Scaling Smart Cities:
An Analysis of how Small Cities Implement Smart Technologies

By

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Abstract

Smart cities have become an incredibly pertinent and intriguing topic across the United States over the last decade. While there is a lot of excitement, many of the testing and research of this new trend has occurred in large cities. This study aims to examine how small cities implement these smart technologies. Furthermore, this study aims to figure out the common obstacles, technologies, and strategies small cities use to incorporate these projects. These research questions are explored through the lenses of the Top-down/Bottom-up model of project implementation and the Quadruple Helix Model of innovation creation. The findings of this study suggest that small cities have similar problems finding funding, obtaining skilled labor, and identifying proven smart city implementation strategies. This study also found that small cities generally implement city management, utility, and transportation technologies when working on smart city projects. Small cities were also found to use similar strategies when implementing smart city technologies. These strategies were; acquiring state and federal funding, collaborating with private industry, and interacting closely with their constituents. This study also found that small cities feel as if there are some big benefits that come with being their size. These benefits are; better interaction with citizens, less bureaucratic inflexibility, and a more controlled testing environment for piloting projects. This study recommends that small cities take a more proactive strategy by approaching government, industry, and university entities for help in implementing smart city projects. This study also recommends that government, industry, and university entities leverage small cities more and take advantage of their beneficial attributes.

Acknowledgments

I would like to thank my thesis advisor, Dr. Arcot Rajasekar, for the instruction he provided me during this project. I would also like to thank Dr. Mohammad Jarrahi for his guidance during this project. Special thanks to both the city representatives that were kind enough to let me interview them and to everyone who assisted me in proof reading my paper. And to my parents for their love and support.

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Introduction

Over the last few centuries, there has been a growing trend of humans moving out of rural countrysides and into cities and urban areas. Today, more than 50 percent of the world's population lives in cities and urban areas. The United Nations (UN) project that this number will increase to 70 percent by the year 2050 due to the rising global population and the continued migration of people from rural areas into urban areas (2010). There is much debate over the exact reasons for this movement, but city planners and managers all agree that cities in the United States and across the globe are not prepared for the influx of people predicted to be in cities by the year 2050 (Cohen, 2004). One solution that has been proposed to this problem has been the creation and incorporation of interconnected smart cities. The definition of smart city that will be used throughout this paper is a city that, "invests in human and social capital, traditional and modern (ICT) communication infrastructure, fuel sustainable economic development, and a high quality of life with a wise management of natural resources, through participatory action and engagement" (Caragliu and Nijkamp 2009). These cities will use ground breaking sensor and telecommunication technologies to help city officials and architects better plan, build, and manage these complex systems. Within the last few years, there has been an increasing amount of study on what smart cities are and how they will be implemented, but the vast majority of these studies have focused on examples of large cities like New York, San

Francisco, and Philadelphia (Shelton 2015, Lee 2014, Winters 2011). While conducting smart city research on these cities is important, these studies fail to realize that smaller cities and communities operate on different scales and have dissimilar needs and smaller budgets than bigger cities. Because of this, small cities will require different strategies when attempting to implement smart city technologies. The goal of this research paper is to explore how these small cities and communities could benefit from the use of smart city technologies and how best they can incorporate them into their smaller scale of design.

The overarching research question that this paper seeks to answer is, how do small cities, towns, and communities implement smart city technology? Furthermore, this paper will answer three additional questions about small smart cities. These questions are, what problems do small smart cities face, what technologies can these cities implement to solve these problems and create new opportunities, and what strategies can small smart cities use to effectively implement these changes? These questions were addressed through a combination of domain research on smart cities and interviews conducted with officials of select small smart cities. As stated previously, the field of smart city research has primarily focused on large cities while overlooking the issues, opportunities, and strategies for developing smaller smart city projects. Lazaroiu touches on this disconnect best when he states, “Even though the large majority of the urban population lives in such cities [small and medium sized smart cities], the main focus of urban research tends to be on the ‘global’ metropolises” (Lazaroiu et al. 2012). This over emphasis on large metropolises has created a gap within the field of smart city research that has left small cities without the proper research and guidance that they deserve. Smart cities are not monoliths and this paper looks to prove that, by taking a deep analytical look into how the scale of smart cities affects their implementation.

Literature Review

This section will cover four key areas within the field of smart city development that will better help put the findings of this paper in context. The first piece of this section will cover three typical models that are used to classify smart city projects. The second piece will cover some of the most common barriers of entry that smart city projects face. The third piece will then describe a few prominent theories used for urban planning and smart city design, most important of which is the "Top-Down/Bottom-Up" model for city development. The fourth and final section will then elaborate on how the "top" and "bottom" ends of the previous section's model may operate together. It will do this through the lens of the Triple Helix Model and its current evolution into the Quadruple Helix Model. The Quadruple Helix Model being a more effective lens to view smart city development through, especially as it relates to smaller smart cities. This section will assist in showing the distinct types of tools and ideas that are being used in smart city planning today.

Models for Smart City Planning and Development

The leaps made in computer processing, sensors, and wireless technology over the last decade have opened the world to the possibility of smart city development. To start a discussion on how these technologies are being incorporated into smart cities, we must first define what they are. When trying to define what a smart city is, it is important to remember that it is a flexible definition that can be applied to many different cities and projects in many different ways. One common definition of modern smart cities is that they are made to run efficiently and sustainably. The argument behind this is, that if in the coming decades much of the world's

population will be moving into cities, then we should be creating these new cities to be more sustainable to combat climate change as well as make sure these increased populations can be accommodated (Höjer & Wangel, 2014). Already, cities consume a massive amount of energy, "demanding more than 75% of world energy production and generating 80% of greenhouse gas emissions" (Lazaroiu et al., 2012). Various ideas have been submitted as to how urban planners can use information and communication technologies (ICT) throughout cities to reduce their energy use. Some of the most popular ideas are based in the power, transportation, agriculture, building, manufacturing, and consumer services sectors (Kramers, Höjer, Lovehagen, & Wangel, 2014) and all generally subscribe to the idea that ICT's can be leveraged to increase efficiency throughout the operations of these fields. By setting up the infrastructures of society in this way, smart city planners hope to better control the carbon footprints of future cities so that they can better meet the carbon reduction goals cities and countries set for themselves while still providing the proper utilities to their citizens (Kramers et al., 2013). In these ways, smart cities can be a major tool in combating climate change and resource scarcity in the future.

