A2 Community Fiber

Cost-Benefit Analysis

Table of Contents

EXECUTIVE SUMMARY

In 2017, the City of Ann Arbor built its first fiber optic network (A2 I-NET) to connect all city locations and provide excess fiber optic capacity to the community. In recent years the city has acquired grant funding to build 2 additional fiber optic networks, one in the Downtown Development Authority (DDA) District (Technology Park) and one connecting the City of Ann Arbor and City of Ypsilanti Smart Zones (A2-Ypsilanti Broadband Fiber). The Technology Park fiber optic network is currently in the construction phase and is due to be completed in the fall of 2022, the A2-Ypsilanti Broadband Fiber network is currently in the design and planning phase and construction is due to begin in 2023.

The City of Ann Arbor has been utilizing the A2 I-NET fiber network since 2017 and has active Fiber and Conduit Use Agreements and a Conduit Lease Agreement with outside organizations to utilize excess city fiber and conduit. The city will possess ownership of all 3 fiber optic networks above and the City of Ann Arbor Information Technology (IT) department will administer, maintain, and operate the networks.

The purpose of this report is to provide a 3-year projected cost-benefit analysis, and financial and operational information to establish the best pricing model to maintain and expand, a high quality, highly available, and sustainable fiber optic network that will be accessible to the community for many years to come.

1. BACKGROUND

A2 Community Fiber Optic Networks
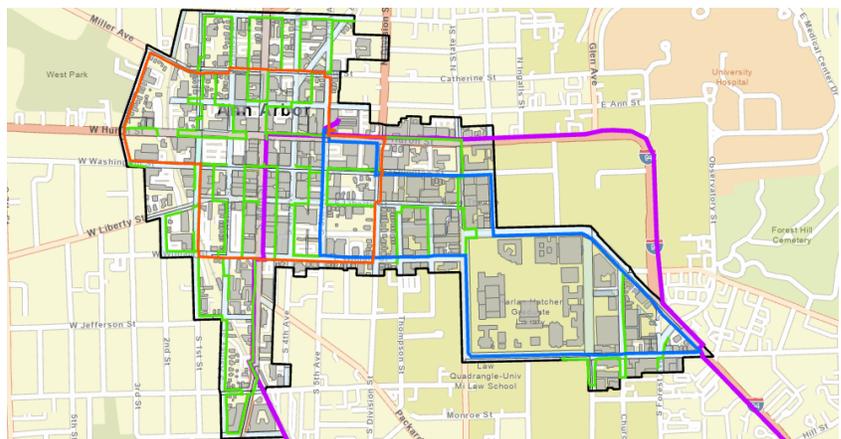
A2 I-NET Fiber Optic Network

This network was built as the result of the termination of a franchise agreement between the City of Ann Arbor and Comcast, who previously provided fiber connectivity to all city locations. The city chose to build our own fiber network, as oppose leasing, and built excess fiber optic capacity for expansion and utilization for other community organizations. As a result, a 35-mile fiber optic network backbone and 10-miles of lateral connections to city locations were implemented to loosely traverse around the border of the city limits with a bi-sector connecting the 2 city data centers. The A2 I-NET consists of 40% aerial fiber and 60% underground fiber with 144 strands of total fiber capacity.
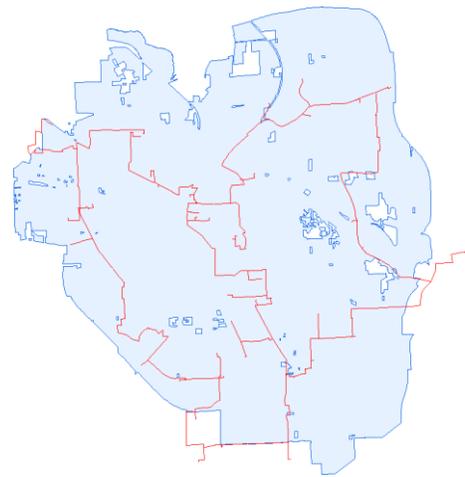
A2 I-NET Fiber Network

Technology Park (DDA District) Fiber Optic Network

The Technology Park is being constructed specifically within the borders of the DDA District in compliance with grant funding provided by the Local Development Funding Authority (LDFA). This network consists of 4-miles of backbone fiber and 5-miles of sub-rings designed to run near every structure in the DDA District for ease of access. The entire build is 100% underground

Technology Park Fiber Network – DDA District

construction, will have an initial capacity of 432 fiber optic strands, and be expandable to between 1728 and 3456 fiber optic strands.

A2 – Ypsilanti Broadband Fiber Optic Network

This network is being funded by a grant from the U. S. Economic Development Administration (EDA). The network will consist of approximately 20-miles of fiber optic backbone connecting the City of Ann Arbor and City of Ypsilanti Smart Zones. The entire build is 100% underground construction and will have an initial fiber capacity of 432 fiber optic strands, expandable to 1728 fiber optic strands.
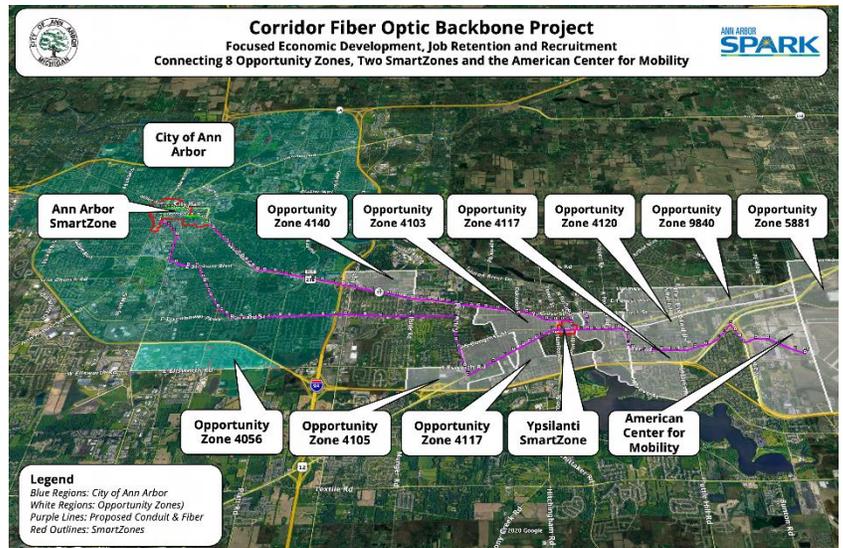
A2 - Ypsilanti Broadband Fiber Optic Network - Preliminary

A2 Community Fiber Optic Networks Comparison

All 3 fiber optic networks have many similarities, but also have their differences. Table 1 below is a summary of key attributes for each network.

