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APPLIED POLICY PROJECT

IMPLEMENTING A BROADBAND NETWORK IN HUNTINGTON BEACH, CALIFORNIA

ENABLING SMART CITY TECHNOLOGY

ANNA HIGGINS
MASTER OF PUBLIC POLICY CANDIDATE
FRANK BATTEN SCHOOL OF LEADERSHIP AND PUBLIC POLICY
UNIVERSITY OF VIRGINIA

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Anna Higgins
May 2019

Frank Batten School of Leadership and Public Policy
University of Virginia
Charlottesville, Virginia

Prepared for:
Antonia Graham
Assistant to the City Manager/Energy and Sustainability Manager
City of Huntington Beach, California

On my honor as a student, I have neither given nor received aid on this assignment.

Anna Higgins

Disclaimer: The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, by the City of Huntington Beach, or by any other entity.

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DEFINITION OF TERMS

5G: Fifth-generation internet

Broadband: data transmission that occurs over the internet; happens through a medium such as fiber optic wires, cable wires, satellite waves, or DSL

Concessionaire model: a P3 model in which a city contracts companies to perform certain services or functions

Dark fiber: a network of fiber infrastructure that does not have internet service running through it

FCC: Federal Communications Commission
Definition: the federal agency that regulates communications technology

FTTP: fiber-to-the-premises
Definition: the connection between a middle-mile network (ex. the network that runs under the street) and a building (ex. a business or home)

IoT: Internet of Things
Definition: implementing internet connectivity onto objects that do not typically feature internet (ex. smart refrigerators, smart watches)

IRU: indefeasible rights of use
Definition: a dark fiber leasing agreement in which the lessee pays an upfront fee per strand per mile and an annual maintenance fee per mile

ISP: internet service provider (ex. Comcast, Verizon FiOS, Ting)

Middle-mile network: the internet infrastructure off of which many buildings (ex. municipal buildings, homes, offices) are connected

OAN: Open Access Network
Definition: a municipally-owned network in which the city leases out space on the network to ISPs to use to provide internet service

P3: public-private partnership

RFP: request for proposal; used when a city is seeking out a company to provide certain services or to engage in a P3

ROI: return on investment

EXECUTIVE SUMMARY

The City of Huntington Beach, California, is seeking to develop smart city technologies that can collect data on city processes and initiatives. This data can then inform new policies that can expedite, optimize, and streamline how the city runs on a daily basis.

Smart city technologies function best on networks made of fiber infrastructure. Cities are increasingly looking to develop their own fiber infrastructure, and many seek to develop public-private partnerships that can cut costs for both municipalities and private sector companies. However, most of these projects aim to provide high-speed, affordable broadband to businesses and residents. The City of Huntington Beach is looking specifically for a network that it can use for municipal purposes.

Based on other cities' solutions and case studies, I developed four alternatives for the city to consider in an effort to have a network for municipal use:

Create a dig-once policy to reduce costs on private sector deployment
Negotiate leasing agreement for Crown Castle's existing dark fiber
Send out an RFP for a shared investment public-private partnership
Build out city network with concessionaire model

In this applied policy project, I evaluate each option by the criteria of **cost**, **ease of negotiation** with the private sector, and **opportunity for future growth**. I quantify costs for each option and provide the potential revenue that the city could bring in annually if it were to expand a network to its businesses and residents.

My recommendation for the City of Huntington Beach will be to implement a dig-once policy that coordinates road work projects with the private sector. While the roads are dug up for other projects, companies will be able to lay down fiber infrastructure, which will reduce construction costs on companies. I project that this option will put the least cost burden on the city given its goals of using a network solely for city use.

PROBLEM STATEMENT

After creating landmark deals with Phillips, Verizon, AT&T, and Mobilitie over small cells — a new form of internet infrastructure — the City of Huntington Beach, California, wants to pursue more smart city technologies to collect data on city procedures, transportation, safety, and more. In order to effectively and securely collect this information**, the city is seeking a broadband network that can facilitate these smart city technologies.**

Despite its previous deals with telecommunications companies, the city — along with many other municipalities — often experiences difficulty in negotiations with the private sector. The City of Huntington Beach hopes to pursue a broadband network at a low cost that will also bring good working relationships with the private sector. The city is also *not* currently seeking to develop a network that is intended to provide internet service to businesses and residents.

BACKGROUND

Internet of Things and Smart Cities

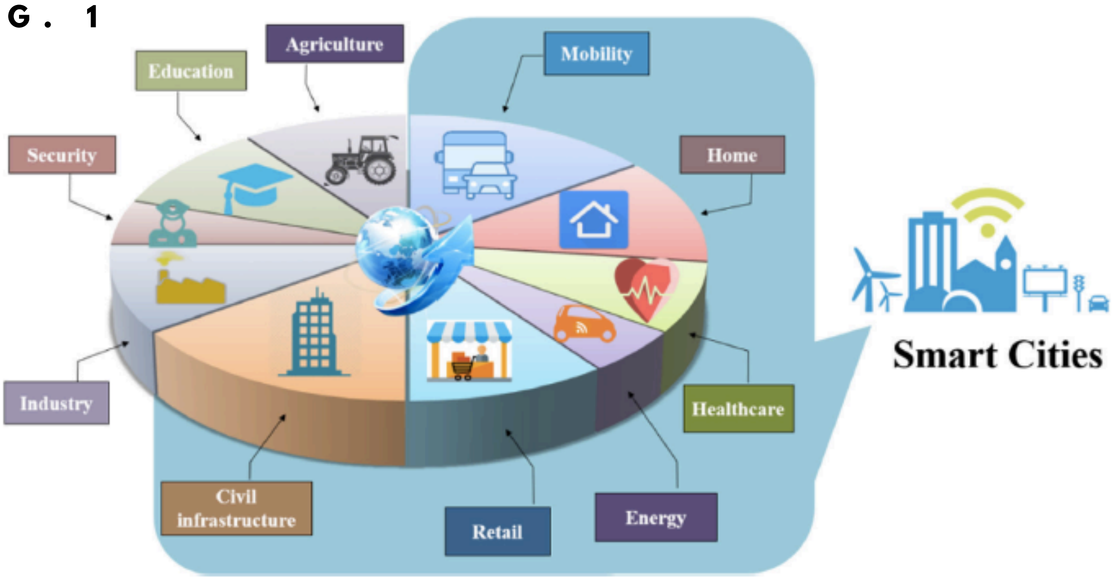
Smart City Technologies Can Provide More Information for Policy Decisions

A smart city is a municipality that utilizes, "intelligent, connected technology solutions that enable cities to provide services more efficiently, consume resources more sustainably, and connect people more effectively to both their government and the rest of the world" (Young, 2017). Smart cities typically use sensors to collect data that they can then use to create more efficient city policies. With more data on how residents and visitors move around, use energy in, and interact with the city, local governments can prioritize certain projects over others.

One example of a smart city technology is in Charlotte, North Carolina, where the city and state's Departments of Transportation installed "EcoCounters" in areas of pedestrian and cyclist traffic. As pedestrians walk along the city's famous Rail Trail, they pass modules about the size of a mall directory that display the numbers of pedestrians and cyclists that have used the trail both that day and that year. The counters track which areas had higher traffic than others. The city and state then used that data to note areas of Charlotte that faced barriers to active transportation and to prioritize those projects (North Carolina Department of Transportation, 2016).

Other benefits of smart city technologies include collecting data on environmental concerns like air quality, energy usage, and public safety (see Fig. 1) (Alavi et al., 2018).

