Network Evaluation

City of Shafter
336 Pacific Ave.
Shafter, CA 93263

GOVERNMENT
TECHNOLOGY GROUP, LLC

2930 Geer Rd
Suite 273
Turlock, CA 95382
(209) 678-3077
Projects@GovTechGroup.net

2925.428.2847 ♦ preston@govtechgroup.net

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2925.428.2847 ♦ preston@govtechgroup.net

Network Evaluation Overview

The City of Shafter is desirous to find a private company partner to help build out a fiber-to-the-home, FTTH, utilizing the city's extensive existing infrastructure. For this to become a reality and find a quality partnership, maximizing the city assets to leverage in the partnership becomes an important task. To find a private sector partner, the City needs to issue an RFP, request for proposal, with information to entice respondents to create the best possible partnership while protecting the cities interests and capital investments made by the city.

The City of Shafter partnered with Government Technology Group, GTG to provide an evaluation of the existing fiber optic network including outside plant and inside plant. A thorough evaluation creates a better network and partnership. The goal of the evaluation is to provide the most accurate depiction of the current state of the network, any issues that need to be addressed, and how the network will perform in the future.

The City of Shafter has an existing network that is capable of meeting current and future needs. The network has vast amounts of conduit and fiber that can be used to further broadband in Shafter and Shafter's infrastructure and vaults are very high quality, properly placed, with plenty of space for future cables and splicing needs. The vaults have been well placed, are clean and include gravel. The amount of conduit available was planned and constructed with future expansion in mind. The splicing is expertly done, and the traces and splicing records are accurate. The only reason to supplement the network would be to add fiber strands and further capacity for the future, with the current splice cases being built and sealed correctly.

The facilities have all been expertly constructed, and have all amenities needed for a fiber-to-the-home (FTTH) network including power, dual AC, rack space, adequate parking, and easy access from the street. The locations are spread out and the central office is just off the highway with access to long-haul fiber and the future California Middle-Mile Broadband Initiative. The central office could be offered to the Middle-Mile Initiative as a "meet-me" room and colocation space for the California Middle-Mile Broadband Initiative.

Inside Plant

General Overview

In the Telecom world, the term "inside plant" refers to all the cabling and equipment installed in the Telecommunication facility. For purposes of this evaluation GTG inspected inside plant elements at 4 locations including:

- Overhead Cable Trays
- Fiber Management Trays
- Battery and Data Racks/Cabinets
- Main Power Distribution Panels/Main Distribution Frame (MDF)
- ATS Panel
- Rack Mount DC Power Plant
- Telemetry panels and wiring
- Rack Mounted Fuse Panels
- Rack Mount fiber distribution panels (FDP)
- Electrical cabling and terminations for A/C, D/C connections

Facilities

Figure 1. Facility Location Map

Lerdo Central Office – 5821 E. Lerdo Hwy

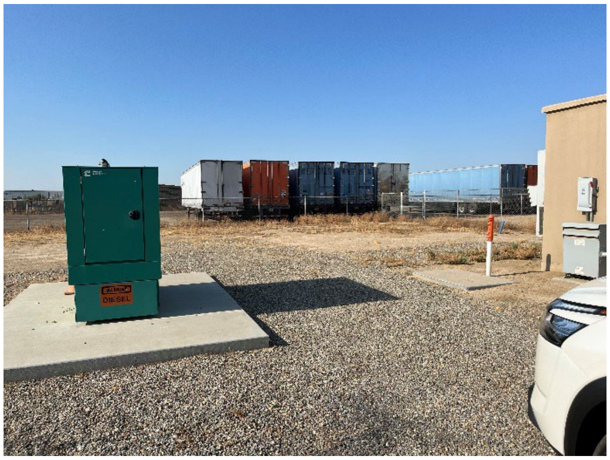
This is the primary point of presence for the network and is intended to house the transport and other "headend" equipment. The location is planned out nicely for future connection with other networks. The California Middle-Mile Broadband Initiative will be built along highway 99 and the proximity is ideal for connecting to the state network. An additional benefit of the proximity to the California network allows the city to offer this location aa meet me room to be included as part of the state-wide network.

Exterior

- Located in a fenced, locked field.
- Outside is free of garbage and debris and has been maintained.
- The building is a very sturdy precast structure with dual entrances with alarmed HID (card access).
- There is backup generator power with an ATS, automatic transfer switch, inside the facility.
  - Generator looks in excellent condition, needs to be tested to verify.

Figure 2. Exterior Headend Doors

Figure 3. Headend Backup Generator



Interior

The interior of the facility is very clean and orderly. This is a top-notch central office environment with all the amenities that would be expected of a headend/central office including:

- Good Lighting
- Clean
- Fenced secure location
- Alarmed
- Separated into two areas with a cage.

Inside the cage there are two racks one that houses the city owned and operated equipment including Juniper QFX5120 switches that operate the City's Municipal Network and the HP Nimble Storage Area Network (SAN). There are Juniper MX80's used for emergency spares. The other rack is open for use by a provider in partnership with the city for fiber and broadband purposes. Also inside the caged area is a Cummings Powercommand Automatic Transfer Switch, ATS, that will instantly switch power from service power to battery backup to generator power when generator is running and producing sufficient power. Once service power is restored the ATS reverts power from the generator back to service power.