	A2 I-NET	Technology Park	A2-Ypsilanti Broadband Fiber
Backbone length in miles/feet	35 miles / 188,918.40 feet	9 miles / 21,120 feet	20 miles / 105,600 feet
Total fiber strands/pairs	144 strands / 72 pairs	432 strands / 216 pairs **Expandable to 1728-3456 strands**	432 strands / 216 pairs **Expandable to 1728 strands**
Total CIP cost	$5.5M	$5M	$3M
Cost Replacement (25 years)	$11.2M	$7.3M	$4.4M
Annual Maintenance	$250,000	$250,000	$250,000
Total cost per strand	$.04	$.09	$.01426
Funding Source	City of Ann Arbor	LDFA grant	EDA Grant
Primary revenue source	City of Ann Arbor, 3rd parties	3rd Parties	3rd Parties
Aerial vs. Underground (UG)	40% aerial, 60% UG	100% UG	100% UG
Urban (Downtown) vs. Rural	Urban/Rural	100% urban	Urban/Rural

Table 1

2. DARK FIBER PRICING ANALYSIS

Research was conducted on numerous dark fiber lease models to assist in determining the best model for the City of Ann Arbor. Municipalities were the primary focus and non-profits, and private companies were included to compare industry pricing.   Table 2 below shows a comparison of dark fiber models. There were an abundance of dark fiber leasing models and the ones selected best represented similarities to the City of Ann Arbor. In addition to the city's experience designing, constructing, and maintaining fiber optics networks, the following sources were referenced as part of this analysis: Municipality web sites, master plan studies, industry and feasibility reports, resolutions, agreements, verbal conversations with industry stakeholder's, legal opinions, and Next Century Cities.

Findings

There are numerous municipalities across the United States leasing dark fiber and (or) offering a variety of fiber network services to their communities. Table 2 shows several municipalities and ISP's, and a comparison of the elements associated with their fiber related service offerings.

Organization	Type of Agreement	Dark Fiber or Conduit	One-Time Fee	Fiber Cost	Annual Cost (per pair)	Annual Maintenance and Admin (per pair)	Length of Agreement	Utility Y,N?	Urban or Rural?	Public/Private Partnership Y, N?	Type of Organization
Organization											
City of Ann Arbor (A2 I-NET)	Fiber & Conduit Use Agreement		$ 105,000.00	$10,500	$10,920 (25 year term)	Included	No Min./Max.		Urban - Small	N	Municipality
City of Holland, MI	Lease	Dark Fiber		.0105, per strand, per month	Minimum $1000 per month			Y	Rural	N	Municipality
Grand Rapids, MI		Conduit Capacity		$.32 - $5.73 per foot, per month		Included		Y	Urban	N	Municipality
Lakeland, FL	License Use Agreement	Dark Fiber	$500 admin fee	$200 per pair, per mile, per month	$2,400	Licensor's expense. Technician rates regular and overtime. Materials - cost +15%	Dept. of Electric Utilities, IT maintains operation				Municipality
Boulder, CO	Lease	Zayo to offer dark fiber	$5.50 per foot or $722,271.00					N	Urban	Y	Municipality
Riverside, CA	Lease	Dark Fiber		$250 per pair, per mile, per month	$3,000			Y	Urban	Y	Municipality
Valparaiso, IN		Dark Fiber	$500	$1000 - $1200 Per Month	$12,000 - $14,400			N			Municipality
Eugene, OR - Water & Electric Board				$21 per strand per mile, per month	$504			Y		Y	Municipality
City of Holly Springs, NC	IRU	Dark Fiber		$250 per year, per route mile, annually			20 years	N		Y	Municipality
City of Rock Falls, IL			10% down, 120 payments, 5% gross revenue from Surf	$100 per strand, per mile, per month	$2,400		10 years	Y		Y	
City of Los Gatos, CA	License Agreement	Conduit	$350,000			Included	20 years	N			Municipality
City of Chesapeake, VA	Lease	Dark Fiber						N			Municipality
City of Anaheim, CA:	Lease	Dark Fiber		$130 - $600 per pair, per mile, per month	$1560 - $7200		2 - 20 years	Y	Urban	N	Municipality
Palo Alto Utility	License Fee	Dark Fiber		$355 - $591 per pair, per mile, per month	$4260 - $7092			Y	Urban - Large		Municipality
Lincoln Nebraska		Dark Fiber		$3.96 per foot, per pair, per mile				N			Municipality
Huntsville, AL	Lease	Dark Fiber		Whole Ring: $2450-$3500 per strand, per month. Partial Ring: $820-$1175 per strand, per month.	Whole Ring: $29,400 - $42,000 per strand, annually. Partial Ring: $9,849-$$14,100 per strand, annually.			Y		Y	Municipality
ISP's											
Merit (ISP): Member (per mile, per pair)	IRU	Y		$ 1,200.00	$ 14,400.00	Included	20 year		Urban and Rural	N	Non-Profit
Merit (ISP): Non-Member (per mile, per pair)	IRU	Y		$ 1,500.00	$ 18,000.00	Included	20 year			N	Non-Profit
Merit (ISP): Lease (per mile, per pair, per year)	Lease	Y			$ 1,267.00	Included	5 - 10 years			N	Non-Profit
Uniti - Fiber Provider	IRU	Y		$850 - $1,350 per strand, per fiber mile.						N	
Lumen				$3000 - $5000 per month, per mile						N	
Comcast		Lit Fiber	$120	50/15 - $140 per month, per pair. 250/25MB - $240 per month, per pair.			24 months			N	

Table 2

Type of Dark Fiber Pricing Models

There are 4 common pricing models utilized in the industry (CTC, 2012). The chart below compares the advantages and disadvantages of each model.