A second model of smart cities is based off the need to handle the very large population of people that will be living in cities and the logistical problems they will bring with them. As stated previously, a vast majority of the human population is expected to be living in cities and urban centers and suburbs by the year 2050. Because of this, it is crucial that cities find different ways to handle the increased amounts of commuter traffic, commercial traffic, and parking shortages that they will inundate them. Smart cities are cited as a potential major solution to these complicated logistical problems. There are four major stakeholders when it comes to the logistics of cities: shippers, freight carriers, administrators, and residents (Taniguchi, 2014). Every city has at least one of the aforementioned stakeholders in which to manage as efficiently

and safely as possible. To do this properly, smart city advocates believe that cities should begin to implement innovative Intelligent Transport Systems (ITS) and ICT systems into their infrastructures. Cities can use ITS to collect precision data on pick-up delivery trucks moving throughout the city (Taniguchi, 2014). By doing this, city administrators and companies can optimize the vehicle routing in dynamic and productive way. This strategy can also be applied to various other logistical problems such as reducing commuter congestion and diminishing the arrival times for emergency vehicles. ICT systems can also be installed at crosswalks to help move commuter traffic more efficiently and safely as well. Smart city advocates believe that the installation of these technologies throughout a city is most effectively done through partnerships with local businesses (Taniguchi, 2014). By implementing these technologies into cities, city planners can not only make cities more efficient, but also makes cities and businesses within these cities more profitable. In this way, cities can make themselves more appealing to outside companies who are looking for urban areas to set up new operations.

The third most discussed definition of smart cities, is based on how cities can use smart, connected technologies, referred to as the internet of things (IoT), to better connect its citizens to the urban environment around them. Thanks to the creation of the smart phone, a large majority of citizens now have the ability to connect to the internet while on the go. Because of this technology, cities, and the citizens that occupy their limits are now able to connect with each other in unprecedented ways. Balakrishna (2012) claims that these smart city services and applications are defined by three characteristics. The first characteristic, is the smart infrastructure uses sensors to merge the physical world of the city environment with the virtual world through real time sensing and information transference. By doing this, the smart city gains a sort of “real world awareness” that it can use to help users. The second characteristic is the use

of knowledge engineering approaches that convert the aggregated real-world data into something that can be used by users across the cityscape. The final characteristic described by Balakrishna is, the ability of the user and the city to have panoramic access to multiple types and domains of data that can be interlinked and synergized together to create more specific and helpful kinds of information. In this definition, it is the duality and interplay between the smart infrastructure and sensors that are installed and the smart applications that the citizens have that make the smart city a reality. The key to the success of this IoT model is cloud computing. Cloud computing is defined as "the practice of using a network of remote servers hosted on the internet to store, manage, and process data." The physical hardware of these servers can be consolidated into a few locations that can process massive amounts of data covering a vast number of users over a vast distance. Many smart city advocates believe that cities can incorporate these IoT and cloud computing technologies into their infrastructures and allow citizens as well as businesses to use them as an infrastructure service that they can pay to use and connect to (Perera et al., 2013). While the idea of including a "pay as you use" cloud computing system into a city's infrastructure might be relatively new in the smart city world, the use of sensors and phone applications that can connect and transfer information between a city and its residents has been in wide use (Sanchez 2014).

Barriers of Entry for Smart Cities

While these technologies have great economic and social benefits for cities to take advantage of, there are multiple barriers of entry that must be considered and overcome before applying them. Vilajosana et al. (2013) cites that some of the major barriers to smart city funding

are the need for policy change, limited capital availability, and inefficient funding structures. Another major hurdle for smart city funding are the political uncertainties that threaten the reliability of steady public and private investment. Getting the national, local, and private sectors to work together, pass legislature, and submit investments is an incredibly difficult goal to achieve especially for a project as large and as time consuming as building smart city infrastructures. Beyond these issues, Vilajosana et al. (2013) also claims that, as of the writing of their paper, there are not many secondary markets in existence that can finance smart city projects. At this time, smart city projects are seen by many investors as too risky.

Urban Design and Smart City Theory

While the idea of smart, connected smart cities is fairly new, the whole field is still deeply rooted in the previous ideas of urban design. For decades now, urban planners have been struggling with theories about how to create successful sustainable cities and how to test these models in the real world. Campbell (1996) proposes that there are three priorities an urban planner must consider when designing a city. The designer must design a city that will successfully grow, will have the cities growth distributed fairly, and will not have this growth irrevocable degrade the surrounding ecosystem. Campbell admits that this is an incredible challenging feat to accomplish as many of these goals are in conflict with each other.

By reaching all three of these goals though, a city could become truly economically and environmentally sustainable and could maintain its structure and organization effectively for generations. This idea of economic and environmental sustainability is a cornerstone of many smart city models today. City planners hope to utilize smart technologies to help spur economic

growth and open up markets and optimization opportunities that have never existed before the advent of this technology. Another feature of smart city development that is being adopted from past urban planning theory is how to use the private sector to fund projects. Ashworth et al. (1990) states that cities are a part of capitalistic system just like businesses. Because of this, cities must "become 'products' to be marketed aggressively in order to attract tourists, residents, commercial activities and investment" (Ashworth 1990). This is especially true for smart cities. As stated previously, smart cities have high barriers of entry that require planners to connect with investors from the public and the private sector. To do this, it is critical to market the benefits of smart cities to these audiences. If done successfully, cities have the ability to grow exponentially and create a feedback loop of benefits that could result in incredible amounts of economic gain. .

One change that is coming to urban planning thanks to smart cities is about how urban planners frame their plans. In the past, most urban planning was done with a long-term mindset. With the introduction of smart cities and the big data it is now collecting, urban planners now have access to the information and processing power to start thinking more in the short term (Batty 2013). Using these tools, city planners are beginning to be able to micromanage cities over minutes and hours instead of only years. This new ability let's cities become even more flexible and efficient. Another way that smart city design is changing the world of urban planning is by shifting urban planning's mindset from a top down approach to a more bottom up approach. This means instead of having cities and corporations purely drive the innovations and changes that come with city development, citizens can now give more voice to how they want their cities to develop.

Cosgrave et al. (2013) believes that smart cities should be treated as living labs from which smart city technologies and applications can grow naturally. The idea behind this is that

applications designed from the top down often don't fully understand the needs of the average citizen and usually end up falling short. Instead, Cosgrave proposes that cities and industries meet citizens half way in the development process. Cities can do this through the creation of open application programming interfaces (API), open data platforms, city dashboards, hackathons, networking events, competitions etc. that would ultimately support successful and sustainable implementation of custom smart city technologies, and the creation of an innovation ecosystem that is valuable for citizens of that specific urban area (Cosgrave 2013). Komninos (2013) goes a step further by saying that smart cities should incorporate this type of crowd sourced creation into all aspects of the cities infrastructure and economy. By doing this, smart city managers can open up a treasure trove of raw data that can be applied to a plethora of different applications. It is important to note though that cities at their core are constantly changing and no "one size fits all" solution will ever be developed. This is, because every city is different and has its own specific culture and challenges. Because of this, every city and urban area looking to implement its own smart city model needs to consider its own unique problems first and foremost (Soumaya 2015). It is also important that these models are created organically and remain flexible to adapt to the everchanging issues and metrics of the cities that they are made for. Only when these aspects are considered can a truly successful smart city model be created.