The Alpha and Ciena power equipment, and everything outside the cage, is not property of the city and although using the city network is not a part of the city network.

The racks outside the cage are in use by third parties and are not property of the city.

Figure 5. Lerdo In-Cage Racks

Figure 4. Lerdo outside the cage racks

Figure 6. Cage

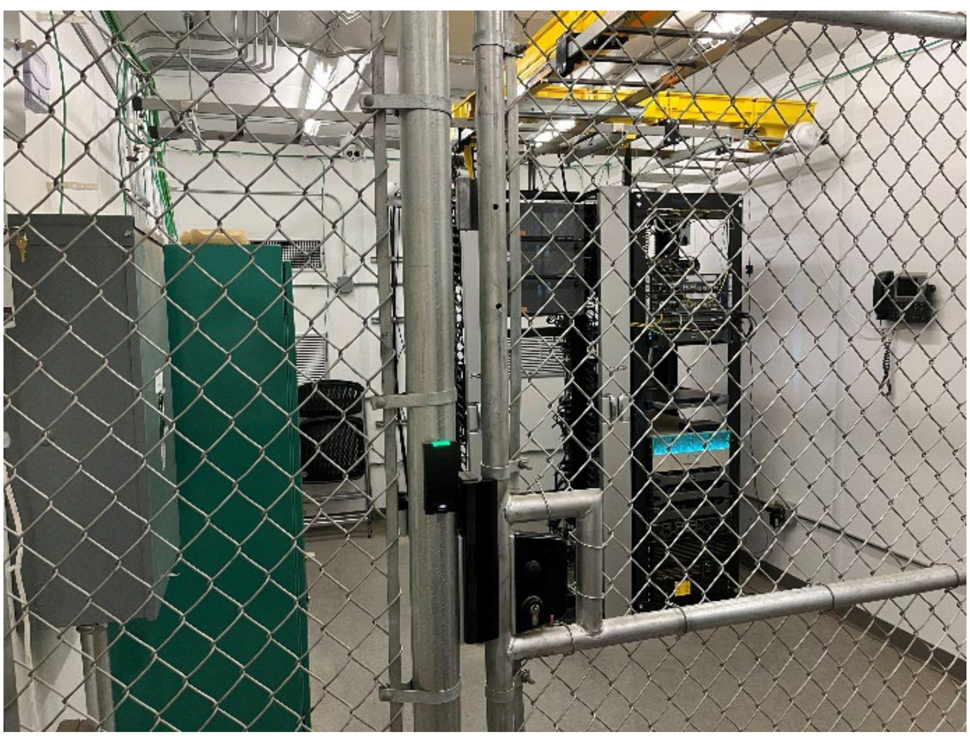


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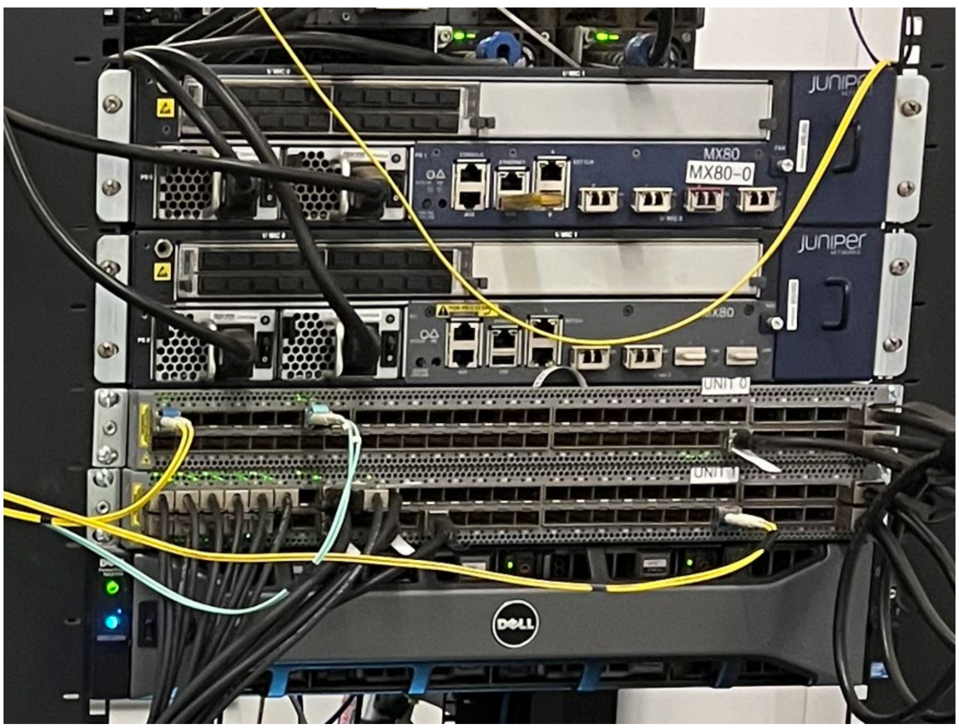
Figure 7. Automatic Transfer Switch