	Advantages	Disadvantages
Up-front payment plus maintenance (Current I-NET model)	• Immediate revenue for maintenance. • Accounting and tax benefits for a lessee. • Potential for longer term agreement because no refund of the cost.	• Large up-front payment for lessee
Per strand, per mile, for a set term (most common)	• No up-front costs for lessee.	• No up-front revenue for lesser
Incremental or proportional cost: Priced at the cost of building and maintaining	• Lowest pricing.	• No revenue for replacement or inflation
Per annum or per month pricing	• Provides steady income. • No up-front cost to lessee.	• No up-front payment

Dark Fiber Agreements

There are a variety of agreements being used in the industry and there does not appear to be a common one among municipalities. Agreements uncovered by this research are: Lease, IRU, License Agreement, and Fiber and Conduit Use Agreement (City of Ann Arbor). Length of agreements tend to be longer term.

Dark Fiber Pricing

Based on the most common industry models pricing varies greatly. Factors that can potentially affect how pricing is determined are: Cost to implement the network, on-going maintenance, urban vs. rural, economic market, public/private partnerships, competition, fair and competitive pricing, length of the agreement, ability to generate revenue up-and-above actual costs, bandwidth, and fiber distance. Guaranteed minimums are set in place for some organizations.

Pricing overview:

- Per pair (2 strands), per mile, set term model:
  - Prices range from $.021($1000.00 minimum) to $591.00 per month
  - Annual costs range from $1000.00 to $7092.00, depending on distance.
  - Whole fiber ring access ranges from $10,920.00 (25-year term) to $84,000.00

- One-time fees or up-front payments plus annual usage and maintenance:
  - Up-front fees range from a $500 admin fee, to 10% down, to $105,00.00.
  - Usage and maintenance cost is typically included. The City of Ann Arbor currently charges $10,500.00 annually for usage and maintenance of the A2 I-NET network.

Public/Private Partnerships

There are a variety of financial arrangements where cities form a partnership with private companies to implement and (or) manage a city's fiber optic networks. A private company may retain ownership or forego ownership to the city. Certain accommodations are made as part of the partnership such as, but not limited to:

- The opposite party will grant a portion of the fiber capacity to the other party.
- The private partner will maintain and manage the network on behalf of the city.
- The private company may be required to make fiber available to their community under a set of conditions, such as bridging the digital divide, promote competition, promote economic development, affordable pricing, digital equity, net neutrality, etc.
- The private party may pay the city a certain percentage of the revenue.

Models and agreements for public/private partnerships vary greatly and are typically utilized to benefit both parties as well as their communities.

Municipal Utilities vs. IT Department vs. Non-profit

The majority of dark fiber service offerings are administered through the municipality's public utility. The remaining are serviced through the organizations Information Technology department and in some cases setup as non-profit or 501(c) corporations.

Depending on the organization, service provided may be one of many of the following:

- Dark fiber only
- Lit or active fiber
- Fiber-to-the-home (FTTH)
- Internet Services Provider (ISP), like Comcast, Spectrum, WOW, etc.

Pricing and Operating Model Descriptions

City of Holland, MI: Fiber Optics network operates within the Public Works department and offers access to the home (FTTH). In the past they were looking for a partner to provide Internet Service Provider (ISP) cable and internet services. Public Works has access to the homes and leases to major communications carriers. (City of Holland Broadband Business Rates, n.d.) –

Grand Rapids, MI: Their cost model or the "Pole Line and Duct System Rate Study" is based on a 5-years running average cost of their fiber and conduit infrastructure. They use

the FCC Duct formula as a guideline to determine pricing using an economic indicator for inflation. (City of Grand Rapids Energy, Lighting, and Commuications, n.d.)

Lakeland, FL: Operates under the Department of Electric Utilities. The City builds and maintains the dark fiber for licensees. The Information Technology department maintains the operations of the fiber. (City of Lakeland Broadband Utility, n.d.)

Eugene, OR: The Water & Electric Board (EWRB) owns the fiber network and private ISP's provide service to individual customers. ISP's can lease the fiber. It is an open access network. (EUGNET, n.d.)

City of Chesapeake, VA: Infrastructure-Only/Government Services Provider Business Model. The city will construct, finance, own, and operate the network as a city enterprise fund. Unused portions will be leased to private companies for providing services to the community. Private companies can jointly build additional infrastructure with the city to reduce city costs. The Enterprise fund, within the IT department, other city departments, government agencies, and education generate revenue to maintain the network. Additional external revenue generated from other sources due to excess fiber capacity will be used to reduce overall costs. The city will not provide FTTH or businesses. Project scheduled to be completed in 2024. (Chesapeake Broadband, n.d.)

City of Holly Springs, NC: Utilize a company called "ting" to offer 1Gbps connection to buildings on the city's municipal fiber network. City buildings are connected to the city's fiber optic network, but State Law prevents the city from providing ISP services. (Article, 2015)

Boulder, CO: Zayo, an Internet Service Provider (ISP), is building a fiber network and will utilize city conduit. The fiber and conduit will be used for city and select community purposes, rather than provide public services in the short term. In the long term, this infrastructure could support gigabit speed internet services to homes and various city applications. (City of Boulder Community Broadband Connectivity, n.d.)

Valparaiso, IN: Fiber was installed and is maintained by a separate company. The city only leases dark fiber and a service provider, ValpoNet, builds and operates the fiber optic network on behalf of the city. ValpoNet provides recommendations for Internet Service Providers (ISPs) to connect businesses. ValpoNet agents work with customers to identify the most cost-effective solution to meet their respective needs. (ValpoNet, n.d.)