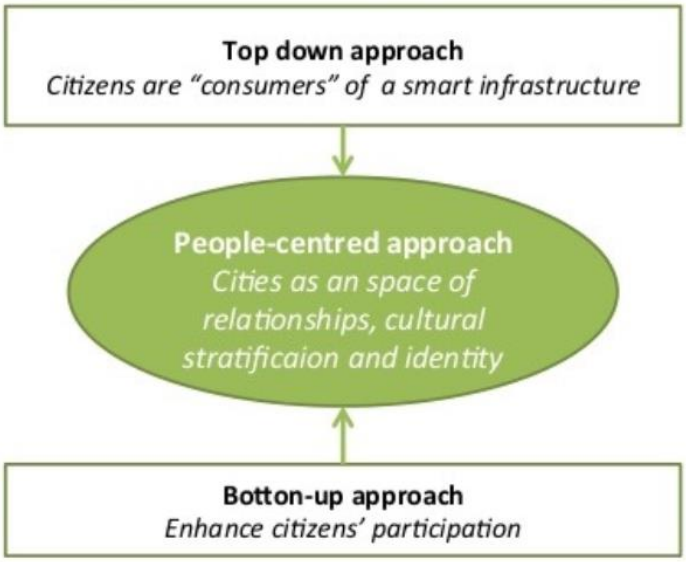

Figure 1: Top-down/Bottom-up Model (Giovanella, 2013)

This theory of implementing change within either a bottom up or top down frame of approach is fleshed out more in a paper written by John Hagel. In Hagel's paper "From Push To Pull: Emerging Models For Mobilizing Resources" (Hagel 2008) bottom up and top down techniques are instead referred to as push and pull models. In this paper, Hagel describes push models as those that are designed to push resources to centralized structures for processing. The pull model on the other hand emphasizes the creation of platforms that help people mobilize and use these resources when the need arises. While Hagel describes these two models in terms of industrial production, it is easy to see how they can be compared to top down and bottom up models of smart city planning. As can be gleaned from the description of the two models, the push model is the more rigid and centralized model and is identical to the top down model. Comparatively, the pull model is the more flexible and decentralized model and compares well with the bottom up model. While both models can be effective to use for the implementation of

smart city technologies, pull models are much better suited for situations where there exists a lot of uncertainty. This is, because instead of dealing with this uncertainty through tighter control this model seeks to expand the opportunity of creativity to local citizens with immediate needs. In this way, a pull model may be a better fit for a smaller city without the resources, experiences, or centralized body to take on many smart city projects. This model's strength lies in its ability to, "treat people as networked creators (even when they are customers purchasing goods and services) who are uniquely positioned to transform uncertainty from a problem into an opportunity" (Hagel 2008). A model such as this can be very effective, especially when paired with telecommunication technologies that can more easily tie communities together. The best way of approaching smart city projects, either by a push or a pull style model, is still up for much debate within the field of smart city research.

The Triple and Quadruple Helix Models

As stated in the previous section, the Top-Down/Bottom-Up Model (or the Push/Pull Model) is an incredibly useful lens in which to view smart city development and implementation. While useful on its own, it is important that both opposing domains of the model be explored and defined as well. To do this, the following section will break down the Top-Down/Bottom-Up Model into both the "Top" domain and the "Bottom" domain and then viewing both of them through the lenses of the Triple Helix Model and, its successor, the Quadruple Helix Model. By doing this, we will be better able to see which elements make up each domain and which strategies may be better suited for supporting each individually or as a whole.

The first domain that we will be analyzing is the "Top" domain. This domain is generally occupied by larger, more centralized, service providing and product producing entities. These entities are usually the owners of massive amounts of resources as compared to the entities that are members of the "Bottom" domain. These resources include anything from wealth, to labor, to intellectual capital. These entities view citizens (who make up the "Bottom" domain) as "consumers" to whom they are providing services and products.

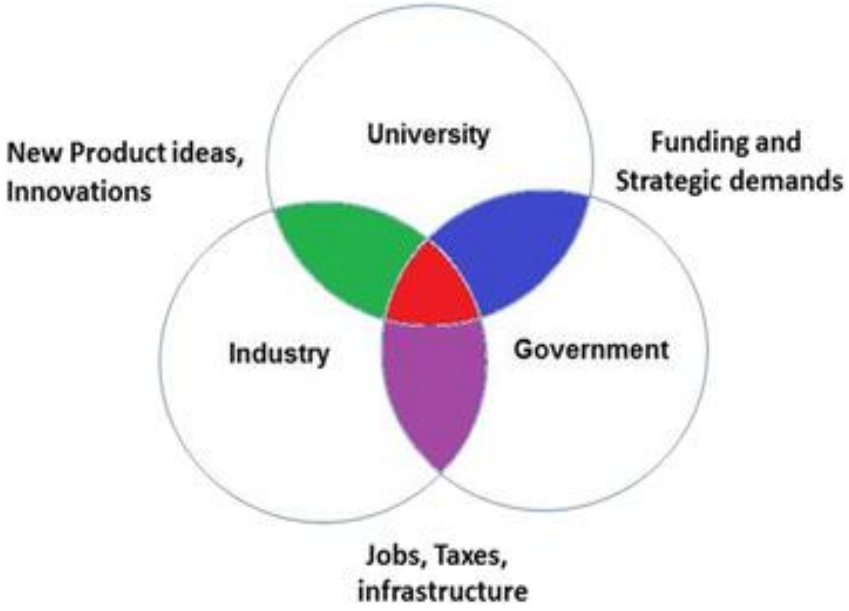

Figure 2: The Triple Helix Model (Kimatu, 2016)