Figure 8. Headend Juniper Equipment



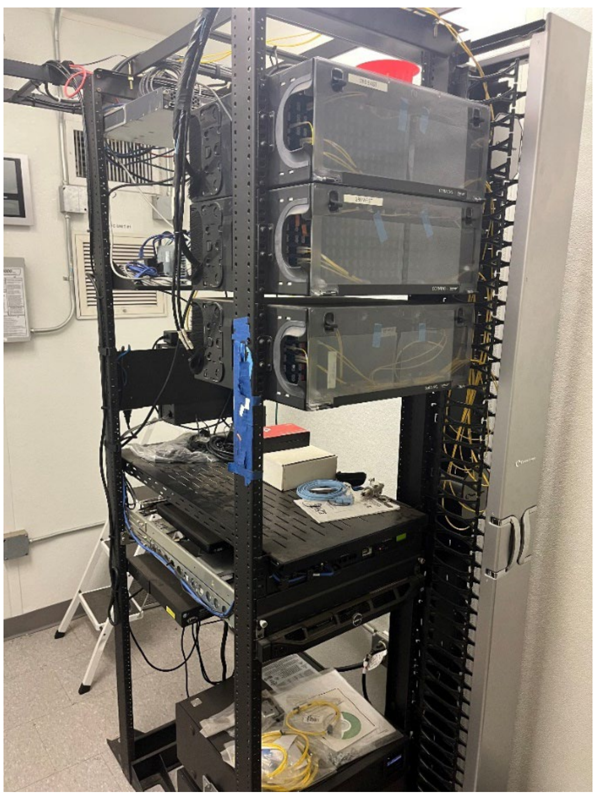
Fanucchi Communications Tower – 4451 Fanucchi Way

The site is located on a secure fenced-in City of Shafter property adjacent to a city owned tower being leased by Verizon. Verizon has a separate building and does not use, house, or maintain the city building at this location.

It is also in a good position on the network adding equipment space with room for growth. The communications building has minimal open rack space, but the site has adjacent ground space available if additional building space or infrastructure is needed.

Figure 9. Tower Location

Figure 10. Tower Rack



Veterans Park – 500 W. Los Angeles Ave

This site is located at the east end of a multi-room structure. The room housing the fiber is very large with ample space for any future needs. There is plenty of RU space in the existing rack for patch panels or

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equipment. This is one of 4 sites that are equally spaced around the network and would be an excellent location for different types of network architecture and deployment strategies.

There is a 96 FOC terminated into a Corning patch panel and there is no other equipment installed here. There is power in the room and easily accessible for equipment if needed. There is no BUSS system or traditional -48V power system installed but has plenty of space and power to tie into if needed. There is a dual 120VAC/20Amp outlet on the wall behind the rack that is a dedicated circuit for use in the rack.

It could be used in its current state, for a passive distribution network or upgraded with all necessary items to make it a full network and transport hub for redundancy.

There is ample space, as seen in figure below, for all upgrades necessary to have this location serve as a major hub, secondary headend, or distribution network. Veterans Park is centrally located in the downtown area and could serve as a HUB location for a PON or Active E network.

Figure 11. Veterans Fiber Room Location

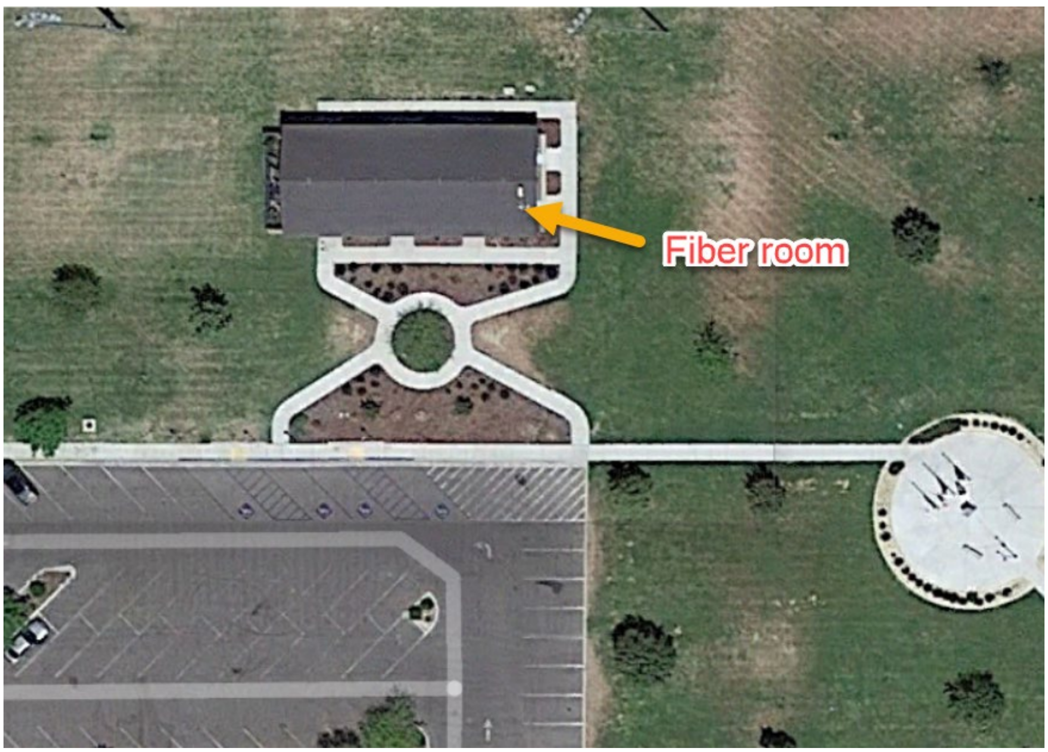
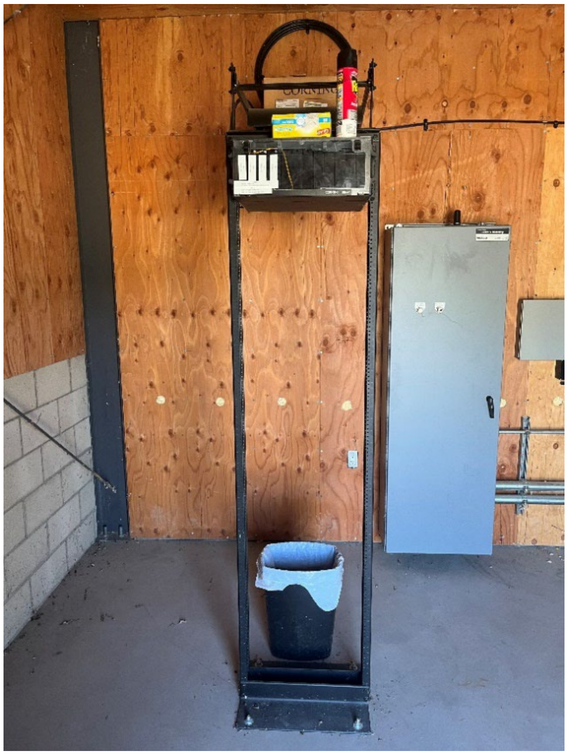