Lincoln, NE: Partnered with Lincoln Partnership for Economic Development, Downtown Lincoln Association, and Lincoln Chamber of Commerce. They are partnered with 11 companies to connect the entire city which generates $1.4 million in new revenue. The city leases access to the conduit system to private Internet Service Providers (ISPs) to deploy

fiber networks. In return for access to the conduit, private companies pay fees and abide by the city's Broadband Franchise ordinance, which stipulates providers follow network neutrality principles, in addition to other policies designed for the public good. Lincoln also requires companies to make available to other Internet Service Providers (ISPs) in the system any new conduit added to the network. The City of Lincoln and Allo Communications, an Internet Service Provider (ISP), partnered to build fiber to all 285,000 homes and businesses in the city. (City of Lincoln Nebraska Broadband Franchise Agreement)

Conclusion

After reviewing all the research data and consultation with my peers and industry professionals I have yet to find any standard dark fiber pricing. I was unable to find another municipality with the same financial and operations model as the City of Ann Arbor. The closest model was the City of Chesapeake, VA, and their network will not be completed until 2024. There are numerous elements and factors that determine an organization's financial and operations dark fiber models. Almost every dark fiber model researched was unique in some respect and appear to be customized towards the respective organizations.

3. FIBER OPTIC NETWORKS COSTS AND EXPENSES

Summary of A2 Community Fiber Network Costs

The chart below is a summary of the costs associated with each of the A2 Community fiber optic networks. These figures are utilized to develop revenue projections and our final pricing model.

Fiber Networks Cost Summary								
	Available Fiber Strands	Available Fiber Pairs	Cost Per Foot, Per Fiber Pair	Original Capital Improvement (CIP) Cost	Replacement Cost (25 years)	Annual Cost Per Fiber Pair Based on Replacement Cost	Total Cost Per Fiber Pair (2 strands) Original Cost	Total Cost Per Fiber Pair (2 Strands) Replacement Cost (25 years)
A2 I-NET	144	72	$ 0.04	$ 5,500,000.00	$ 11,216,674.25	$ 6,231.49	$ 76,388.89	$ 155,787.14
Technology Park (DDA District)	432	216	$ 0.09	$ 5,000,000.00	$ 7,537,575.84	$ 1,395.85	$ 23,148.15	$ 34,896.18
A2-Ypsilanti Broadband Fiber	432	216	$ 0.01	$ 3,000,000.00	$ 4,393,492.60	$ 813.61	$ 13,888.89	$ 20,340.24
A2 Community Dark Fiber (All 3 networks combined)	**1008**	**504**	**$ 0.14**	**$ 13,500,000.00**	**$ 23,147,742.69**	**$ 8,440.94**	**$ 113,425.93**	**$ 211,023.57**

Individual Fiber Optic Network Cost and Expense Models

The cost and expense models below indicate direct and indirect costs associated with the original implementation and the future maintenance expenses for the three A2 Community fiber optic networks. Our pricing model is based on the replacement cost and future anticipated maintenance expenses of all 3 networks. Each model is broken up into 3 sections:

Original Capital Cost

Indicates all contractor and city staff labor, engineering, construction, and materials costs associated with the original implementation of the fiber optic networks.

Replacement Cost

Estimates the cost to replace the fiber network after a useful life of 25 years at a 4% annual inflation rate. An assumption is made that any replacement will be an underground implementation.

Annual Maintenance Expenses

Annual labor and materials cost needed to maintain and expand a highly available and quality network to meet service level agreements for all customers.

A2 I-NET Fiber Optic Network

A2 I-NET Fiber Network				
Original Capital Costs				
	Cost Per Strand Foot Per Year	Cost Per Strand Per Year	Total Cost	
Original Capital Cost				
Engineering and Construction Costs	$ 0.00497	$ 938	$ 3,377,677	Resolution 16-1666 V2
Network Data Closet Upgrades	$ 0.00011	$ 20	$ 72,874	Resolution 17-0552 V1
Fiber Optics Management Software	$ 0.00015	$ 29	$ 41,520	
Utilization of existing City conduit	$ 0.00297	$ 561	$ 2,018,312	Existing Conduit Used for Network
Total			$ 5,510,383	
Replacement Cost				
	Cost Per Strand Foot Per Year	Cost Per Strand Per Year	Annual Cost	
Future Replacement & Improvement Costs	$ 0.01658	$ 3,133	$ 11,216,674	Useful life of 25 years, 4% Inflation, assumes all underground replacement.
Annual Maintenance Expenses				
	Cost Per Strand Foot Per Year	Cost Per Strand Per Year	Annual Cost	
Scheduled Maintenance	$ 0.00276	$ 521	$ 75,000	Estimate: Annual ride out, tree trimmimng, telephone pole maintenance, minor fiber repair, permitting.
Unscheduled Maintenance				
Backbone Repairs	$ 0.00165	$ 313	$ 45,000	Estimated 3 breaks a year @ $15k/break
Lateral Repairs	$ 0.00055	$ 104	$ 15,000	Estimated 3 breaks a year @ $5k/break
Administration				
City IT Staff Support	$ 0.00634	$ 1,198	$ 172,494	
Technology Hardware & Software Maintenance	$ 0.00055	$ 104	$ 15,000	Fiber Optic Management software maintenance cost
City property insurance costs related to FON	$ 0.00003	$ 5	$ 739	Portion of IT Insurance Premium allocated based on % of IT Salary allocated to the A2 I-
External Legal Counsel	$ 0.00037	$ 69	$ 10,000	
Pole Attachment Fees: DTE/ATT	$ 0.00056	$ 106	$ 15,306	
Contingency	$ 0.00184	$ 347	$ 50,000	
Annual Maintenance and Administration Cost Total	$ 0.01465	$ 2,768	$ 398,538	