FIG. 1



Source: Alavi et al., 2018

Internet of Things: An Essential Technology for Smart City Initiatives

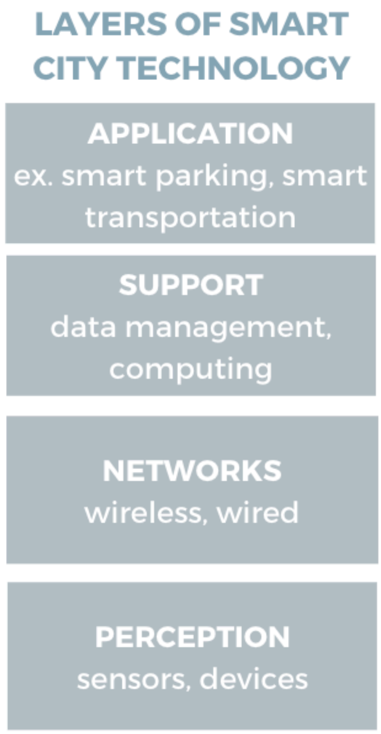
Internet of Things — or IoT — is the implementation of internet onto devices that may not otherwise hold internet capabilities. IoT applications use sensors to collect data, which city government staff can then analyze and use to inform their city policy decisions (Alavi et al., 2018). The Charlotte EcoCounters are an example of IoT technology; they collect data that is sent back to the Charlotte Department of Transportation and North Carolina Department of Transportation (North Carolina Department of Transportation, 2016). Through IoT, devices can "talk" to one another and share data through computing and sensor networks (Alavi et al., 2018).

These IoT devices require a broadband network to facilitate their connection to each other and to the city's data management systems. Cities are increasingly looking to gain control over their own broadband networks as IoT devices become more helpful to cities looking to gather more data and better inform their policymaking processes (Finer, 2017; Alavi et al., 2018).

Technical Structure

There are four layers that comprise smart city technology. These include a base perception layer of sensors that detect activity, a network layer of technology that transmits the sensors' findings, a support layer of computing technology, and a final application layer that provides the services of smart city technologies to users (see Fig. 2) (Cui et. al., 2018). This APP acknowledges the importance of each layer, but I will focus exclusively on the network level throughout this report.

FIG. 2



Information source: Cui et. al., 2018

The network layer directly affects the support layer, which captures and processes vast amounts of data from throughout a city. A city with such technologies would require proper data management and storage that can identify relevant data, trends, and predictions (Yaqoob et. al., 2019). Each layer is necessary because the devices do not have the physical storage capacity to hold and process the data they collect and must send that information through the network to cloud-level technology. It is in the cloud-level where data managers can process and store the information collected (Yaqoob et. al., 2019).

5G

While smart city and IoT technologies function with current broadband speeds, many cities are looking towards 5G as the next fastest speed in the next few years. Faster speeds will become increasingly necessary as cities prepare for technologies that require high-speed, dependable internet. For example, autonomous vehicles will have to make split-second decisions to keep their passengers safe, necessitating a quick and reliable connection. Municipalities already utilize LTE to gather, analyze, and transmit data on city functions such as traffic control, water, and sewer; 5G creates a more reliable network to do so (Levin, 2018).

A 5G network features minimal latency (or lag), high reliability and availability, high data processing rates, a secure and energy-efficient operation, and large system capacity (Larsson et al., 2018). The International Telecommunication Union (ITU)'s radiocommunications sector (ITU-R) and the 3rd Generation Partnership Project (3GPP) will define 5G. 3GPP — a collaboration group of seven telecommunications organizations — decides upon technical specifications while the ITU-R translates those specifications into global standards (Zaidi et al., 2018). Internet operates through spectrum, or electromagnetic waves, similar to the way radio works. LTE internet currently runs on mid- to low-band spectrum, but 5G will operate on high-frequency spectrum (Blake, 2017).

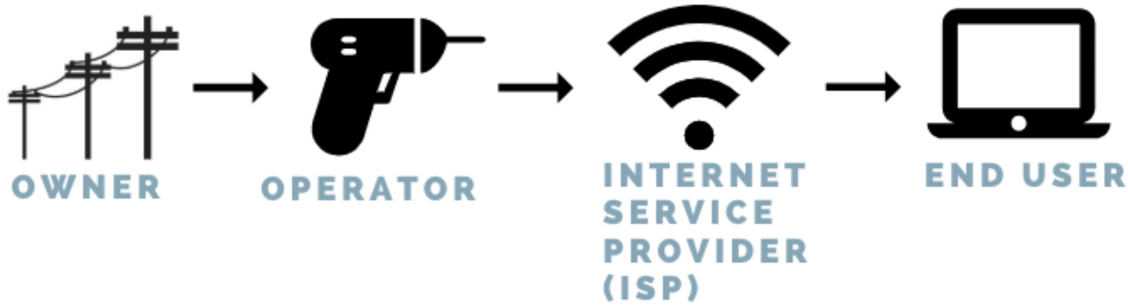
Fiber and Small Cell Infrastructure

For 5G to operate efficiently, it requires a dense network of connected devices called small cells. Small cells are nodes of radio equipment and antennae that often attach to streetlights and other poles (Sullivan, 2018). Small cells also connect to fiber optic networks and currently provide "densified" 4G coverage (Blake, 2017; Alnoman and Anpalagan, 2016). While cable, satellite, and DSL internet are more widely available, fiber internet is generally faster in both download and upload speeds (BroadbandNow, 2018). Municipalities generally look to deploy only fiber internet moving forward (Community Networks, 2015).

Broadband Network Deployment & Operations

There are four primary roles when it comes to deploying and running a broadband network — owner, operator, internet service provider (ISP), and end user (see Fig. 3). The typical model is for a private company to act as the owner, operator, and ISP. Municipalities are increasingly occupying these roles and creating public-private partnerships (P3s) to contract out companies to fill in the other roles.

FIG. 3



Information source: Community Networks, 2016

Deployment and Maintenance Costs

Institutional network deployment requires significant upfront costs such as the physical fiber network materials, construction, electronics, and potential delays to the normal pace of a city including traffic. There are also personnel costs involved — many cities hire consultants to perform the hours of research and analysis required (Community Networks, 2018).

Institutionally-Owned Broadband Savings and Benefits

Broadband — whether institutionally-owned, private, or as part of a public-private partnership — often brings savings and benefits to a community through improved economic outcomes. Martin County, Florida, saved an estimated $30 million over the next fourteen years by building out its own fiber network rather than resigning a franchise agreement with Comcast that was subject to rate hikes (Gonzalez and Mitchell, 2014). A significant benefit and savings point from Martin County was also the faster internet the county's institutions (government buildings, schools, libraries, etc.) experienced at a lower cost. Compared to estimates from AT&T, Martin County's own fiber network for the first five years of deployment was 325.67 percent faster for $100 worth of service. After five years, Martin County's fiber network was 14,161.33 percent faster for $100 worth of service (Gonzalez and Mitchell, 2014). A caveat is that cities use revenue to offset the upfront construction costs. The City of Huntington Beach is looking to do a network for city use, meaning there is, in theory, no revenue.

Cities can provide expanded services with faster, more affordable broadband networks and the technologies that come with it. Cities have used institutionally-owned broadband networks to facilitate virtual field trips for public school students, teach music via online programs, and educate with a greater focus on technology (Community Networks, 2018).

Right-of-Way Agreements

When beginning projects, telecommunications companies and governments — usually local governments — work out right-of-way agreements that allow for the companies to attach their technologies to above-ground poles, underground pipes, and other infrastructure (Cramer, 2016). Establishing rights-of-way for companies to build on pre-existing infrastructure can be an arduous process; there are multiple regulations and permitting processes (Federal Communications Commission, 2010).