Figure 12. Veterans Rack



Gossamer Grove Fiber Node – 3851 Gossamer Grove Blvd is a two-cabinet powered fiber node with battery backup only. There are two cabinets both are climate controlled. It is fenced with padlocks on the exterior gates as well as padlocks on the cabinet doors. The gate and cabinet doors are keyed differently. The cabinet is setback approximately 30 feet from the edge of road with no path leading to it. Construction of more residential units is going on around the cabinet which add to the difficulty in accessing the cabinets. Once the construction is nearing completion there will be roads and paths to access the location.

Figure 13. Gossamer Hub Location

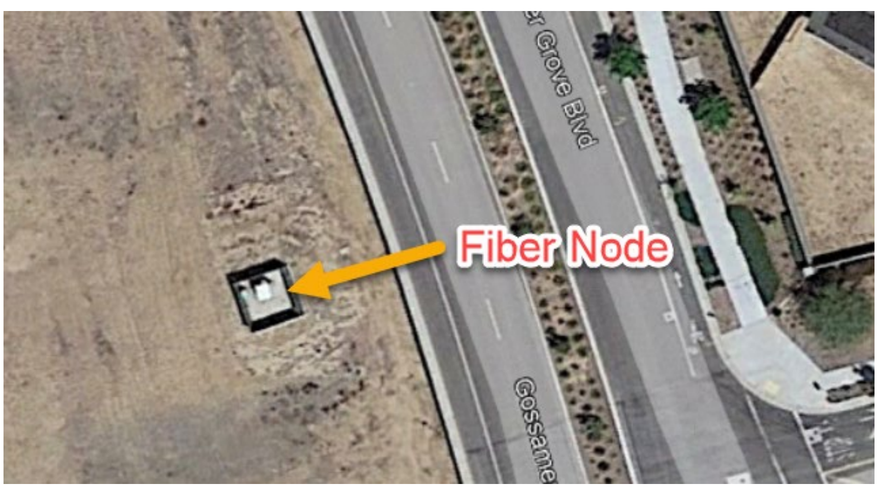


Figure 14. Gossamer Hub Exterior

Figure 15. Gossamer Racks

As you can see from the above image there is space for more patch panels and equipment when needed to serve the entire 1200 home development. There is plenty of conduits for additional cables to be added. Future growth will be easy with the addition space around the structure.

There is an existing Calix E7 and Trimm Power fuse panel.

Figure 16. Gossamer PON Equipment

Outside Plant

General Overview

The first step in evaluating the outside plant is to refer to documentation in any form; Geospatial, PDF, handwritten, etc. Shafter has great record of fiber optic conduit placement, as well as GIS formatted cables. Everything reviewed and inspected in the field came from the GIS information and was accurate with a few minor corrections. The inaccuracies were limited to the location of several handholes/vaults and conduit availability. Also there are more conduits in the field between handholes than are reported in the GIS. More conduit is always a good thing and should be reconciled and accurately documented later. That said, the fact that there is more conduit is a very attractive asset to possible partners.