Technology Park (DDA District) Fiber Optic Network

Technology Park DDA District Fiber Network					
Original Capital Cost					
	Cost Per Strand Foot Per Year	Cost Per Strand Per Year	Total Cost		
Original Capital Cost					
Engineering and Construction	$ 0.02151	$ 462.96	$ 5,000,000		
Utilization of existing City Conduit	$ 0.00066	$ 14.11	$ 152,400		Conduit previously constructed and paid for by the city that will be used for the Tech Park. Cost is $25
Fiber Asset Management Software (3-GIS)	$ 0.00008	$ 1.79	$ 7,730		Fiber Optic Management software maintenance
IT Staff Project Management: Engineering and construction	$ 0.00033	$ 7.01	$ 75,701		IT Director, Network Manager, GIS Specialist
Finance Administration Labor	$ 0.00002	$ 0.46	$ 5,000		Marti Praschan
Legal Administration - Internal	$ 0.00004	$ 0.93	$ 10,000		Michelle Landis, Tim Wilhelm
Legal Administration - External	$ 0.00004	$ 0.93	$ 10,000		
Total			$ 5,260,831		
Replacement Cost (25 years)					
	Cost Per Strand Foot Per Year	Cost Per Strand Per Year	Total Cost		
Future Replacement and Improvement Cost	$ 0.03248	$ 699.00	$ 7,537,576		Useful life of 25 years, 4% Inflation, assumes all underground replacement.
Annual Maintenance Expenses					
	Cost Per Strand Foot Per Year	Cost Per Strand Per Year	Annual Cost		
Scheduled Maintenance	$ 0.00323	$ 69.44	$ 30,000		Estimate: Annual ride out, minor fiber repair,
Data Center Services for Fiber Distribution Panel	$ 0.00465	$ 100.00	$ 43,200		Space, electricity, general data center maintenance. $75 per month, per 1 rack space unit.
Unscheduled Maintenance					
Backbone Repairs	$ 0.00484	$ 104.17	$ 45,000		Estimated 3 breaks a year @ $15k/break
Lateral Repairs	$ 0.00161	$ 34.72	$ 15,000		Estimated 3 breaks a year @ $5k/break
Administration					
IT Staff Support - Post Implementation	$ 0.01689	$ 363.55	$ 157,055		IT Director, Network Team, GIS Specialist
Finance Staff Administration			$ 5,000		
Internal Legal Counsel			$ 10,000		
External Legal Counsel	$ 0.00108	$ 23.15	$ 10,000		
Technology Hardware & Software Maintenance	$ 0.00083	$ 17.89	$ 7,730		3 -GIS Software
City property insurance costs related to FON	$ 0.00007	$ 1.56	$ 673		on % of IT Salary allocated to FON; Insurance policy costing $7-10K per year not utilized
Pole Attachment Fees from DTE/ATT	$ 0.00011	$ 2.31	$ 1,000		Anticipated costs. Build is entirely underground. May need to utilize poles in the future.
Contingency	$ 0.00215	$ 46.30	$ 20,000		
Annual Maintenance and Administration Cost	$ 0.03546	$ 763.10	$ 344,658		

Ann Arbor – Ypsilanti Broadband Fiber Optic Network

Ann Arbor-Ypsilanti Broadband Fiber Network					
Original Capital Cost					
	Cost Per Strand Foot Per Year	Cost Per Strand Per Year	Total Cost		
Original Capital Cost					
Engineering and Construction	$ 0.00265	$ 277.78	$ 3,000,000		
Fiber Asset Management Software (3-GIS)	$ 0.00002	$ 1.79	$ 7,730		Fiber Optic Management software maintenance cost
IT Staff Project Management: Engineering and construction	$ 0.00007	$ 7.01	$ 75,701		IT Director, Network Manager, GIS Specialist
Finance Administration Labor	$ 0.00000	$ 0.46	$ 5,000		Marti Praschan
Legal Administration - Internal	$ 0.00001	$ 0.93	$ 10,000		Michelle Landis, Tim Wilhelm
Legal Administration - External	$ 0.00001	$ 0.93	$ 10,000		
Total			$ 3,108,431		
Replacement Cost (25 years)					
	Cost Per Strand Foot Per Year	Cost Per Strand Per Year	Total Cost		
Future Replacement and Improvement Cost	$ 0.00388	$ 407.88	$ 4,393,493		Useful life of 25 years, 4% Inflation, assumes all underground replacement.
Annual Maintenance Expenses					
	Cost Per Strand Foot Per Year	Cost Per Strand Per Year	Annual Cost		
Scheduled Maintenance	$ 0.00066	$ 69.44	$ 30,000		Estimate: Annual ride out, minor fiber repair,
Data Center Services for Fiber Distribution Panel	$ 0.00024	$ 25.00	$ 10,800		Space, electricity, general data center maintenance. $75 per month, per 1 rack space unit. Space needed
Unscheduled Maintenance					
Backbone Repairs	$ 0.00099	$ 104.17	$ 45,000		Estimated 3 breaks a year @ $15k/break
Lateral Repairs	$ 0.00033	$ 34.72	$ 15,000		Estimated 3 breaks a year @ $5k/break
Administration					
IT Staff Support - Post Implementation	$ 0.00346	$ 363.55	$ 157,055		IT Director, Network Team, GIS Specialist
Finance Staff Administration			$ 5,000		
Internal Legal Counsel			$ 10,000		
External Legal Counsel	$ 0.00022	$ 23.15	$ 10,000		
Technology Hardware & Software Maintenance	$ 0.00017	$ 17.89	$ 7,730		3 -GIS Software
City property insurance costs related to the fiber network	$ 0.00001	$ 1.56	$ 673		% of IT Salary allocated to FON; Insurance policy costing $7-10K per year not utilized
Pole Attachment Fees from DTE/ATT	$ 0.00002	$ 2.31	$ 1,000		Anticipated costs. Build is entirely underground. May need to utilize poles in the future.
Contingency	$ 0.00044	$ 46.30	$ 20,000		
Annual Maintenance and Administration Cost Total	$ 0.00655	$ 688.10	$ 312,258		

4. REVENUE MODEL AND BENEFITS

Revenue Projections by Model

The chart below indicates the potential revenue of each network utilizing 3 different pricing models. The cost is derived from the cost and expense models in section 3 using the 25-year replacement cost and an annual usage and maintenance fee applied to each fiber optic pair.