Many large telecommunications companies descend from older companies that previously had right-of-way agreements, giving them a leg-up. Sprint, for example, came from the Southern Pacific Railway's communications division, meaning it already had right-of-way permits via that company (Cramer, 2016). Right-of-way contracts are also franchise contracts — agreements that mean a company has rights and privileges to public land that the general public does not. A regulatory contract derives from this — it is a contract between a government entity and a private company that allows the private company to perform functions under the general public under the watch of the government (Cramer, 2016).

Another barrier is to proper information regarding who controls which poles, ducts, conduits, and other infrastructure. The FCC — as the federal point organization for telecommunications companies — works on gathering data as to who owns what so companies can more easily identify who to make deals with and can invest more easily (Federal Communications Commission, 2010).

The FCC under the Trump administration and under the direction of Chairman Ajit Pai passed a declaratory ruling to streamline right-of-way processes to limit the fees city and local governments can charge to telecommunications companies looking to build out in their localities (Federal Communications Commission, 2018). Critics argue that regulations such as these undermine local governments' authorities; local governments oversee and manage accommodations for traffic, street conditions, disruptions to homes and businesses, etc. Local authorities may be entitled to negotiating right-of-way agreements on their own due to this added responsibility (Cramer, 2016).

CLIENT PROFILE

The City of Huntington Beach, California, is located in Orange County, California, about 35 miles south of Los Angeles. It has about 200,000 residents and has a median household income of about $88,000 a year (Data USA, 2019). It is well-known for its tourism and beaches — it was voted the Best California Beach by USA Today and is affectionately known as “Surf City USA” (Visit Huntington Beach, 2019).

The city’s telecommunications landscape features Frontier Communications and Spectrum as its two main providers in residential and business broadband. The top mobile providers are MetroPCS, T-Mobile, AT&T, Verizon, and Sprint (BroadbandNow, 2019).

The City of Huntington Beach gained recognition within the broadband policy community for its agreements with companies like Phillips, Verizon, AT&T, and Mobilitie for small cell deployments (Next Century Cities, 2018). Small cells are nodes of radio equipment and antennae that companies and cities typically attach to streetlights and other poles. Small cells currently provide more connection points for the traditional low-frequency wavelength that our current internet uses, but they can support higher-frequency wavelengths that 5G will require (Sullivan, 2018). To prepare for small cell planning and deployment, the City of Huntington Beach launched an internal telecommunications committee to evaluate permitting processes for attaching new technologies to light poles. The city also collaborated with providers to create pre-approved small cell designs and consulted with other Orange County cities (Graham, 2018).

POLICY OPTIONS

The policy options listed below represent various models that cities have already attempted with varying success — and in some cases, failure — in the United States. Many of the options vary on the spectrum of public investment to private investment in public-private partnerships. The options listed only consider fiber as a viable option for broadband infrastructure due to its high speed and compatibility with Huntington Beach's preexisting small cells and future 5G technology (Community Networks, 2015).

1. Create a dig-once policy to reduce costs on private sector deployment
2. Negotiate leasing agreement for Crown Castle's existing dark fiber
3. Send out an RFP for a shared investment public-private partnership
4. Build out city network with concessionaire model

Create a dig-once policy to reduce costs on private sector deployment

The first option that the City of Huntington Beach can pursue is a dig-once model that involves California's Department of Transportation. This model calls for public coordination with the private sector by allowing companies to deploy network infrastructure whenever the city or state is performing construction projects. Dig-once policies typically apply to deploying fiber infrastructure under roads, but they can also facilitate access to buildings (Hovis et al., 2017). Huntington Beach could implement a dig-once policy to cut costs for companies that may shy away from investment due to high implementation costs.

The idea of the dig-once policy gained national recognition when the FCC's 2010 National Broadband Plan called for legislation enforcing dig-once. The plan advocated for the federal Department of Transportation to only provide federal funding to projects if they included laying broadband while the road was dug up (Federal Communications Commission, 2010). The Government Accountability Office (GAO) then issued a report that a mandatory dig-once policy could result in unused networks, but that dig-once policies generally speaking would significantly reduce the cost for broadband deployment and allow for more access (Trogdon, 2013).

Cities can also use their information on right-of-way and permitting processes as a resource for private sector investment. Providing upfront information can expedite processes and signal willingness to negotiate for companies. Cities can also provide information via open access data online, such as GIS data, existing utilities, and existing fiber assets (Hovis & Afflerbach, 2014).

Case Study: Kansas City, Mo., Kansas City, Kan., and Google Fiber

Kansas City's example of incentivizing private investment demonstrates the key considerations that municipalities should keep in mind when pursuing broadband networks. Google held a competition among cities in 2010 to decide which city would be the first recipient of its new fiber infrastructure, and it picked Kansas City, Kansas, in 2011. Google also decided to expand to Kansas City, Missouri, and neighboring suburbs. Kansas City offered a significant amount of support for the project. The city allowed Google to use public resources, and it facilitated permitting processes and lowered infrastructure access fees (Alizadeh et al., 2017). Kansas City assisted with private investment, but critics argue that the city government went too far and provided "corporate welfare" (Williams, 2017). The city government also forewent an opportunity to gain revenue by charging Google fees for access to its poles. Instead, the city government waived the fees altogether (Alizadeh et al., 2017). The Google Fiber project failed to bring broadband to the populations that it promised despite Kansas City's financial breaks. This case demonstrates that the projected returns on investment must hit a company's bottom line to be worth the costs of deployment; companies do not consider the same intangible benefits like a city does (Trogdon, 2013). The Google Fiber case differs from Huntington Beach's goals since the City of Huntington Beach is not seeking to implement residential broadband access, but the lessons regarding bottom lines prove important considerations when deciding upon a network model for implementing smart city technologies.

Negotiate leasing agreement for Crown Castle's existing dark fiber

Crown Castle — an internet infrastructure company — owns about 21 route miles of dark fiber in the City of Huntington Beach.[1] Dark fiber is a fiber network that is not attached to electronics and is not receiving service (CTC, 2016). Dark fiber is a network that is deployed, but is not in use.

Typically, leasing agreements between cities and companies for dark fiber occur when a city owns the network and charges companies leasing and maintenance fees to use the network as their own and provide service to it. In this model, the city usually turns a profit while the companies charge businesses and residents using their service over the network for a profit (Crawford et al, 2014). Because cities may generally have lower bottom lines than telecommunications companies, the leasing fees for access to dark fiber may be higher when a company sets them.

This dark fiber reaches buildings including schools and municipal buildings — a police station, for example — and areas with many stores and economic activity. A company called Sunesys previously owned the fiber, but Crown Castle acquired Sunesys in 2015 and made Sunesys the arm of the company that deals primarily with public buildings like libraries and schools, enterprise markets, and healthcare buildings (Crown Castle, 2015; CTC, 2016). The city can utilize its interest in developing a municipal-use network to negotiate with Crown Castle over the dark fiber available in the city.