An effective way to view what entities make up this "Top" domain, is through the lens of the Triple Helix Model. As shown above, the Triple Helix Model is made up of three entities: Universities, Industry, and Government. Deakin and Leydesdorff (as cited in Deakin, 2018) define these three entities in broader terms when they state, "there are three evolutionary

functions cultivating the selection environments of both national and regional research and innovation: (1) intellectual capital of organized knowledge production; (2) wealth creation; and (3) reflexive control". The Triple Helix Model also does an excellent job at defining the relationship each of the entities individually have with each other. As depicted in figure 2, each entity within the Triple Helix Model interacts and supports the others in critical ways. As the above figure and Deakin and Leydesdorff's quote clearly show, each entity within the Triple Helix Model plays its own unique role in creating a smart and innovative city. The University, for example, creates innovative ideas and technologies and also provides a trained labor force to implement them. Industry and Business provides funding, jobs, and commercial infrastructure. While the Government provides direction, policy, infrastructure, and funding grants as well. All three of these entities working in tandem create a complex and dynamic system of innovation that is further defined by other dynamic subsystems as described by Etzkowitz et al. (2000), "The complex dynamics is composed of sub-dynamics like market forces, political power, institutional control, social movements, technological trajectories and regimes". While the sub-dynamics of these three entities vary throughout time and continue to influence the overall structures of society in major ways, the cooperation between these three entities can assist them in adapting to new developments and issues. The organized system of innovation production that is created through the specialization and cooperation of these entities can be crucial to the development of a town or city. By following this model, a region is better able to sustain its economic growth (Deakin et al. 2018) and provide services and products to its inhabitants.

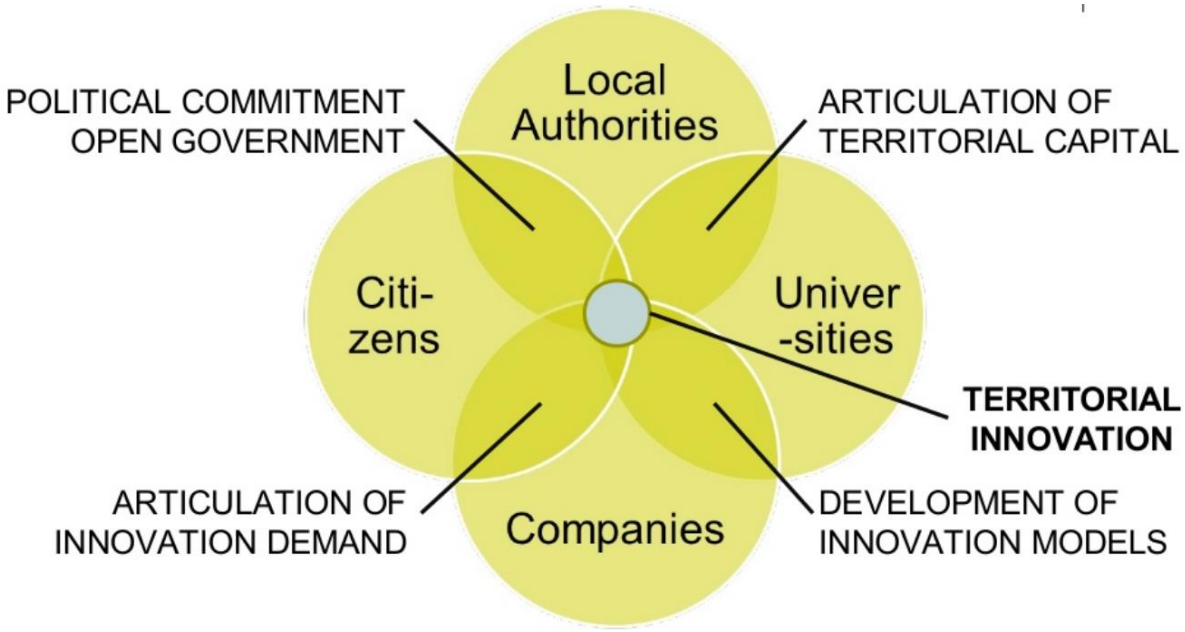

Figure 3: The Quadruple Helix Model (Marsh, 2013)

Although the Triple Helix Model is a popular and useful lens to view smart cities, it lacked a key element that was later added to its successor more than 10 years after its creation. This addition came in 2006 with the creation of the Quadruple Helix Model by Carayannis and Campbell. While the Triple Helix Model had originally been more concerned with a top-down approach of innovation, Carayannis and Campbell's new model integrated in Citizens as an entity. The Citizens entity represented a more bottom-up approach to creating innovation that was increasingly complex and involved a higher number of interconnections and actors (Cavallini et al. 2016). The Quadruple Helix Model describes a more participatory system of innovation where citizens within a region are not just consumers but are active participants within the innovation production system. Carayannis et al. (2017) describe it best when they say, "This Quadruple Helix Innovation System Framework puts innovation users at its heart and encourages the development of innovations that are pertinent for users (civil society)". As

Figure 3 shows, the Quadruple Helix Model highlights how Citizens specifically interact with their Government through political commitment (i.e. voting, town hall meetings, use of services, etc.) and also how governments can better interact with their constituents (i.e. transparency, reliable service delivery, efficient use of tax dollars, etc.) to better promote successful innovation. Figure 3 also shows that it is important for this relationship to exist between Citizens and Businesses as well. By connecting Citizens with Businesses, Citizens are given the ability to articulate what they want out of an innovative product while Businesses are better able to focus research and production on a product that will be used. By using the Quadruple Helix Model as a lens for smart city development, we will achieve better insight into how the "Bottom" domain fits into the overall structure of smart city development. More importantly though, using this lens will help identify how both the "Bottom" and "Top" domains interact with each other and reveal how their cooperation has benefitted smart city implementation overall.

Method

For this study I contacted the local governments of small and medium sized cities across the United States (US) to ask them questions about their experiences implementing smart city technologies. I contacted these city governments by emailing the heads of its technology divisions. In these emails, I stated the purpose of my project and the reasons that I was interested in their specific city's smart city experiences. I explained the nature of my research questions in my email and the gap within the sphere of smart city research I was attempting to fill. I then went on to request an interview by telephone at a date that was convenient for them. Each interview took between 30 and 60 minutes depending on how much time the interviewee had available. The interview was comprised of a series of prewritten questions that was designed around the cities' experience implementing smart city technologies, what its perceptions were of the differences between their small city and larger cities, and in what way these differences affected how they consider smart city projects. I also asked questions about the strategic approaches they took to apply smart city design to their localities and whether or not their strategies were affected by the scale of their city's size. The questions I asked the interviewees were created along with a code book that I used for analysis with the help of the project's mentor professor. The above protocol for the interview as well as the specific questions asked were refined and submitted to the University of North Carolina at Chapel Hill's Institutional Review Board (IRB) for approval.

