

Public switched telephone network (PSTN) – the telephone networks that connect landline phones

Pull box – a small vault that is installed underground at regular distances along a network's conduit pathway to enable internet service providers to install and maintain underground fiber optic cables

Quality of service (QoS) – the performance of a network as measured by certain criteria; also used to refer to an operator's efforts to control network traffic and prioritize transmission of critical data (sometimes as part of a contractual guarantee offered to an enterprise or premium customer)

Right-of-way (ROW) – land that typically abuts public roadways and is reserved for the public good; sidewalks and utility poles typically are in the right-of-way

S-Z

Satellite internet – a type of internet access delivered to a customer's satellite dish from satellites orbiting the Earth; satellites can be either low Earth orbit or geostationary

Spectrum – the range of radio frequencies assigned to various types of wireless services; spectrum is limited and is regulated by federal agencies that coordinate public and private uses

Take-rate – the percentage of potential subscribers that are passed by a network and that subscribe to the internet service provider's service

Upload – the speed at which an internet service provider can deliver information from a user's device to the internet; a network's upload speed is often slower than its download speed

Vault – an enclosure installed in the ground or at ground level (as a "pedestal") to protect fiber optic cable splice points and other communications equipment; vaults can be opened for fiber maintenance or to install service

Voice over internet protocol (VoIP) – a digital voice telephone service using packet data standards to make the voice connection between users; it differs from plain old telephone service by using the same electronics and physical medium as internet data services

Wi-Fi – a common wireless networking technology by which users can connect their devices over short distances to an internet service provider's electronic equipment (i.e., a router), either at home, in an office, or in a public place over unlicensed spectrum available to any user

Wireline – a network that relies on fiber optic, copper, or coaxial cable or wires, as opposed to wireless technology