FIG. 4

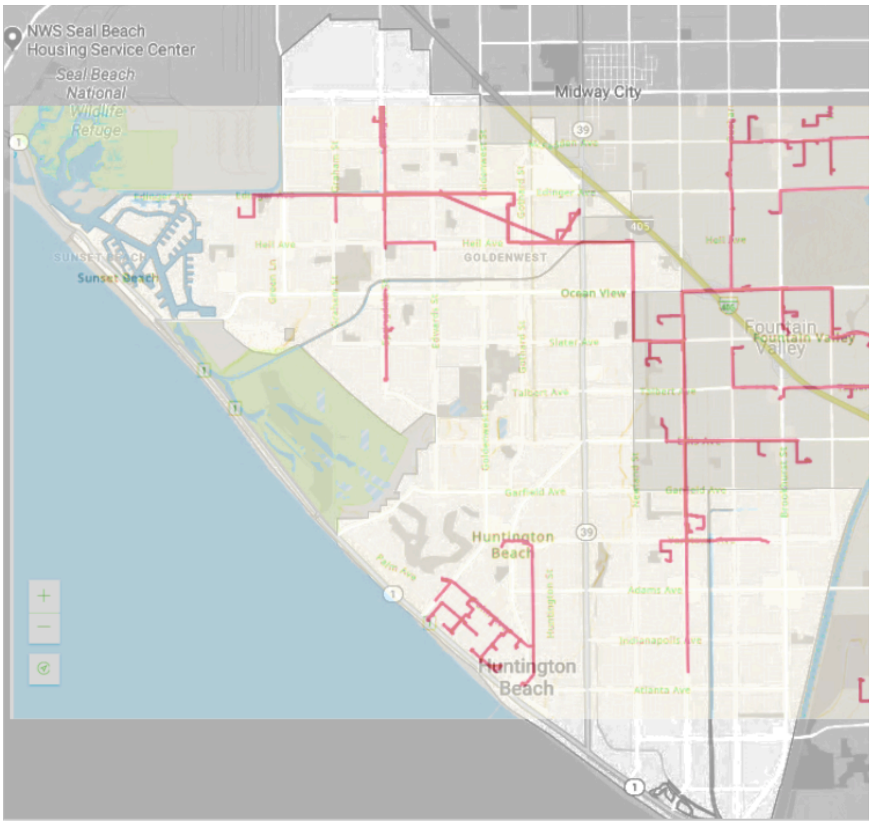


Fig. 4 shows Crown Castle's fiber in red lines, and the city limits of Huntington Beach are within the light gray area (Crown Castle, 2019).

[1] I found this approximate mileage by tracking publicly-available corporate information of Crown Castle's southern California assets.

Build out city's own network with concessionaire model

A P3 that follows the concessionaire model involves the municipal government – Huntington Beach in this APP — investing in a fiber network while a chosen private sector company executes some or all of the design, construction, financing, operations, and maintenance of the network (Hovis et al., 2017). The concessionaire model at its core is a municipal government contracting a private company to perform the work of network deployment. Unlike other kinds of P3s, the concessionaire model requires a significant amount of public risk compared to little private sector risk (Hovis et al., 2017). The concessionaire model usually includes a fixed price that the municipality pays to the company (Federal Highway Administration, 2013).

Case Study: Leverett, Mass.

Leverett, Massachusetts, a small rural town outside of Amherst, developed a concessionaire model and enlisted three companies to help it develop its own broadband network. As a small rural town, Leverett had little interest from large ISPs to invest in the community due to the cost of deployment. At a town meeting, a broadband committee proposed that Leverett raise the property tax by 6 percent to save money for the network, which overwhelmingly won in a town vote (Lucey & Mitchell, 2013).

Leverett employed three different companies to carry out the network construction, act as the network operator, and ISP. Millennium Communications Group — the network builder — had an upfront and straightforward agreement. Holyoke Gas & Electric and Crocker Communications — the network operator and ISP, respectively — have continuing agreements with Leverett. While Leverett sets the prices for service, Crocker collects an additional monthly fee from users for service which it uses for profit and to pay Holyoke for its network operations (Lucey & Mitchell, 2013). While this case study focuses on residential broadband, its approaches to the concessionaire model demonstrate valuable lessons for how a city and the private sector can interact and create deals that last.

In deployment, the concessionaire model calls upon the city to give right-of-way privileges to a private partner in order to deploy. This brings in aspects of the incentive structure model; cities can make it easier for private companies to deploy broadband. The concessionaire model can also differentiate between how the private partner receives revenue; they can receive one-time payments, or they can receive ongoing payments as the network operates (Hovis et al., 2017; Lucey & Mitchell, 2013).

Under this option, Huntington Beach would recruit partners to invest in a P3 agreement in which the city and a company or companies would share investments and risks. This kind of shared investment P3 calls for the city and the company(ies) to allocate the capital, operating, and maintenance costs of a broadband network according to each organization's strengths and weaknesses (Hovis et al., 2017).

The value of balanced responsibility in a P3 ensures that both parties involved have a large enough stake in the project that it is unfavorable for either to back out. For private partners, a balanced P3 could mean less upfront capital and more opportunities for future revenue (Hovis et al., 2017).

Balanced P3s provide significant challenges for the public and private sectors due to clashing interests on either side. Public partners take into consideration positive externalities that can benefit the community such as improved outcomes in education or health. Private

Case Study: Urbana and Champaign, Ill.

The cities of Urbana and Champaign, Illinois, in partnership with the University of Illinois developed the Urbana-Champaign Big Broadband Project (UC2B). UC2B included other local stakeholders including an ISP, a telephone company, and the area's mass transit authority. Urbana and Champaign built out a municipally-owned and -operated network that connected the city government buildings, libraries, schools, youth centers, and low-income neighborhoods (Lucey & Mitchell, 2013). Upon deciding to expand the network, Urbana and Champaign opted to seek out a private sector partner. UC2B became a not-for-profit entity, and selected the ISP iTV-3 through a request for proposal (RFP) process (UC2B, 2014). UC2B set out a clear set of three non-negotiable principles in the RFP process — the network had to be high-speed fiber, have open access to competition, and reach all members of the community (Lucey & Mitchell, 2017). The terms of the partnership included that iTV-3 would construct the network and own the last-mile infrastructure to the houses, meaning the fiber infrastructure that goes directly into users' homes. UC2B also set up contingency plans in its partnership with iTV-3 so it would be the first to purchase iTV-3's equipment and infrastructure in the case that the partnership did not function. UC2B eventually opted not to buy the equipment, in which case the infrastructure sold to another small ISP that was able to more quickly expand (Lucey & Mitchell, 2017). The case of UC2B demonstrates how a city government can make straightforward demands for its broadband network and cooperate to find a partner that is willing to attend to those needs.

partners are likely to care more about the bottom line and what specific benefits a network can bring to their company (Lucey & Mitchell, 2016).

The public and private sectors' values may also clash in regard to timeliness. Businesses tend to desire faster returns on investment (ROIs), while local governments can have a longer payback period and may be able to withstand longer periods of time without ROIs (Lucey & Mitchell, 2016).

With this balanced P3 model, Huntington Beach would seek out local companies with which it can enter negotiations. The city would have to take account of its own strengths and weaknesses as an institution and identify a partner who could fill in potential weaknesses. The ideal arrangement would be for the City of Huntington Beach and the private sector to split investment equally with 50 percent on either side.

The following criteria — cost, ease of negotiation, and opportunity for future growth — provide the framework for the option evaluations. These criteria aim to provide a comprehensive outlook on what factors will carry the most weight into Huntington Beach's decision on identifying a broadband deployment model that facilitates smart city technologies. Each criterion also identifies the type of information that will be integral in evaluating each policy alternative. The cost criterion will rely solely on quantitative measures. The other criteria's measures will come from anecdotal and qualitative evidence derived from case studies and interviews and will rank policy options on a scale of low, medium, and high. Cost is the most important criterion followed by ease of negotiation. Opportunity for future growth is the least important criterion because the City of Huntington Beach's current priorities do not lie with providing municipal broadband service to businesses and residents.