Interview Design

Collecting this information by way of a telephone interview was the best strategy for the project for many reasons. First, it gave my interviewees the flexibility to do the interview when

they were most available. Most of the city representatives I contacted were incredibly busy people, so the interview schedule needed to be able to meet their time constraints. The second reason was, that by doing telephone interviews gave this project the ability to reach interviewees across the US providing me the opportunity for a larger sample size. Finally, this method of data gathering gave me access to firsthand knowledge about how the field of smart city development works in small cities. Receiving firsthand accounts with follow up questions provided me with a more accurate and detailed picture of what the process of smart city integration encompasses for these small and medium sized cities and communities.

For this project, I reached out to a total of 30 cities across the United States to get a diverse range of responses. I received replies from and interviewed eight of those cities from across the nation. The eight cities I interviewed were: Albany, New York; Burlington, Vermont; Chapel Hill, North Carolina; Longmont, Colorado; Palo Alto, California; Portland, Maine; Queen Creek, Arizona; and Seat Pleasant, Maryland. I was permitted to interview representatives from each of the aforementioned cities and did so over the duration of a month. Interviewees were provided a copy of the questions before the interview to give them time to consider their answers. All interviews were voluntary and in line with the ethics and rules set by the IRB.

Defining the Sizes of Cities

One of the most critical parameters that was set for this paper was what classifies a city as small. While there may be many different techniques to do this with, the one used for this project was based on population. The city chart (which can be found below) was created with

data from the US Census Bureau from the year 2015. The chart shows the number of incorporated cities, towns, and villages within the US organized by their population size.

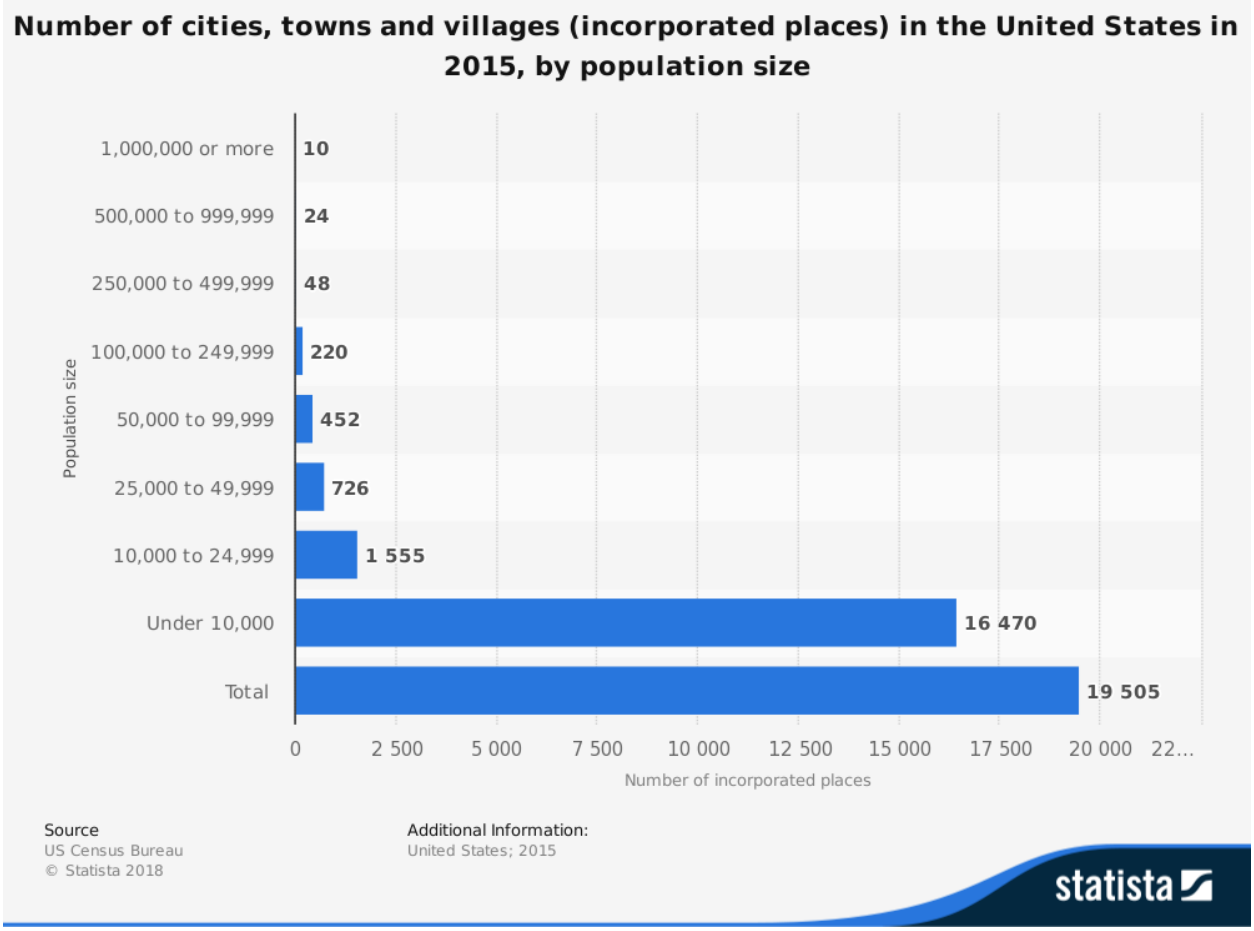

Figure 4: United States' cities by population (U.S. Census Bureau, 2015)

Population was determined to be the best qualifier for defining which cities I will be using for this project, because population is a major indicator of overall development and resources. Within this study, small cities were those defined as having populations that were less than 100,000 people. This number was chosen for a couple of reasons. First, it is commonly used as a delimiter by the US Census Bureau as shown in the chart above. Cities are defined by the US

Census Bureau as a region where the core has a population of 50,000 or more. Large cities are defined as having populations of 250,000 or more; midsize are defined as having a population less than 250,000 and greater than or equal to 100,000; and small are defined as having a population fewer than 100,000 residents (U.S. Census Bureau 2010). Second, it is a delimiter that, while big enough to include a vast majority of U.S. cities, does not come close to including the larger cities that are typically studied in other papers on smart city design (i.e. New York, San Francisco, Boston, etc.). This standard of acceptable city parameters will help me better determine which cities were more beneficial to contact and also assisted in standardizing the set of city interviewees.

Data Analysis

The audio of each interview was recorded by microphone with the expressed permission of all interviewees. These audio recording were then transcribed into a word document with timestamps included to mark changes in speakers and to help better organize and back-reference the information. After the interviews were transcribed, a code book was created to analyze the interviews. Interviews were analyzed to find trends in what advantages, disadvantages, technologies, and strategies small smart cities encounter or use when implementing smart city design. A series of these trends were codified and then the interviews were analyzed for them. Evidence that fit a trend was highlighted within the transcription and marked with the code number of that trend. In this way, data analysis was made more organized and straightforward.