Handholes/Vaults

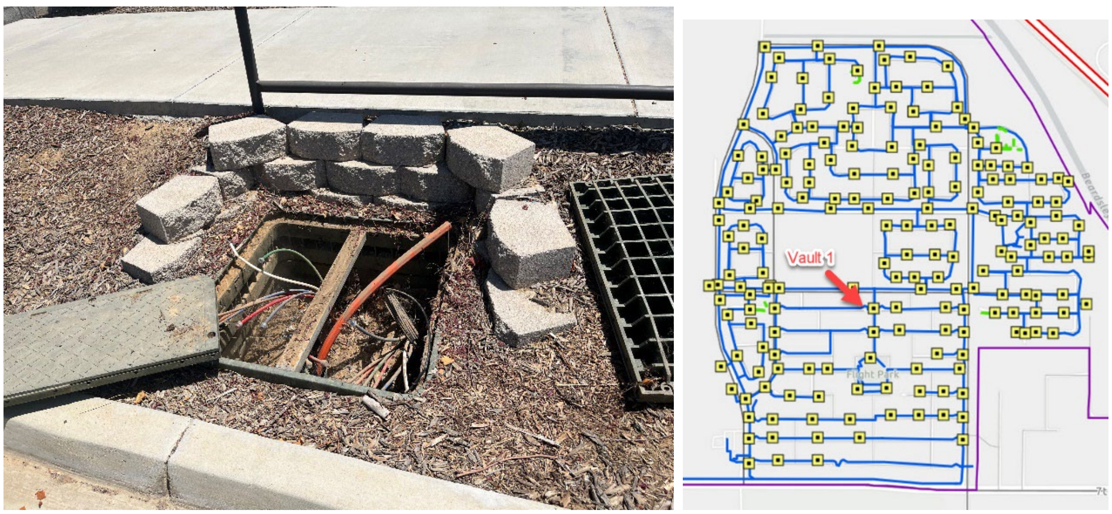
Vaults allow for personnel to enter the structure and handholes do not. Although slightly different, for the purpose of this report they will be synonymous and interchangeable. During the evaluation process, 110 vaults, roughly 20%, were inspected. Below are the general findings. (See appendix B for pictures.)

- Vaults were assembled properly.
- Vaults were placed properly.
- All vaults had gravel in the bottom with proper drainage.
- Vaults were level with the ground.
- Vaults properly sized to accommodate fiber cable bend radius requirements.

- Splice cases fit properly.

In every network there are issues with the placement, sizing, and construction of vaults that need to be addressed. In some cases, the defects in the vaults are caused by outside forces such as cars or trucks that have driven over the vaults creating issues such as lids cracking, overly compacted dirt, or other minor issues. We found one vault that was not constructed properly and in need of repair. The sides of that vault are pushed in not allowing the stress bar across the top to seat in the groves properly. The vault needs to be dug up, have a stress bar installed properly, and the lids put in place then backfill and pack dirt around the vault to the required compaction.

Figure 17. Improperly placed/vault 1

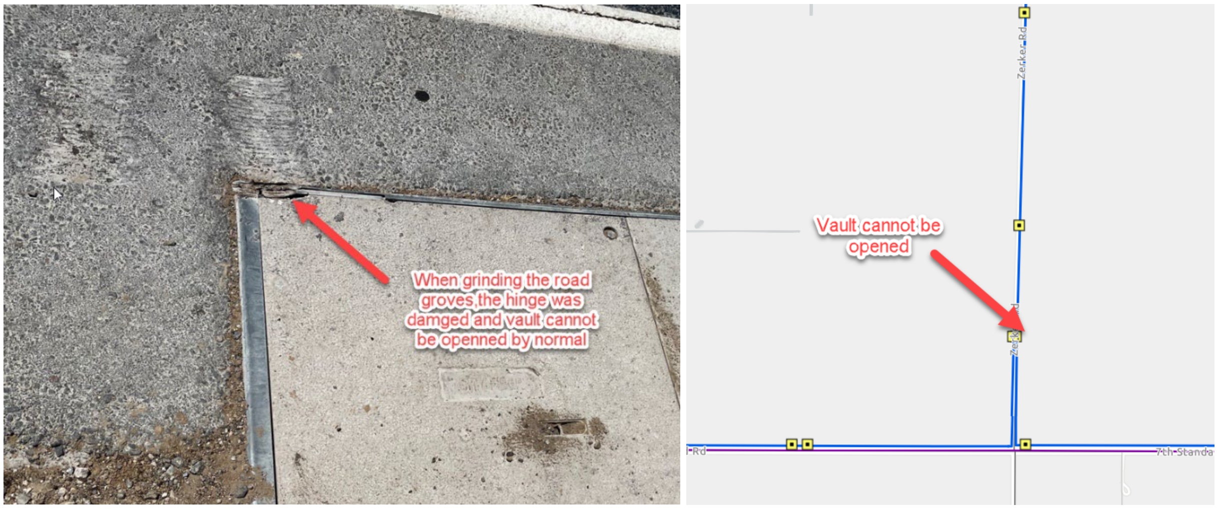


One vault lid was cracked and needed replacement with a traffic rated vault. Although this vault is in the right-of-way 15' from the edge of road, semi-trucks cut the corner and run the lid over and are causing the lid to crack and eventually fail. A traffic rated vault with a non-spring-loaded lid needs to be installed, one that can handle the semi-truck traffic. That or another solution to prevent vehicles from cutting the corner would solve the issue.

Figure 18. Cracked Vault Lid

The vault pictured below cannot be opened due to the hinges being ground down when the road grooves were done. This vault should be opened and hinge repaired.

Figure 19. Vault Issue



Fiber Cables

The cables that were inspected included micro cable and regular fiber optic cables. All cables are di-electric, with no metal armor, and placed properly. There were no cables found that were kinked or showed any other type of damage and all cables had the proper bend radiuses. Unfortunately, the cables did not have readable footage marks making it impossible to determine length of cables. All sizing matched the GIS information.