Cost — in 2019 dollars

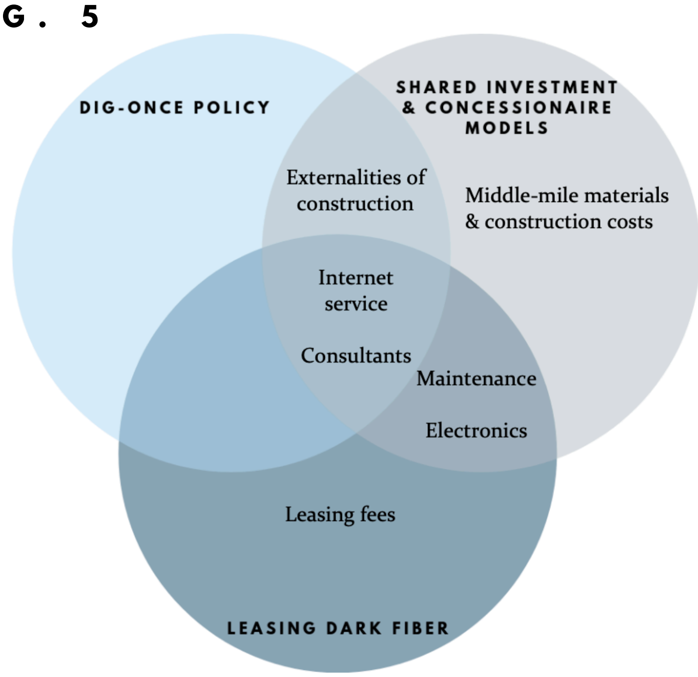
Ease of Negotiation — scale of high, medium, low

Opportunity for Future Growth — scale of high, medium, low and 2019 dollars when applicable

Cost

This criterion will assess the financial costs of each alternative. Many options share similar cost buckets, but some require cost buckets that are unique to individual options (see Fig. 5). This criterion will evaluate all options by the estimated net present value of internet service and approximate cost of consultants. For the leasing fees option, shared investment model, and concessionaire model, I will

FIG. 5



provide the estimated costs for the net present value of network maintenance over 20 years and network electronics. The shared investment and concessionaire models will include approximate costs for the materials and construction of a middle-mile network throughout targeted areas of Huntington Beach. The dark fiber leasing option will include the projected net present value of leasing fees over 20 years. The estimated cost of externalities — such as productive time lost in traffic as a result of construction — has not been calculated due to the lack of information regarding length of construction. This criterion evaluates ***cost based on dollar amounts***. Cost estimates come from reports and feasibility studies for Huntington Beach and other cities by consulting groups including CTC Technology & Energy and Magellan Advisors.

For complete costing tables, please refer to Appendix B.

Ease of Negotiation

This criterion will evaluate how easy or difficult it will be to negotiate with companies over contracts and leasing agreements. The data on negotiation feasibility will come from case studies of other cities' successes and failures as well as interviews with cities who have come to agreements with companies before. The criterion will rank alternatives on a scale of ***low***, ***medium***, and ***high*** ease of negotiation.

Opportunity for Future Growth

This criterion will evaluate how easily the option would allow the City of Huntington Beach to expand the network for potential business and residential use in the future. The city expressed that it is currently interested in municipal use only, but many municipal broadband projects opt to move towards expansion in an effort to bring in more revenue. Case studies of other municipal broadband projects will inform this criterion's evaluation of the different options. This criterion will rank the alternatives on a scale of ***low, medium,*** and ***high*** opportunity for future growth and will provide ***potential revenue in 2019 dollars*** when applicable.[2]

For tables projecting potential revenue, please refer to Appendix C.

[2] Potential revenue numbers come from data from Ammon, Idaho's open access network (Strategic Networks Group, 2017).

ASSUMPTIONS ACROSS OPTIONS

An initial assumption I made was that the City of Huntington Beach would only pursue a broadband network of fiber optic infrastructure. This is due to fiber's reputation as the broadband infrastructure that offers the highest speeds (Community Networks, 2015).

To calculate costs for internet service, I used the current prices that the City of Huntington Beach pays and assumed a four percent discounting rate that I found was common in other feasibility studies (Magellan Advisors, 2016). I also assumed that the city would utilize those rates for 20 years to match the common use of 20 years as a benchmark for discounting rates (CTC, 2016).

Another assumption I made was that the City of Huntington Beach would want to hire consultants to help write specific policies and agreements involved with each option. I gained this assumption through conversations with professionals in the internet policy space and the fact that many of my resources were studies by consulting groups such as CTC Technology & Energy and Magellan Advisors.

Many feasibility studies for broadband networks include the costs for outside plants (OSPs), or the hubs of infrastructure required to connect fiber to businesses and residences. Because the City of Huntington Beach is currently focusing on a city-only network, the costs for constructing OSPs and connecting them to buildings were not considered. The cost in 2019 USD for connecting the middle-mile network to the premises is about $5,500 per building; the city can multiply that approximate cost by the number it would wish to connect in order to find the total cost for constructing fiber to the premises. This cost includes OSPs, central network electronics, and other variable costs (CTC, 2016). I did choose to utilize the cost of electronics for municipal buildings from the City of Ontario, California's Fiber Optic Master Plan (City of Ontario, California, 2013).

For a full list of assumptions throughout the entire project, please refer to Appendix A.

Create a dig-once policy to reduce costs on private sector deployment

Cost

The total cost for this option is **about $835,000.** These total costs include the cost of consultants (about $52,000) and internet service provision (about $783,000). While I assumed that the cost for internet service provision would remain the same as the City of Huntington Beach's current costs, this option may lend itself to higher service rates so the company that Huntington Beach goes with can meet its bottom line.

This option would also include cost of loss of productive time and environmental damage from construction.

Ease of Negotiation

Due to previous successes in dig-once policies and the opportunity for private sector-led investment, this option ranks as **high**. A dig-once policy would likely experience less pushback from the private sector compared to other options because it preserves private sector autonomy in deployment and cuts construction costs. The city may have to face some private sector backlash due to how long it may take to coordinate construction projects with the companies, but the city can still reserve the option for companies to pay the right-of-way fees and construction costs for deployment on the companies' schedules. However, this alternative scenario would not be any different from present trends.

Opportunity for Future Growth

This option ranks as **low**. The City of Huntington Beach would not own the network in this model, and therefore the city would not have control over expansion into business or residential use. The city could possibly add elements to the public-private partnership it would have with the company that owns the network to expand to business and residential use, but this kind of agreement would go beyond the scope of this option and the city's dig-once policy.

Negotiate leasing agreement for Crown Castle's existing dark fiber

Cost

The total estimated present value cost for leasing Crown Castle's pre-existing dark fiber is **about $6 million**. The main advantage to pursuing a dark fiber leasing agreement is the elimination of the upfront costs of deploying a fiber network. The most common model of dark fiber leasing is indefeasible rights of use (IRU) agreements in which lessees pay an upfront fee per strand per mile (also known as "strand miles"). Under the IRU model, the lessee also pays a monthly maintenance fee per mile (CTC, 2016). The estimated cost for leasing fees is about $4.6 million over a 20-year period. This cost assumes that Crown Castle's fiber has 96 strands and about 21 miles of coverage (CTC, 2016; Crown Castle, 2019a). The monthly maintenance fees will cost an estimated present value of $76,00 under the assumptions of a 20-year contract and a four percent interest rate (CTC, 2016; Magellan Advisors, 2016).