For the Discussion section of this paper, I will be analyzing the interviews I conducted using the theories that I outlined in the Literature Review portion of this paper. I will be using

the Top-Down/Bottom-Up Model to examine the implementation strategies that the interviewed cities are using. I will use this lens to see whether the strategies stem from a more centralized, Top-Down approach or from a decentralized (citizen focused) Bottom-Up approach. Furthermore, I will also use both the Triple Helix and the Quadruple Helix models to examine the entities that make up the both sides of the Top-Down/Bottom-Up Model. I will use the Triple Helix Model to primarily examine the entities that make up the centralized, Top-Down approach to project implementation. By doing this, I will be better able to see which entities cities are leveraging to their fullest extent and which they are not. I will then be using the Quadruple Helix Model, with its addition of the "Citizens" entity, to examine the Bottom-Up focused strategies more fully and analyze how they interact with the centralized, Top-Down entities.

Conclusion

The field of smart city research is still a relatively new, but important field that is just at the beginning of exploration. While new, smart cities will be a powerful force for change in the coming years as increasing urban populations will require better systems of organization, interconnectivity, and sustainability. To this end, it is crucial that while we progress we do not forget about the small cities and towns that could benefit from these smart projects. Smart cities and the technologies that come with them will not only provide solutions for these small cities and towns, but also economic opportunities that could truly revitalize many of these communities. As stated at the beginning of this paper, smart cities, and cities in general for that matter, are not monoliths. It is vital that we recognize this fact so that we can provide these novel technologies and urban planning models in effective and accessible ways.

City Profiles

Albany, NY

Albany, New York is the capital city of New York State and the seat of Albany County. Albany has a population of 98,111 (U.S. Census Bureau 2016) and is located on the west bank of the Hudson River roughly 150 miles north of New York City. Albany is considered to be the economic and cultural center of the New York State "Capital District", which includes neighboring cities of Troy, Schenectady, and Saratoga Springs. In recent years, Albany and its surrounding region have been home to a large array of high-tech industrial growth and have earned the moniker of "Tech Valley". Albany is also home to a series of accredited universities such as the University at Albany, Albany Medical College, and the College of Saint Rose.

Albany faced several obstacles while implementing smart city projects. One of the biggest issues has been the lack of both labor and funding resources. The city reports that it had trouble acquiring the amount of skilled labor needed to take on many of these smart city projects. Albany also stated that not having adequate staff to analyze project data has made it difficult to really take advantage of some of the projects already implemented. The city tried investing in training, but much of the needed training requires time and money that the city cannot spare. The city also believes that it does not have the amount of staff in general to take on many of the projects they want to try. Albany stated that the staff they have for smart city projects is incredibly small, especially when compared to cities such as New York City. This shortage of staff not only affected the city's ability to implement some of the projects but has also affected its ability to conduct outreach to the citizens. Its inability to hire more staff is directly connected

to Albany's lack of sufficient monetary resources. Albany indicated that staffing currently makes up around 70 to 80 percent of its budget. This funding restriction has greatly affected the amount of smart city projects the city has been able to implement. Albany claims that these two issues are the direct result of the city's small size. One of the next greatest issues that Albany faces is with implementing the technologies itself. Albany reports some reluctance within certain segments of the city government to accept some of the new technologies. This reluctance was mainly grounded in the resistance to learning how to do things differently. While this reluctance has been somewhat resolved, Albany felt that enforcement was still an issue. The city also has struggled with the affects these technologies have on its staff's employment. These technologies have made some of staff jobs obsolete. The city does not want to fire staff. There has been attempts to retrain and transfer displace staff to other city departments. However, this does not always preserve every staff position. Additionally, Albany has had trouble with project management in implementing the smart city projects. While Albany has not had any failed smart technology implementation projects, its lack of experience with managing the project has led to some issues. The city does not have many staff that have experience with implementing smart city technology projects or technology projects in general. Furthermore, once the projects are installed, the city does not have much experience with analyzing and implementing improvements resulting from the data they receive from these technologies. This confusion can be attributed to the innovative nature of many of the projects. The city stated that getting the city council to focus on a cohesive smart city strategy has been challenging. The city claims that while many smart city projects require long term planning and development, members of the city council are more focused on short term goals. This is because these council members want to see results from completed projects by the end of their term on the council. The final obstacle

Albany faces in implementing smart city projects is the lack of university resources and support. While Albany has several universities within its city limits, none are technology focused. Therefore, Albany has been unable to work closely with them to implement smart projects.

Even with these challenges, Albany has implemented a fair number of smart city technologies. Some of the most successful technological projects have been internally implemented software. The city has implemented a Kronos timekeeping system that has helped better organize its staff's work schedule. The city claims that this has decreased overtime expenses by $200 thousand. Also, Albany installed an Enterprise Resource Planning (ERP) system to assist in better planning of current and future city projects. Recently, the city has implemented an internal facing, city dashboard system. The city dashboard is used by the Mayor and their senior management team to track metrics relating to overtime costs, expenses, revenues, workers comp costs, building permits, citizen complaints, and more. Albany has worked with outside contractors to create a website allowing citizens to access city data. This open data website is important, because they felt that citizens would appreciate their transparency and could make use of the data too. The city has deployed Global Positioning System (GPS) tracking devices on all city vehicles. This not only tracks where the vehicles are at any given time during the day, but also helps the driver find the best route to the next work site. The city also helps its waste removal workers by installing Radio-frequency Identification (RFID) into trash bins around the city. These "smart trash bins" can sense when a bin is full and ready for pick up so waste removal workers do not have to check them personally. Also, Albany invested resources into a variety of sustainable technology projects. One project is its utility tracking software. This software allows Albany to track around 270 buildings to better manage each building's energy consumption. Before this technology was implemented, the city recorded

all information manually. The implementation of this software saves the city much time and labor and energy expenditures. Two other green technologies that Albany has implemented are solar photovoltaic (PV) installations and electric vehicle charging stations. The city is currently in negotiations to buy its streetlights from its local utility company. Albany hopes to replace all the lights with light emitting diode (LED) fixtures. This project not only saved the city money, but it also allowed it to install ports onto these lights that the city hopes to use for other smart city technologies. One project it would like to use the ports for is to provide wi-fi citywide. The city wants to partner with wireless providers to help fund the streetlight project in exchange for the opportunity to install their devices on the streetlights. The final major smart city technology Albany implemented is their city application (app). The city app, called "SeeClickFix", can be accessed by Albany residents at any time of the day to report city problems and comments directly to city officials. Albany has been very happy with the smart city technologies implemented so far and wants to add more projects in the near future.