Splicing

The splicing we inspected was well done and the splice cases were built properly and had the necessary pieces to close properly, namely the O-ring to keep the dirt and water out of the case. All cases were sealed prior to opening. The fibers inside the case trayed properly with no macro bends or other issues. The heat shrinks were in the correct placement. The only issue I found was the counts of the fibers and the fibers spliced should be written on the clear lids covering the fibers. The image on the right has the counts written on the splice tray like it should be. It is recommended that as new cables and splices are being completed, that it is made a requirement that the fibers being spliced are documented on in GIS and also written inside the splice case.

The larger splice points were inspected, the below right image is the splice point at the NE corner of James and Sunset. This splice case and vault were built well with the cables routed and coiled in the vault like they should have been.

In general, all the splicing that was inspected was found to be high quality and with great attention to detail.

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Figure 21. Splicing Tray

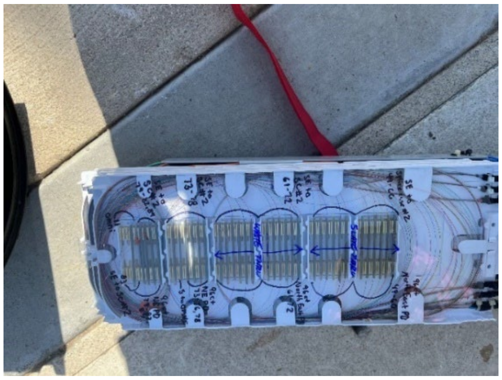

Figure 22. Splicing Tray 2

Figure 20. Splice Case in Vault

Conduits

Conduits are the lifeblood of any network, especially when they are empty and ready for use. The conduits in the Shafter network are plentiful, no run was found that didn't have an extra conduit that could be used to place more fiber in the future when needed. Most conduit was 2' HDPE, high density polyethylene. All conduits on the same paths were of varying colors to keep them easily identifiable at any vault. The vast majority of the empty conduits were capped, or foam filled to keep debris out.

Figure 23. Conduits

Network Worth

Assigning value to fiber network relies on many variables including cost of engineering, permitting and construction as well as quality. The most important factors in providing a valuation is the potential revenue streams and potential partnership desirability.

Existing fiber optic cables and conduit costs are estimated to be around $23.03 million including handholes, vaults, splice cases, and other associated outside plant infrastructure. The estimation is based on current outside plant construction and material pricing.

Existing Fiber Optic Cables

Location	Miles	Footage	Avail Strands	Total Strands	Material $	Labor $	Total $
Downtown Corridor	1.9	10,032	36	96	$1.50	$3.00	$45,144.00
North Mannel Ave Schools	1.1	5,808	8	24	$1.25	$3.00	$21,780.00
Statewide Long-haul Interconnect	1.8	9,504	18	48	$1.35	$3.00	$38,491.20
Backbone Ring	20.3	107,184	192	288	$3.00	$3.00	$964,656.00
Industrial Park Ring	4.3	22,704	18	48	$1.35	$3.00	$91,951.20
Southeast Residential Development	2.5	13,200	18	48	$1.35	$3.00	$53,460.00
Core Southwest to School/Park	1.5	7,920	48	96	$1.50	$3.00	$35,640.00
							$1,251,122.40

Existing Conduit

Location	Miles	Footage	# of Conduits	Size	Material $	Labor $	Total $
Downtown Corridor Extension	1.9	10,020	1 - <2	2	$1.50	$75.00	$1,127,250.00
North Mannel Ave Schools	1.1	5,560			$1.50	$75.00	$625,500.00
Backbone Ring	20.2	106,900	1 - <2	2	$1.50	$75.00	$12,026,250.00
Statewide Long-haul Interconnect	1.8	9,682	1 - <2	2	$1.50	$75.00	$1,089,225.00
Industrial Park Streets	4.3	22,757	1 - <2	2	$1.50	$75.00	$2,560,162.50
Southeast Residential Development	2.5	13,140	2	2	$1.50	$75.00	$1,478,250.00
Core Southwest to School/Park	1.5	7,785	2	2	$1.50	$75.00	$875,812.50
							$19,782,450.00

Facility value is based on current approximate construction costs for those facilities with the appropriate security and amenities found at those facilities. Headend is top-notch and could be constructed for $1.75 - $2.00 million. The tower location has a stand-alone prefabricated building ($30k-$40k) including the security and excellent building could be build any from $100k-$150k. Veterans park is really just the building and one rack. Gossamer Hub is an excellent facility with double powered cabinets, $45k each, add in power and batteries, with the Calix E7 totals $150k-$200k.

Facility Value

Location	Low end	High end
Headend	$1,750,000.00	$2,000,000.00
Tower	$100,000.00	$150,000.00
Veterans Park	$50,000.00	$75,000.00
Gossamer HUB	$150,000.00	$200,000.00
Total	**$2,050,000.00**	**$2,425,000.00**

The current network Valuation for the City of Shafter network is estimated to be around $23.458 million. This does not include the potential revenue sources working with a partner. The potential revenue sources working with a partner can be subjective and dependent upon the negotiated partnership. The partnership should take into account the cost of construction to finish the buildout of the network as well as maintenance costs and customer installation costs.