The total cost also factors in the estimated cost of utilizing consultants (about $52,000) and the likely present value cost of service based on the City of Huntington Beach's current service prices (about $783,000 over 20 years at four percent interest) (Community Networks, 2017).

Ease of Negotiation

This option ranks as **medium** for ease of negotiation due to Crown Castle's expressed willingness to work with the City of Huntington Beach and previous work with municipalities such as Palo Alto, California; Baltimore, Maryland; and Vail, Colorado (Crown Castle, 2019b). The hesitation for classifying this option as having a high ease of negotiation is the uncertainty of what negotiations may actually look like. There is a lack of evidence regarding the current status of dark fiber and its current use (CTC, 2016). There is also a lack of evidence regarding failed or tense negotiations between Crown Castle and other municipalities.

Opportunity for Future Growth

This option scores as **medium** for opportunities for future growth. Crown Castle's fiber covers about 21 route miles of Huntington Beach, but the network can still expand to other business corridors and residential areas (CTC, 2016; Crown Castle, 2019a). The city continues to have the option of building out more of a network to businesses and residents.

Build out city's own network with concessionaire model

Cost

The total cost for the city to build out its own network would be **approximately $7.8 million**. This option is the most expensive because it calls for the city to invest the most cost burden and contract services to carry out the different facets of network development and deployment.

A study by CTC Technology & Energy concluded that a high-level estimate of the costs for materials and construction in certain focus areas for a middle-mile network would be about $5.7 million in 2019 USD. The high-level cost estimate for the core electronics necessary for a network in Huntington Beach is about $542,000.[3] The approximate net present value of expected maintenance costs over 20 years at a four percent discount rate is about $771,000. Annual maintenance costs are about one percent of the construction costs, so the City of Huntington Beach can expect to pay about $57,000 a year in maintenance (CTC, 2016).

Similar to the other options, the city can expect an approximate cost of $52,000 for consultants and an estimated net present value of $783,000 for internet service. This option would also include cost of externalities such as loss of productive time and environmental costs as results of construction.

Ease of Negotiation

The ease of negotiation for this option is **medium** to reflect the private sector's historic opposition to cities putting public money towards broadband investment, but also the lack of negotiation involved with determining what the city needs a contractor to perform.

The private sector has historically pushed back on municipal broadband investment through lobbying power. This famously happened in the City of Wilson, North Carolina. Wilson built out its own fiber broadband network after companies did not express interest in providing internet to the city's businesses and residents (Schwarze, 2018). Following the deployment, companies lobbied the North Carolina state legislature, which then passed laws that restricted Wilson's network expansion

[3] This number comes from the 2013 cost estimates for core electronics for Ontario's project. The CTC study also found costs for electronics, but the report's calculated costs included electronics expansion to businesses and homes without differentiating between necessary electronics for a municipal use network.

(Schwarze, 2018). This example demonstrates the lengths that the private sector may go in order to combat publicly-owned networks.

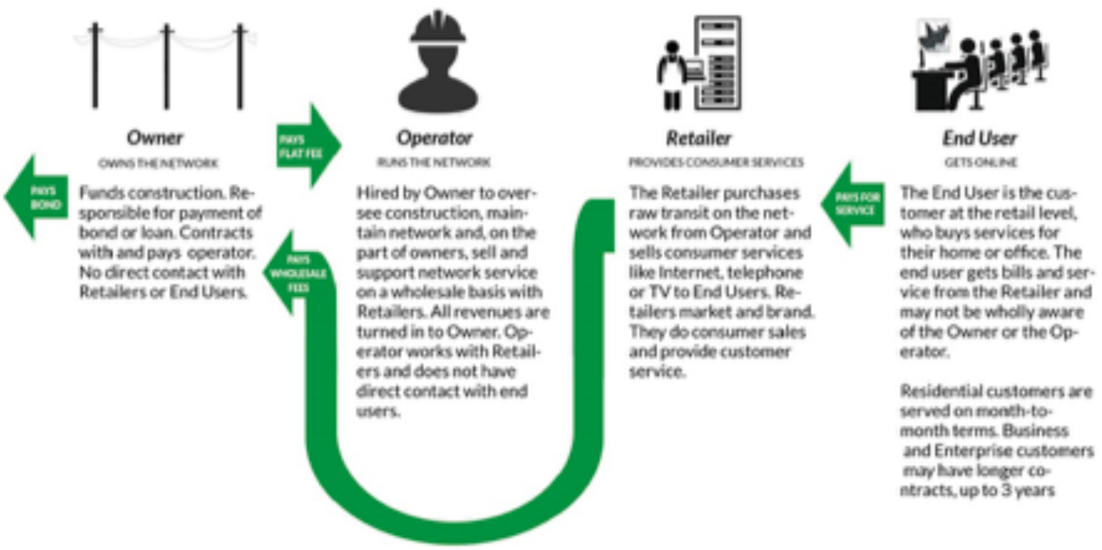
This case study reflects what many municipalities have experienced and would push the ease of negotiation towards low if it were not for the City of Huntington Beach's current goal to use the network for municipal use only. The city would not be creating direct competition for end users in the same way that the Wilson network did. Considering this, the private sector may be more open to having the city own the fiber network that only the city uses.

Opportunity for Future Growth

This option scores as **high**. This option would provide the City of Huntington Beach ample room for expand and monetize its network if it wishes. This option would also best position Huntington Beach to pursue an Open Access Network (OAN) model. Under this model, a municipality builds out a fiber network that ISPs can connect to in order to bring service. Municipalities typically partner with a private company to provide the physical infrastructure and the construction. In an OAN model, cities also usually lease out access to the network to ISPs that can then use it to provide internet service (Leerssen & Talbot, 2017).

Cities can develop OANs in two or three layers. Under the two-layer system, the city owns and operates the network while ISPs provide the internet service. The three-layer system includes another party that operates the network (see Fig. 6) (Community Networks, 2016).

FIG. 6



Source: Peggy Dolgenos, Cruzio Internet

If the City of Huntington Beach pursued an OAN model, the **estimated revenue per year would be about $16 million.** This estimation comes from inflation-adjusted pricing models from Ammon, Idaho, assuming a take-rate of 40 percent of the households in Huntington Beach and two ISPs operating on the network. This is with the caveat that building fiber-to-the-premises (FTTP) will come at a significantly larger cost to the city; CTC Technology & Energy estimates that it could cost the city up to about $209 million to build fiber-to-the-premises for business and residential use.

Cost

The total estimated cost for this option would be **$3.9 million**. This option includes the same costs as the concessionaire model; in an ideal situation, the city would reach agreements with companies that allow for a perfectly balanced shared investment of 50 percent on both sides. If the city pursued shared investment models that ended up with a 60 percent/40 percent split with the city taking on the majority of the burden, it would cost about $4.7 million. For a 70 percent/30 percent split, it would cost about $5.5 million. For an 80 percent/20 percent split, it would cost about $6.3 million. Because the theoretical balanced model would be 50/50, this APP will consider the split to be 50 percent on either side. However, the cost of externalities from construction would remain the same as in the concessionaire model.

Ease of Negotiation

The ease of negotiation for this option is **uncertain** given the unknown nature of which companies will respond to the request for proposal. In the neighboring city of Ontario, California, the city government had an easy negotiation process due to the companies that responded to their RFP. Inyo Networks — which ultimately became the network operator and ISP for Ontario — was a smaller, local company that was eager to reach an agreement with the city (Chang, interview, 2019). As a result, Ontario's negotiation process with Inyo Networks was easy to navigate. It took about four to six months, but negotiations with companies that have previously worked with municipalities may take less time. Ontario's negotiations with Inyo Networks were lengthier because working with a municipal government was a new structure and business plan for the company (Chang, interview, 2019).