Albany has accessed a wide degree of resources and strategies to implement smart city projects. One of the biggest resources the city has at its disposal is State grant money. Albany received around $5 million in aid by the State of New York to assist in the purchase of its enterprise resource planning (ERP) system. The State also provided Albany grants towards installing electron volt (EV) charging stations and to hire additional employees. New York City provided grants to allow Albany employees to receive training. Albany collaborated with the State's "Build Smart New York" program to define energy standards within the city. Albany also worked with Public Financial Management (PFM), an advisory firm to help organize its finances to better fund its projects. The city has been able to take advantage of industry partnerships. One of its most recent partnerships is with General Electric (GE). GE offered to train some of its

employees in project management at no cost to the city. GE has also offered to give the city's management "Change Acceleration Process" (CAP) training. The purpose of the CAP training is to help Albany's city managers become more experienced in implementing city technology projects. This is an exciting opportunity for Albany, since it had issues managing technical projects. The city worked with several consulting firms to assists with planning for its smart city projects. One of the most important resources Albany leveraged is its supportive mayor. The mayor is a major supporter of smart city technologies and has pushed it as an agenda item for the city. The support of the mayor has not only been a driving force for implementing these projects but also in applying and for receiving smart city project funding and grants. Albany believes it is crucial to have such a leader push for these technologies and project throughout the government. The final strategy Albany claims as an advantage to implement smart city projects is its small size as a city. While being a smaller city does have its disadvantages, Albany believes it also has some benefits. One of these major benefits is that Albany has to deal with a smaller bureaucracy. Albany points to New York City as an example of a city with such a large bureaucracy that it reduces flexibility and slows the speed on developing projects. Albany on the other hand can be much more flexible with how it executes a project. Albany says that its smaller size also means that staff across departments are more likely to know one another, meaning an increased chance of departmental collaboration. The city states this flexibility and speed makes it a more viable candidate for implementing industry piloting programs. Albany indicates the feedback received from partnering companies has been positive, with the companies noting a major benefit for them is the city's bureaucratic flexibility. Albany plans to continue leveraging these resources and relationships in the future to implement more smart city projects.

Burlington, VT

Burlington, Vermont is located in the north-western region of the state of Vermont and is the seat of Chittenden County. Burlington is the most populous city in the State with a population of 43,552 (U.S. Census Bureau 2016). Burlington is home to the University of Vermont (UVM) and Champlain College. Burlington also holds the distinction of being the first major US city to run on 100 percent renewable energy (Woodard 2016).

To implement its smart city projects, Burlington had to overcome many challenges. One of the greatest challenges that Burlington faced was trying to work across the different city departments to implement these projects. The city claimed, especially when it came to collecting data and discussing future projects, it was difficult for different departments to communicate with each other and determine which data sets within each department could be pertinent to them. Another issue was that a lot of Burlington's projects were very innovative. Burlington found they had problems with some of its projects because there were no models to reference on how to do them properly. Burlington also stated there were huge capacity issues within their process as well. This meant its capacity to figure out how best to manage and use data to make sound decisions was low because it did not have experience in how to implement these types of projects. Burlington claimed that one of its biggest worries when implementing these technologies was not knowing if there were any unintended consequences or costs to be dealt with in the future. These worries were exaggerated by the fact that Burlington felt like they were mostly being held back by both its low financial and resource capacity. Therefore, Burlington believes it needs to be more careful with the projects it funds since smart city projects can be risky because they are considered so new. A minor issue Burlington reported was a minority of

citizens raised concerns about the implementation of some of smart city projects and what that meant for their security.

Burlington is still early in its process of incorporating smart city technologies, however it has had some success. Burlington states its biggest project implemented so far is a smart meter project. The city has about 20,000 plus customers they serve electricity to and a majority of them have opted into the smart metering program with a smart meter installed at their houses. The smart meter program provide data in 15-minute increments on electricity consumption. This saves both the participating citizens and Burlington money. This means city workers do not drive around town as much to check meters and the city can respond to city-wide demand for electricity in a faster and more efficient manner. Along with smart meters, Burlington also acquired the Energy Star Portfolio Manager. It is a US Environmental Protection Agency (EPA) benchmarking and energy management tool for residents and commercial properties. It allows customers to track their daily energy usage and customers can access it on Burlington's website. Burlington Telecom also installed a large gigabit network to provide the community with faster internet connectivity and to attract businesses to the city. Burlington has also become the first city in the US to become 100 percent reliant on renewable energy for electricity. It did this by investing in solar, hydro, nuclear, and biofuel projects.

To implement the above projects, Burlington relied on a mixture of strategies and collaborative assistance. One of the most useful strategies Burlington used was to seek federal and state money to help them implement some of the projects. The smart metering system for example, was integrated into the city with the help of money provided by the State of Vermont. The city also stated it relies heavily on the private sector for support in implementing the projects. Burlington collaborates with BTV Ignite, a non-profit organization sponsored by the

leading government, business, and academic stakeholders of Burlington, to help take advantage of the city-wide fiber optic gigabit digital network infrastructure. BTV Ignite serves as an incubator space for new technologies and works directly with the city to solve problems. Burlington allows companies to use the city as a pilot site in exchange for free installation. Currently, Burlington is working with a small startup called Packetized Energy to pilot a system that allows some of the city's hot water heaters to serve as small energy reserves. Beyond working with the public sector, Burlington also keeps in contact and works closely with its universities. Burlington states as a small city, it must leverage all the resources it can and that includes depending on their universities for research and skilled labor to properly implement these projects. One of the greatest resources the city has is its close connection with its citizens. Burlington states that cultivating this social capital is most important when trying to develop the technologies to solve large problems. Prior to implementing a smart city technology, it is crucial to know whether or not your citizens want it and will use it. Without this knowledge, these projects would be useless. Burlington believes the strategy of cultivating its constituents trust was extremely important to the success of the smart city projects. The city expressed its greatest strengths when compared to larger cities was its ability to cultivate this trust in such an intimate way along with the flexibility as a small city.

Chapel Hill, NC

Chapel Hill is a town in North Carolina that straddles the line between both Orange and Durham Counties. It is a town with a population of 59,246 residents (U.S. Census Bureau 2016) making it the 15th largest municipality in the state. The town makes up one of the three corners of

the “Research Triangle” with its neighboring cities, Durham, and the state capital, Raleigh. The Research Triangle is a region within North Carolina created by the proximity of three tier-one research universities: University of North Carolina at Chapel Hill (Chapel Hill), Duke University (Durham), and North Carolina State University (Raleigh). The Research Triangle is named such, because of the vast amount of research created by the three universities and the educated workforce that resided locally. The Triangle serves as a major attraction for business within North Carolina and is home to a large amount of high-tech companies.