Existing Network Valuation

Fiber Optic Cables	$1,251,122.40
Conduits	$19,782,450.00
Facilities	$2,425,000.00
Total	**$23,458,572.40**

Revenue from fiber networks comes from many different sources each offering different strengths and weaknesses. Data centers are colocation spaces that offer cross connect services between different providers. Other services include peering and if available internet and point to point connections. Offering data center or colocation space one way to bring in revenue, the problem in Shafter is that is geographically isolated and would struggle to find occupants. This scenario might change with the California Middle-Mile Broadband Initiative by becoming a data center/colocation space on that network.

Another revenue source is leasing fiber strands to private ISPs for their use as part of their networks. This is a good model if there is a high number of ISPs and the new construction costs are cost prohibitive for the ISPs to build. This is not an ideal strategy for Shafter with the relatively low number of potential customers.

The last revenue source is finding a partner to use the city network and either the partner or the city augmenting the network to complete a FTTH, fiber-to -the-home, network and offer services to all residences and businesses in the City of Shafter. The Tables below show the realistic residential and business revenue potential on an annual basis.

There is no one scenario that fits all partnership models and all aspects of the partnership need to be evaluated for the best possible outcomes for both parties. The typical starting point in partnership negotiations is the model where the city allow the use of the City owned network to the partner and either the city, the partner, or both build the remaining needed portion of the network, the partner runs, maintains, and supports the services on the network.

Potential - Residential

# of	Take Rate	Subs	Monthly $	Annual Rev	City Rev Share %	Partner Rev Share %	City Annual Revenue	Partner Annual Revenue
5,000	25%	1250	$50.00	$750,000.00	25%	75%	$187,500.00	$562,500.00
9,000.00	25%	2250	$50.00	$1,350,000.00	25%	75%	$337,500.00	$1,012,500.00

Potential - Business (Census 2021)

# of	Take Rate	Subs	Monthly $	Annual Rev	City Rev Share %	Partner Rev Share %	City Annual Revenue	Partner Annual Revenue
316	25%	79	$ 200.00	$ 189,600.00	25%	75%	$ 47,400.00	$ 142,200.00

Summary

All fiber optic networks require secure building locations, redundancy, vaults of correct size, vault locations with good construction, access to the internet, and all equipment necessary to operate the network. Shafter has 4 secure building locations that are in prime locations for a properly operated network. The locations have excellent spacing to provide redundancy and multiple equipment locations. The headend is top-notch and will not require upgrades to be a fully functional headend. The other three locations could use simple upgrades, depending on the desired use, including power systems, battery backup, and additional racks.

The outside plant infrastructure has been engineered and constructed as good as any fiber network in existence from the vault size and location, fiber optic cables used, and vast amount of extra spare conduit that is ready for use. Vaults have been engineered to the best standards including the proximity to streets, accessibility, sizes are large and will accommodate future cables and splice cases as needed. There are a few issues that need addressing, none of which are network impacting and can be done in time.

Splicing is of high-standards and the splice cases have been built properly with future access available. The strands of fiber inside the cases have been coiled and trayed properly and pose no issue to the network with any current work or future cables being added.

The city of Shafter has a top-notch network that was built with the future in mind. The network can be used by the city or partner without worry of the network being insufficient or inadequate in any way.

Appendix A – Glossary of Terms

Band
A range of optical spectrum allocated based on optical amplifiers. Six bands are specified: O (original), E (enhanced), S (short), C (conventional), L (long), and U (ultra). These cover the optical spectrum from 1260 nm to 1675 nm.

Bandwidth
The difference between the highest and the lowest frequencies of a transmission channel or path. Identifies the amount of data that can be sent through a given channel. The greater the bandwidth, the greater the information-carrying capacity.

CLEC
A company that provides alternative services to customers that were historically served by local telephone companies. These services are normally data and video transport that the existing telephone network cannot handle.

Coarse wavelength division multiplexing (CWDM)
Applies to greater separation of wavelengths than DWDM. In the case of single-mode applications CWDM defines 20-nm separation from 1270nm to 1610nm, with 1470nm to 1610nm the most commonly used wavelengths. With multimode fibers, the wavelengths are 778, 800, 825 and 850 nm.

Data Rate
The number of bits of information in a transmission system. Expressed in bits per second and which may or may not be equal to the signal rate.

dB/km
A logarithmic unit describing the ratio of loss of power per kilometer distance.

dBm
Decibels relative to one milliwatt. A positive number indicates the power is above one milliwatt; a negative number indicates the power is below. This unit has become common in fiber-optic communication systems because the power of light sources used with optical fibers is on the order of one milliwatt.

Dense wavelength division multiplexing (DWDM)
Combining four or more wavelengths into an optical window (e.g., 1550 nm). DWDM devices have a channel spacing less than or equal to 1000 GHz and can cover one or more spectral bands.

Ethernet
A data communications protocol originally developed for premises and local access networks (IEEE 802.3) operating at speeds from 10 Mbps to 10 Gbps. It was originally developed for peer-to-peer communications using shared media over relatively short distances. Ethernet features variable length packets that allow data to be sent with less overhead.

Fiber
A single optical transmission element characterized by a core, a cladding, and a coating.

Fiber-optics
Light transmission through optical fibers for communications purposes.

Fiber to the home (FTTH)
The distribution of communications services by providing fiber-optic links all the way to each house.

Gigabit (Gb)
One billion bits.

Gigahertz (GHz)
A unit of frequency equal to one billion Hertz.