The private sector has also made it difficult for cities to pursue shared investment models in past case studies. In Philadelphia, Pennsylvania, large incumbent providers Verizon and Comcast played major roles in curbing the city's attempt to implement a municipal network. One tactic they used was to immediately offer lower-cost service once Wireless Philadelphia (the municipal network) released its projected prices. The companies also demonstrated intense opposition through lobbying on the city and state government levels (Breitbart, 2007). The lobbying efforts failed to ban Philadelphia from using public money towards a broadband network, but the opposition led the city to stop using public money to avoid further issues with incumbents (Breitbart, 2007). The Philadelphia example demonstrates the pressures that incumbent providers may put onto cities to stymie municipal network attempts.

In a study by the consulting group CTC Technology & Energy, companies like Crown Castle, AT&T, and TelePacific have expressed interest in working with the City of Huntington Beach on a potential project (CTC, 2016). Verizon FiOs is also a notable incumbent provider in Huntington Beach that may be a potential roadblock to deploying city fiber due to its history of attempting to block municipal deployment. Due to the varying histories of RFPs and private sector responses to municipal network initiatives, this option's ease of negotiation is *uncertain.*

Opportunity for Future Growth

This option scores as **high** for opportunity for future growth because it positions the City of Huntington Beach such that it can opt to provide internet service to its businesses and/or residents if it wishes. In the example of Ontario, the city's original intention was for the network to provide connectivity to municipal buildings for applications such as emergency services, water services, camera systems, and traffic control (City of Ontario, California, 2013).

If the City of Huntington Beach were to pursue a similar OAN model with shared investment, the **estimated annual revenue would be about $8 million.** This estimate assumes Huntington Beach shares a 50/50 split with its partners, 40 percent of the households in Huntington Beach opt to use the OAN, and two ISPs operate on it. This estimated revenue also uses prices for connectivity and leasing fees from similar markets to Huntington Beach. The revenue estimate does not take into account what profits Huntington Beach may garner; FTTP attachments would cost an estimated $209 million for the City of Huntington Beach alone, but assuming a 50/50 investment split, it would cost about $104.5 million (CTC, 2016).

OUTCOMES MATRIX

		DIG-ONCE	DARK FIBER	SHARED INVESTMENT	CONCESSIONAIRE
COST	INTERNET SERVICE	$782,802.80	$782,802.80	$391,401.40	$782,802.80
	MAINTENANCE	--	$75,569.10	$385,783.85	$771,567.70
	LEASING FEES	--	$4,595,791.02	--	--
	MIDDLE MILE EXPANSION (CONSTRUCTION & MATERIALS)	--	--	$2,838,665.08	$5,677,330.16
	EXTERNALITIES	$X	--	$X	$X
	ELECTRONICS	--	$542,356.60	$271,178.30	$542,356.60
	CONSULTANTS	$51,852.56	$51,852.56	$51,852.56	$51,852.56
	TOTAL	$834,655.36 + $X	$5,996,519.51	$3,887,028.63 + $X	$7,825,909.82 + $X
EASE OF NEGOTIATION		HIGH	MEDIUM	UNCERTAIN	MEDIUM
OPPORTUNITY FOR FUTURE GROWTH		LOW	MEDIUM	HIGH; ABOUT $8 MILLION A YEAR	HIGH; ABOUT $16 MILLION A YEAR

Create a dig-once policy to reduce costs on private sector deployment

Based on the evaluative criteria, I recommend that Huntington Beach pursue a dig-once policy that would reduce costs on the private sector's broadband deployment efforts. This policy would incentivize a company to build out a fiber network that the city can then use to implement its smart city initiatives. This policy had the smallest cost burden on the city and also had the highest ease of negotiation among the options. It had the lowest opportunity for future growth, but given Huntington Beach's current focus on using the network for smart city initiatives rather than for business and residential use, this low score is not a deal-breaker. However, the cost reduction for the private sector may incentivize more affordable, high-speed broadband that businesses and residents can utilize if the private sector chooses to build out to them.

One of the main issues with the dark fiber option is the lack of information around Crown Castle's expectations for a leasing agreement. The cost calculated for leasing and maintenance fees for an IRU agreement comes from the average of high and low estimates for market rates of leasing fees, but Crown Castle may want to include higher fees than market rate. If the city is confident that negotiating with Crown Castle over a leasing agreement would be easy, it could choose to pursue this option to supplement the shared investment model or concessionaire model options. The dark fiber covers many economic areas and school areas in the city, but it may not reach all the municipal buildings or key places where the city may want to develop smart city technologies.

The shared investment model was not the recommendation due to the cost it would bring upon the city and potential for pushback from the private sector. It would, however, provide a good basis upon which the city could grow a network if it wishes to expand to businesses and residents in the future. If the City of Huntington Beach is eager to have a publicly-owned network, the shared investment model would be the best option. The city already has companies interested in working with it, and it already has a history of creating mutually-beneficial agreements with companies such as the small cell agreements with Phillips. If the city wants to pursue this kind of model instead, it could still implement dig-once policies to reduce construction costs on itself and its partners. It could also attempt to negotiate with Crown Castle to coordinate where the city could pursue a leasing agreement rather than building out a network if it wishes. However, even if the city pursues these potential cost-saving mechanisms, the city would still carry more of the burden of the cost than it would with the recommended option.

The concessionaire model is not the recommendation because it is the costliest of the options and could also face pushback from the private sector. It would also allow for the future growth of the network, but this consideration does not override the costliness of the deployment. Similar to the shared investment model, the concessionaire model could implement facets of the dig-once and dark fiber leasing models to reduce the cost burden on the city. These cost reductions would still leave the concessionaire model the costliest of the options.

IMPLEMENTATION

The city should carry out its dig-once policy by first communicating with companies over expectations and potential service charges. Huntington Beach can also streamline processes within the city to ensure the staff has the channels in place to enforce dig-once. After the necessary preparations, the city should issue an RFP and develop construction plans with companies based on the city's standing road work schedule. During and after deployment, the city should begin considering strategies for gathering and managing data that it can use for smart city initiatives in the future.

- Communicate with companies
- Streamline internal processes and policies
- Seek out partners
- Develop construction plans and coordinate road work schedules
- Focus on strategies for collecting and analyzing data that can better inform city policy decisions

To implement the dig-once policies, the city should begin by connecting with interested companies to demonstrate its goals and interest in a fiber network for smart city technology use (BroadbandUSA, 2017). Companies such as Crown Castle, AT&T, and TelePacific have already demonstrated interest in expanding networks within the city, so those companies may be ideal places to start conversations (CTC, 2016).

As part of conversations with companies, the city should begin to gather information as to what service charges may look like if it chooses to work with a specific company. The costs calculated for the net present value of internet service over 20 years derive from what the city currently pays for internet service; it is plausible that companies may raise prices to account for more data traffic associated with smart city technologies or to offset deployment costs.

The city can also prepare to implement a dig-once policy by streamlining internal processes within the city. The city should ensure that it has the communication networks in place to coordinate roadwork projects with the offices and individuals that work more directly with companies. The city should also draft a streamlined dig-once policy and sample right-of-way agreements to use with companies. This is where the city can begin to bring in consultants to help draft these documents. The city can also create resources for companies at this point, such as lists of contractors that the companies can hire to perform the construction (BroadbandUSA, 2017).