	Replacement Cost plus Annual Usage and Maintenance Fee		Per Pair, Per Mile plus Annual Usage and Maintenance Fee		Incremental or Proportional (Original CIP cost) plus Annual Usage and Maintenance	
	Annual Revenue	25 years	Annual Revenue	25 Years	Annual Revenue	25 Years
A2 I-NET						
2 strands (1 Pair)	$ 18,231.49	$ 455,787.25	$ 27,113.47	$ 677,836.80	$ 15,055.56	$ 376,388.89
25% Capacity (18 Pair)	$ 328,166.82	$ 8,204,170.50	$ 488,042.50	$ 12,201,062.40	$ 271,000.00	$ 6,775,000.00
50% Capacity (36 Pair)	$ 1,312,667.28	$ 32,816,682.00	$ 976,084.99	$ 24,402,124.80	$ 542,000.00	$ 13,550,000.00
100% Capacity (72 Pair)	$ 2,625,334.56	$ 65,633,364.00	$ 1,952,169.98	$ 48,804,249.60	$ 1,084,000.00	$ 27,100,000.00
Technology Park						
2 strands (1 Pair)	$ 13,395.85	$ 334,896.25	$ 15,801.60	$ 395,040.00	$ 12,925.93	$ 323,148.15
25% Capacity (54 Pair)	$ 723,375.90	$ 18,084,397.50	$ 853,286.40	$ 21,332,160.00	$ 698,000.00	$ 17,450,000.00
50% Capacity (108 Pair)	$ 1,446,751.80	$ 36,168,795.00	$ 1,706,572.80	$ 42,664,320.00	$ 1,396,000.00	$ 34,900,000.00
100% Capacity (216 Pair)	$ 2,893,503.60	$ 72,337,590.00	$ 3,413,145.60	$ 85,328,640.00	$ 2,792,000.00	$ 69,800,000.00
A2-Ypsilanti Broadband						
2 strands (1 Pair)	$ 12,813.61	$ 320,340.25	$ 14,982.00	$ 374,550.00	$ 12,555.56	$ 313,888.89
25% Capacity (252 Pair)	$ 691,934.94	$ 17,298,373.50	$ 809,028.00	$ 20,225,700.00	$ 678,000.00	$ 16,950,000.00
50% Capacity (108 Pair)	$ 1,383,869.88	$ 34,596,747.00	$ 1,618,056.00	$ 40,451,400.00	$ 1,356,000.00	$ 33,900,000.00
100% Capacity (216 Pair)	$ 2,767,739.76	$ 69,193,494.00	$ 3,236,112.00	$ 80,902,800.00	$ 2,712,000.00	$ 67,800,000.00
A2 Community Dark Fiber (All 3 Networks)						
2 strands (1 Pair)	$ 20,440.94	$ 511,023.50	$ 102,730.94	$ 2,568,273.60	$ 16,537.04	$ 413,425.93
25% Capacity (252 Pair)	$ 5,151,116.88	$ 128,777,922.00	$ 25,888,197.89	$ 647,204,947.20	$ 4,167,333.33	$ 104,183,333.33
50% Capacity (504 Pair)	$ 10,302,233.76	$ 257,555,844.00	$ 51,776,395.78	$1,294,409,894.40	$ 8,334,666.67	$ 208,366,666.67
100% Capacity (1008 Pair)	$ 20,604,467.52	$ 515,111,688.00	$ 103,552,791.55	$2,588,819,788.80	$ 16,669,333.33	$ 416,733,333.33

Benefits of Community Dark Fiber

Providing dark fiber access to the community has many benefits and will facilitate achieving the following goals and objectives for our community.   They are:

- ✓ Bridging the Digital Divide
    a. Attract and retain people
    b. Promote broadband competition and provide more choices
    c. Affordable, high-speed broadband access for all
    d. Digital Equity
- ✓ Promote Economic Development
    a. Attract and retain businesses
    b. Develop Public/Private Partnerships
    c. Promote new business, upstarts
- ✓ Enhance city services, operational efficiencies, and reduce expenses
- ✓ Support a Smart City ecosystem
    a. The fiber backbone is necessary for a Digital Transformation and to achieve the goals of the city's Smart City Strategic plan. (City of Ann Arbor Smart City Strategic Plan, 2021), (Foundation, 2014)
- ✓ Leverage city investments for the benefit of the community
- ✓ Efficiently utilize the Right-of-way (ROW) by reducing the congestion of assets and while maintaining aesthetics
- ✓ A "connected" community. Densify our communications foundation and remove barriers to allow for seamless connectivity where feasible.

5. DARK FIBER PRICING MODEL

Replacement Cost plus Annual Usage and Maintenance Fee Pricing Model

Based on this research and previous experience operating and maintaining a fiber optic network we are recommending the following pricing model below to facilitate the use of our A2 Community dark fiber. The price includes the cost for the city to replace a pair of fiber optics strands in 25 years plus an annual usage and maintenance fee of $12,000.00 to maintain and sustain the network. In addition to the benefit of dark fiber cited in section 4, the primary factors involved in determining this pricing model is equity, maximizing utilization of the network, being competitive, and benefiting our community.