Handholes
are confined spaces allowing access to underground infrastructure where a person can reach in only.

Jitter
Small and rapid variations of timing of a waveform due to noise, changes in component characteristics, supply voltages, imperfect synchronizing circuits, ets.

Laser
Light Amplification by Stimulated Emission of Radiation; a coherent source of light with a narrow spectral width. DFB, Fabry-Perot and VCSEL are the three types of lasers used in fiber-optic communication systems.

Light
The region of the electromagnetic spectrum that can be perceived by human vision, designated by the visible spectrum and nominally covering the wavelength range of 400-770 nm. In optical communications, it includes the much broader portion of the electromagnetic spectrum that can be handled by the basic optical techniques used for the visible spectrum. This region is not clearly defined but may be considered to extend from the near-ultraviolet region of approximately 300 nm, through the visible region, and into the mid-infrared region to 30,000 nm.

Loss
The portion of energy applied to a system that is dissipated and performs no useful work. Also called attenuation.

Loss budget
The tolerable difference between the light impulse where it originates and the light impulse where it arrives at the receiving end. If too much light power has been lost along the way through deficiencies in the cable or connectors, the signal cannot be read and interpreted.

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Macrobending
In a fiber, all macroscopic deviations of the fibers axis from a straight line that will case light to leak out of the fiber causing signal attenuation.

Megahertz (MHz)
Unit of frequency equal to one million Hertz.

Microbending
Small imperfections in the core/cladding boundary. The larger the core, the less effect imperfections will have. Also defined as pinching effects.

Microbending loss
In an optical fiber, loss caused by sharp curvatures involving local axial displacements of a few micrometers and spatial wavelengths of a few millimeters. Such bends may result from fiber coating, cabling, packaging, installation, et cetera.

Optical line terminal (OLT)
In FTTx, the OLT is the main services interface between the customer and the service provider. Located in the central office, this equipment provides voice, video, and data downstream to the customer, while using a voice and/or data interface upstream from the customer to request services. The OLT handles downstream transmission at either/or 1490 nm and 1550 nm and upstream traffic from the ONT at 1310 nm through an optical diplexer or triplexer.

Optical loss
The amount of optical power lost as light is transmitted through fiber, splices, couplers, etc. Also known as attenuation; measured in dB.

Optical network terminal (ONT)
The ONT, used in FTTx applications, provides the subscriber interface (upstream requests for voice video and data) over the fiber-optic network to the optical line terminal (OLT). Conversely, the ONT distributes to the subscriber the services requested through the ONT from the service providers. The ONT demultiplexes downstream 1490nm and 1550 nm transmission while multiplexing upstream 1310 nm transmission through an optical diplexer or triplexer.

Optical transport network (OTN)
Designed for high speed services including 10 and 40 Gigabit systems including ROADM networks. Specified by the ITU-T G.709 standard.

Passive-optical network (PON)
A point-to-multipoint system, specified by the ITU and IEEE, that is made up of fiber-optic cabling, passive splitters and couplers that distribute an optical signal from the service provider to homes or buildings.

Power
The rate at which energy is absorbed, received, transmitted, transferred, et cetera, per unit time, measured in dBm or watts.

Ring Network
A network Topology in which terminals are connected in a point to point serial fashion in an unbroken circular configuration.

Vaults and Manholes are confined spaces where a person's entire body can enter as opposed to "handhole vaults" where a person can reach in only. USIC personnel are authorized to only enter telecommunications manhole vaults when a second person is onsite, but not inside the manhole vault, in a supporting safety role.

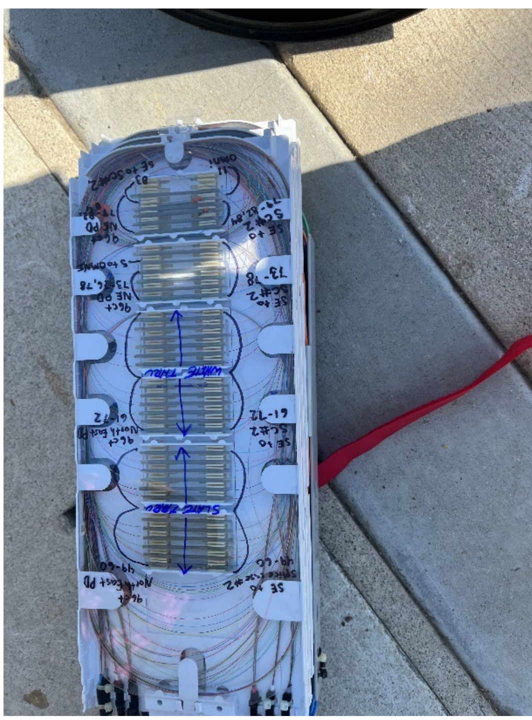
By definition, manholes and vaults are structures that are designed to allow the entry of personnel with adequate working space within a structure designed for personnel to enter.

Wavelength
The optical term for frequency. Fiber-optics generally uses the 850 nm, 1300/1310 nm, 1550 nm and 1625 nm wavelengths for transmission purpose due to the marriage of performance with light sources, optical fibers, and optical detector technologies.

Wide area network (WAN)
A telecommunications or computer network that extends over a wide geographic area (as opposed to local area networks or LANs) and allows business, education, or government users to share data regardless of their location.

Appendix B - Pictures



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