After establishing the dig-once policy and the internal processes necessary to enforce it, the city can issue an RFP to recruit companies that want to carry out the construction. After consulting with the respondents, the city can begin coordinating on construction plans and integrating road work plans ahead of deployment (BroadbandUSA, 2017). A dig-once policy necessitates that other construction happens in the first place, so the city should be prudent with communicating schedules with the companies.

Since the City of Huntington Beach is planning on using the network for smart city technologies, the city will also have to seek out recommendations and best practices for data gathering and management strategies. The city should also consider what specific smart city technologies it wants to implement with the network and the costs and benefits associated with those strategies. One example of a smart city strategy is using sensors to track pedestrian and bike traffic throughout the city; this data can allow the city to determine how people move throughout the city and use that information to create infrastructure that can facilitate more active living. Another example is using sensors on municipal dumpsters to track how full they are. The city can use that data to determine when it actually needs to empty the dumpster. This strategy can expedite public works processes and allow the city to use its public works employees on other projects rather than on waste disposal. After planning the network level, the city will have the baseline from which it can begin to address the other layers of smart city technologies (sensors, support, and application). The network will facilitate these layers so the City of Huntington Beach can better inform, enforce, and evaluate city policies as it moves into next-generation internet technology.

APPENDIX A

List of Assumptions

All Options

Type of network infrastructure	Fiber optic
Internet service costs will remain the same	$57,600 a year
Time frame	20 years
Interest rate	4%
Consultants	$50,000 in 2016 USD; $51,852.56 in 2019 USD
Not using CTC's estimates for OSP, central network electronics, and variable costs for FTTP	
All costs change with the CPI every year	

Leasing Dark Fiber

Number of strands in fiber wires	96
Number of route miles of Crown Castle fiber	21
Type of leasing agreement	Indefeasible Rights of Use (IRU)

Concessionaire Model

Electronics costs for city use only	Same as in Ontario, California, case study
Maintenance costs	1% per year of what the total construction & materials cost
City/private sector investment split	100% / 0%

Shared Investment Model

Electronics costs for city use only	Same as in Ontario, California, case study
Maintenance costs	1% per year of what the total construction & materials cost
City/private sector investment split	50% / 50%

Projecting Potential Revenue

Number of ISPs that will use the network	2
"Take rate" what percentage of households and businesses will decide to use the network	50%
Utility fees, taxes, and monthly leases	Same as in Ammon, Idaho, case study

APPENDIX B

To access full costing spreadsheet, please go to https://tinyurl.com/AnnaHigginsAPP.

Total Costs Table

DIG ONCE		LEASING		CONCESSIONAIRE		SHARED INVESTMENT	
CONSULTANTS (UPFRONT)	$ 51,852.56	Consultants (upfront)	$ 51,852.56	Consultants (Upfront)	$ 51,852.56	Consultants (upfront)	$ 51,852.56
INTERNET SERVICE	$782,802.80	Internet Service	$ 782,802.80	Internet Service	$ 782,802.80	Internet Service	$ 782,802.80
LEASING FEE	$ -	Leasing Fee	$4,595,791.02	Leasing Fee	$ -	Leasing Fee	$ -
MIDDLE MILE (UPFRONT) (MATERIALS & CONSTRUCTION)	$ -	Middle Mile (upfront) (materials & construction)	$ -	Middle Mile (upfront) (materials & construction)	$ 5,677,330.16	Middle Mile (upfront) (materials & construction)	$ 5,677,330.16
MAINTENANCE	$ -	Maintenance	$ 75,569.10	Maintenance	$ 771,567.70	Maintenance	$ 771,567.70
ELECTRONICS	$ -	Electronics	$ 542,356.60	Electronics	$ 542,356.60	Electronics	$ 542,356.60
EXTERNALITIES	X	Externalities	$ -	Externalities	X	Externalities	X
TOTAL	$834,655.36	**TOTAL**	$5,996,519.51	**TOTAL**	$7,825,909.82	**TOTAL**	$7,774,057.25
						If city invests 50%	$3,887,028.63
						If city invests 60%	$4,664,434.35
						If city invests 70%	$5,441,840.08
						If city invests 80%	$6,219,245.80

Leasing Fees Costs Table

		2016 USD	2019 USD
UPFRONT PAYMENT PER STRAND MILE	Low estimate	$ 1,500.00	$ 1,588.72
	High estimate	$ 2,388.00	$ 2,529.24
	Average	$ 1,944.00	$ 2,058.98
UPFRONT PAYMENT PER STRAND MILE X 96 STRANDS	Low estimate	$ 152,516.75	$ 168,863.57
	High estimate	$ 242,806.67	$ 268,830.81
	Average	$ 197,661.71	$ 218,847.19
		TOTAL (with 21 miles)	$ 4,595,791.02

Current Internet Service Costs Table

	PER MONTH	PER YEAR
COGENT COMMUNICATIONS	$ 2,500.00	$ 30,000.00
CENTURYLINK	$ 1,500.00	$ 18,000.00
TOWERSTREAM	$ 800.00	$ 9,600.00
TOTAL	$ 4,800.00	$ 57,600.00

Projected Present Value of Internet Service Charges Formula

$$PV = \frac{\$57{,}600}{(1 + 0.04)^{20}} = \$782{,}802.80$$

Leasing Fees Table

	2016 USD	2019 USD
MAINTENANCE COST PER MILE	$ 250.00	$ 264.79
PV OF MAINTENANCE FOR 20 YEARS, 4% INTEREST PER MILE		$ 3,598.53
TOTAL PV OF MAINTENANCE		$ 75,569.10

Maintenance Costs for Concessionaire and Shared Investment Models

Maintenance= 1% of the total cost of construction per year	*Annual Maintenance Costs*	*Present Value of 20 years of Maintenance Costs*
	$ 56,773.30	$ 771,567.70

Middle-Mile Expansion Estimates Table

	2016 USD	*2019 USD*
Bella Terra	$ 448,000.00	$ 474,496.56
Gothard Industrial Corridor	$ 1,200,000.00	$ 1,270,972.93
Holly-Seacliff	$ 352,900.00	$ 373,771.96
Main Street and Pier	$ 305,400.00	$ 323,462.61
Northwest Industrial Area	$ 2,842,600.00	$ 3,010,723.04
Southeast Opportunity Area	$ 211,400.00	$ 223,903.06
Total	$ 5,360,300.00	$ 5,677,330.16

Ontario Core Electronics Costs

2013 USD	2019 USD
$ 497,029.00	$ 542,356.60

APPENDIX C

Potential Revenue Projections from OAN

	Open Access Network Fees	*2016 USD*		*2019 USD*	
END USERS' FEES	Monthly Utility Fee	$	16.50	$	17.48
	Monthly Tax	$	17.00	$	18.01
ISPS' FEES	Monthly Lease Fee for ISPs	$	49.50	$	52.43
UPFRONT COSTS FOR ISPS TO ENTER	Based on Ammon, Idaho model	$	100.00	$	105.91
	Based on UTOPIA model	$	5,000.00	$	5,295.72

Estimated Revenue from Open Access Network (if implemented)		
Residents' fees (utility + tax)	$	35.48
Profit from utility fees & taxes/month	$	1,349,195.22
Profit from utility fees & taxes/year	$	16,190,342.68
Concessionaire: Total Est. Revenue/Year	$	16,191,600.95
Shared Investment: Total Est. Revenue/Year	$	8,095,800.47

Cost of fiber-to-the-premises (FTTP) buildout (based on CTC 2016 Broadband Strategic Plan)	**2016 USD**	**2019 USD**
Total Est. Cost (OSPs, Central Network Electronics, and Variable Costs)	$197,732,610	$209,427,329

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