	A2 I-NET	Technology Park	A2-Ypsilanti Broadband	A2 Community (all 3 networks)
Annual Maintenance and Usage Fee – Per Pair	$12,000	$12,000	$12,000	$12,000
Annual Replacement Cost Per Pair	$6,231.49	$1,395.85	$813.61	$8,440.94
Total Annual Cost	**$18,231.49**	**$13,395.85**	**$12,813.61**	**$20,440.94**

A2 Community Dark Fiber Use Requirements Summary:

- Fiber and Conduit Use Agreements are the legal governing mechanism for dark fiber optic use.
- Use can include one, two or three of the A2 Community fiber optic networks.
- Minimum use is one pair of fiber optic strands.
- Maximum use is no more than 25% of the total capacity of the network unless otherwise agreed upon. Bulk rates beyond 25% will be considered on a case-by-case basis.
- Each fiber optic pairs procured is reserved around the entire individual network.
- The City of Ann Arbor will exclusively maintain the fiber as part of the annual maintenance and usage fee and the Maintenance Requirements and Procedure section of the Fiber and Conduit Use Agreement.

- The city of Ann Arbor will exclusively manage all adds, moves, and changes to the network(s).
- All add, moves, and changes to a network requested by a grantee will be at the expense of the grantee. The city will retain ownership of any adds, move, or changes to the A2 Community networks unless the grantee chooses to construct their laterals at their expense, and therefore retain ownership of the lateral. The city will be responsible for all splicing into the city's backbone network(s).
- Any fiber optic pairs, and network(s) defined in the Fiber and Conduit Use Agreement must be activated within 90 days after the fiber is ready for activation.
- Payments will occur annually.
- The City of Ann Arbor reserves the right to reserve certain portions of the at A2 Community fiber optics strands.
- Metro Act permitting and fee requirements applied to telecommunication provider(s):
  - The first non-exempt telecommunication provider granted use of the A2 Community dark fiber must file for a Metro Act Permit and administer all elements of the application and pay the fee requirements.
  - The Metro Act permit application must be filed by the grantee on behalf of the City of Ann Arbor if within the city limits, and other jurisdictions outside the City of Ann Arbor city limits.
  - The Metro Act permit and fees are limited to each linear foot in the right-of-way granted to the telecommunications provider.
  - If additional telecommunications providers are granted use to the A2 Community dark fiber and is not being utilized by another telecommunications provider, they are required to administer all elements of the application and pay the fee requirements of the existing Metro Act permit on behalf of the City of Ann Arbor and (or) other jurisdictions on the route.
  - If additional telecommunications providers are granted use of the A2 Community dark fiber and that is currently being utilized by another telecommunications provider, they are required to administer all elements of the application and pay the fee requirements utilizing the existing Metro Act permit on behalf of City of Ann Arbor or other jurisdictions on the route. Applicable fees will be split evenly among telecommunications provider(s) based on each linear foot utilized. Annual fee payment(s) will begin on the anniversary date of the original fee payment. For example, if a single telecommunications provider is utilizing linear footage, they will pay 100% of the annual fees. If 2 telecommunication providers are utilizing the same linear footage, they will split the annual fees 50/50. As additional telecommunications providers are added and utilize the same linear footage the annual fees will be divided by the total number of telecommunications providers.

6. A2 COMMUNITY FIBER 3-YEAR COST-BENEFIT PROJECTION

The following table shows a projection of the revenue and expenses for the next 3 fiscal years. Currently the City of Ann Arbor generates over $418,000.00 in revenue for use of the current A2 I-NET fiber optic network. The projection shows the addition of 5 pairs per year for the next 3 years for an increase in revenue of $100,000 per year. Additional revenue is unknown at this point and will depend on the adoption of fiber optic use by the community. Annual expenses were increased 25% above the current A2 I-NET budget to accommodate for the additional 2 networks and 3% increase was applied to staff support for a COLA increase.

Staff time to support the fiber optic networks is our greatest expense. Un-scheduled or emergency repairs are the greatest unknown and depend on extreme weather or other catastrophic events. Since 2017, repair expenses have been minimal, and contractors have mostly absorbed the cost for damages incurred to our fiber existing fiber network. As the networks age this expense will increase.

	FY2023	FY2024	FY2024
Revenue			
Current Revenue	$ 418,993.75	$ 518,993.75	$ 618,993.75
Projected Revenue	$ 100,000.00	$ 100,000.00	$ 100,000.00
Subtotal	**$ 518,993.75**	**$ 618,993.75**	**$ 718,993.75**
Expenses			
Scheduled Maintenance	$ 75,000.00	$ 75,000.00	$ 75,000.00
Unscheduled/Emergency Maintenance	$ 60,000.00	$ 60,000.00	$ 60,000.00
Data Center Services	$ 10,000.00	$ 10,000.00	$ 10,000.00
Administration			
Staff support	$ 157,055.00	$ 161,766.65	$ 166,619.65
Fiber Management Software	$ 8,000.00	$ 8,000.00	$ 8,000.00
External Legal Counsel	$ 10,000.00	$ 10,000.00	$ 10,000.00
Pole Attachment Fees	$ 20,000.00	$ 20,000.00	$ 20,000.00
Contingency	$ 50,000.00	$ 50,000.00	$ 50,000.00
Subtotal	**$ 390,055.00**	**$ 394,766.65**	**$ 399,619.65**
Revenue less Expenses Total	**$ 128,938.75**	**$ 224,227.10**	**$ 319,374.10**

7. A2 COMMUNITY FIBER DESIGN STANDARDS AND OPERATING MODEL

Fiber Optic Network Design Standards

The IT department has developed a set of standards when designing and constructing fiber optic networks to ensure reliability, resiliency, high availability, sustainability, and quality.

Underground vs. Aerial Construction

Our preference is to place new fiber underground if possible. It is less vulnerable than aerial builds because of weather and traffic related incidents. It is located primarily in the city's right-of-way and is not subject the telephone pole attachment fees by 3rd party utilities. Aerial construction will be utilized on an as needed basis.

Fiber Optic Network Physical layout

All current and future A2 Community fiber networks are designed in a ring configuration so resiliency and failover can be achieved for non-critical as well as critical or high availability communication needs.

The A2 I-NET consists of 2 fiber rings, with a bi-sector between the city's 2 data centers. This configuration, with the proper networking equipment, remains active in the case of a single failure. The network is 60% underground and 40% aerial. Aerial construction was due to initial budget constraints. Our goal is to move all aerial connections underground in the future, if feasible.

The Technology Park fiber optic network backbone consists of 2 fiber rings and 2 lateral connections from each ring that run in close proximity to all structures in the DDA District. This configuration can accommodate organizations that require 2 physically separate connections in the case of a single failure. This network is 100% underground.

The A2-Ypsilanti Broadband fiber optic network will consist of a fiber ring from the City of Ann Arbor to the City of Ypsilanti. It will be configured in a ring configuration and traverse to and from each city on separate physical paths.

Central Fiber Termination

All fiber networks are terminated and patched into one or both city data centers for easy cross connections.

Corning Warranty

All fiber optic networks utilize Corning products, are certified by Corning, and hold a 25-year Corning warranty.

Design and Construction Standards

Each fiber network design and construction utilize a specific set of standards to ensure quality and consistency. This includes, but not limited to, handholes, grounding, testing, conduit, splicing, etc.

A2 Community Fiber Operating Model Overview

The City of Ann Arbor owns, operates, and maintains the A2 I-NET fiber optic network and will retain ownership of both the Technology Park and A2-Ypsilanti Broadband networks. Excess fiber capacity was built into all networks to make dark fiber available to the community. The city is subject to the Michigan Telecommunications Act (MCL 484.2252 *et seq*.) and the METRO Act (MCL 484.3101 *et seq*.) and cannot activate or light fiber for anyone but the City of Ann Arbor. In addition, the City of Ann Arbor is not an Internet Service Provider (ISP), nor does it intent to become one.

Budget and Financials

Our current fiber network budget is funded through a chargeback to City of Ann Arbor departments, revenue generated from 3rd parties, and a separate conduit-only lease. In 2017, it was decided to build our own network, maintain it ourselves, and retain unrestricted ownership and control. The reasons for the decision are cost avoidance, ability to control bandwidth, not having to rely or wait for contractors for problem resolution, manage adds/moves/changes to maintain consistency and quality, and allow IT staff to maintain the network. Unused funds are utilized to connect new city locations to our fiber network or move existing aerial fiber to underground.

Fiber and Conduit Use Agreement

The city IT, Finance, and Legal departments worked to create this agreement so other community members could utilize excess city fiber. This agreement has been utilized as our legal mechanism since 2017.

Maintenance

The city maintains our fiber networks through a combination of IT staff and contractors. Our maintenance terms and conditions are specified in our Fiber and Conduit Use Agreement. When issues occur, city staff, or customers will contact the IT department Help Desk 24 hours a day, 7

days a week, 365 days of the year. It is the responsibility of the City of Ann Arbor IT department to make repairs on a reasonable effort basis.

Network Expansion

Any request to implement a new location by the City of Ann Arbor or community organization is bid out and project managed by the City of Ann Arbor IT department using the city's purchasing policies. All cost associated with the addition is paid for by the requesting organization. The City of Ann Arbor IT department uses its Project Delivery Methodology and a 2 phased approach. The first phase is to design and plan the new route and provide labor and materials pricing for construction. The second phase is to utilize the design and planning documentation and bid out the construction.

REFERENCES

(n.d.). Retrieved from EUGNET: https://eugnet.org/

Advisors, M. (2019). *City of Golden Fiber Master Plan Broadband Study.*

Article. (2015, November 13). Retrieved from Community Networks:
https://muninetworks.org/content/ting-holly-springs-nc-get-gig

Chesapeake Broadband. (n.d.). Retrieved from
https://www.cityofchesapeake.net/government/city-
departments/departments/Information-Technology-Department/Chesapeake-
Broadband.htm

City of Anaheim. (n.d.). Retrieved from Fiber Lease Agreement.

City of Ann Arbor Net Neutrality Resolution R-18-162. (n.d.).

(2021). *City of Ann Arbor Smart City Strategic Plan.* Tom Shewchuk.

City of Boulder Community Broadband Connectivity. (n.d.). Retrieved from
https://bouldercolorado.gov/projects/community-broadband-connectivity

City of Grand Rapids Energy, Lighting, and Commuications. (n.d.). Retrieved from
https://www.grandrapidsmi.gov/Government/Departments/Energy-Lighting-and-
Communications

City of Holland Broadband Business Rates. (n.d.). Retrieved from
https://hollandbpw.com/en/customer-service/business/business-rates#broadband

City of Lakeland Broadband Utility. (n.d.). Retrieved from https://www.lakelandgov.net/citizen-
perspectives/broadband-utility/

City of Lincoln Nebraska Broadband Franchise Agreement. (n.d.).

City of Los Gatos Conduit Use Agreement. (n.d.).

City of Palo Alto. (n.d.). Retrieved from Dark Fiber Licensing Services Utility Rate Schedule.

City of Riverside. (n.d.). Retrieved from Dark Fiber Leasing Program:
https://riversideca.gov/utilities/utilities/businesses/dark-fiber-leasing-program

CTC. (2012). *Dark Fiber Lease Considerations.* Retrieved from
https://www.ctcnet.us/DarkFiberLease.pdf

(2021). *Dark Fiber Market Expected to Hit USD 9.3 Billion by 2026 Growing at CAGR of 11.0% .*
Future, Market Research.

Energy, C. T. (2017). *Fiber Business and Finacial Model - City of Virginia Beach.*

FCC Duct Use Formula. (n.d.).

Foundation, N. A. (2014). *The Art of the Possible.*

Group, P. L. (n.d.). Applicability of MTA Section 252 and Metro Act Section 14.

Huntsville, Alabama Dark Fiber Lease Pricing. (n.d.).

State of Michigan. (n.d.). Retrieved from M.C.L.A 484.3114 Metro Act.

ValpoNet. (n.d.). Retrieved from https://www.valponet.com/
https://www.valponet.com/faqs/#toggle-id-14