While implementing its smart city projects, Chapel Hill had to overcome various obstacles. One of the most difficult problems Chapel Hill dealt with was negotiating agreements with their vendors. The town states beyond the typical legal wrangling that needs to happen when creating contract work, it also had to invest extra time in making sure it got exactly what it wanted out of the technology and that the town’s interests was protected. Another challenge that Chapel Hill faced is that there are limits to its financial and staffing resources. The town believes that especially its lack of available financial resources leads it to be more cautious when implementing smart city projects. This lack of financial flexibility has forced Chapel Hill to have to prioritize certain projects over some of its potential smart city projects. The town has experienced problems bringing vendors to pilot its projects because of the size of their town. Unlike bigger cities like Austin, Texas, Chapel Hill has only a limited amount of real estate or number of people to offer a company trying to pilot their technologies. Therefore, Chapel Hill sometimes finds it difficult to accommodate or attract companies trying to test smart technologies such as autonomous driving technologies. Bigger cities can definitely offer better geographical resources than a town the size of Chapel Hill. Furthermore, since Chapel Hill is so small it cannot afford to close off areas of town for testing because each area is so vital.

Therefore, hosting major piloting projects that require town resources in this way are near impossible in Chapel Hill.

Chapel Hill has implemented a variety of smart technologies. One of the most successful projects has been the implementation of a variety of cloud services to store town data and upgrades to the town telephone system. The town partnered with AT&T to help bring their gigabit networking to the area. Google is also considering Chapel Hill to put in a fiber network. Chapel Hill has worked with vendors to create a town app that citizens can use to report problems and complaints to the town directly. The town also uses its new cloud services to more easily store the data collected from these reported problems and complaints. Other Chapel Hill smart mobility projects include everything from smart bike kiosks, to electric charging stations, to a proposed light rail system potentially in a few years. Chapel Hill has communicated with vendors about implementing a video analytics system to create a smart parking project. This project would use cameras to help citizens find free parking spots within the town. The town has implemented a smart energy plan for public buildings by installing smart meters. There is some prototyping being done on a smart dashboard system being installed in the town hall. When finished, this smart dashboard will be automatically updated with town data that will let government workers stay up to date on what is going on in the town. This data is already open source to the public and can be accessed on the town website. Chapel Hill has most of its vehicle fleet outfitted with locators so that they can keep track of where workers are at all times and make sure that they are taking the most economic routes to work destinations. Chapel Hill feels it is just starting to get involved in smart city technology. It is comfortable with the technologies it has prototyped so far and is excited about implement additional smart city projects in the future.

Longmont, CO

Longmont is a city within the state on Colorado and straddles Boulder and Weld County. Longmont is also located near Colorado's state capital, Denver. Longmont has a population of 92,858 residents (U.S. Census Bureau) making it the 13th most populous city in the state of Colorado. It is home to the Boulder County Campus of Front Range Community College and the Master Instructor Continuing Education Program (MICEP).

While implementing its smart city projects, Longmont had to contend with various concerns and issues. Unlike many of its contemporary cities, Longmont states resource and funding scarcity is not its biggest problem. Its biggest problem has been trying to apply smart city strategies to the city's problems. Longmont stated its strategy for implementing these technologies is rather light and it has been difficult figuring out how to operate in such a novel field. The city also said that it especially had trouble discerning which city services would actually be improved through the introduction of smart technologies and which were better performed without. Another issue Longmont is concerned about is the sustainability of these smart city projects. By this, the city meant it is concerned about how much maintenance and attention these projects require in the long term. Longmont is worried that as the complexity of these smart city projects increases, more and more complex maintenance will be required to take care of them. This is especially troubling to Longmont when considering the longevity of the vendors with which they are working. Longmont is concerned that it, as a city, will outlast many of the vendors that assisted in introducing these technologies into its infrastructure. In the absence of these companies, maintenance will only become more difficult as other vendors may not know how to fix some of these proprietary technologies. Longmont ran into this problem specifically when it hosted its own city hackathon.

The city stated that although it received a lot of great entries for the hackathon event, none of the designers wanted to stick around to help maintain their creations. Additionally, Longmont itself did not have the proper resources to take care of many of these projects so they had to be scrapped. Finding a way to guarantee longevity in these smart city technologies has been a major barrier for Longmont's adoption of some of these projects. Another problem Longmont has been dealing with is the availability of staff. While Longmont's information technology (IT) staff is excited by many of the potential smart city projects that the city has been considering, the IT staff finds themselves too busy to implement many of them. Longmont contends that its IT staff already must maintain massive systems within the city and that adding on to the already heavy workload would be difficult. If the city had more staffing resources, it would be able and willing to take on more smart city projects. The final issue that Longmont reported was centered around how isolated the city is from certain resources. Unlike some of the other cities interviewed for this project, Longmont does not have a major educational institution within its city limits. Based on its geographical location and distance from other major metropolitan areas, Longmont considers itself a "stand alone city". Longmont states that it is difficult to convince bigger companies and service providers to move to or provide the best services in its city because of this isolation and fewer financial incentives for these companies. Therefore, Longmont feels that it had to be much more creative and innovative in how it implemented many of its smart city projects.

Longmont has been able to implement some very major and interesting smart city projects into its city due to its inventiveness and entrepreneurial spirit. Longmont's greatest success came from the implementation of a city-wide, fiber home network. The city states this has been the backbone of its community and not only incentivized business to come to its city

but has also greatly benefitted the citizens. Longmont also invested some of their resources into creating the city's 4G infrastructure. Currently, Longmont is also cooperating with Verizon to allow them to build smart cell sites for the implementation of 5G service. By creating this smart mobile device infrastructure, Longmont has been able to leverage it to help provide better services to its constituents. This infrastructure allows public safety officials to always stay connected and up to date with developing incidences and keep the public safe. It has also allowed city officials to have a more flexible workplace, giving them the ability to work from almost anywhere. The city of Longmont has also passed a city-wide sustainability plan that will have it investing more resources into more smart and sustainable technologies. Overall, the city of Longmont hopes to continue to build upon their current projects and are eager to implement more smart city projects in the coming years.

Longmont has been able to utilize an array of different strategies and resources to help implement its smart city projects. One of the most useful resources the city has been able to tap into is federal grant money. Longmont's school district won the federal "Race to the Top" grant that gave them $16 million to better fund the districts science, technology, engineering, and math (STEM) curriculum. While this does not directly help implement smart city projects, Longmont claims that by funding the districts STEM curriculum, it is better preparing citizens to embrace and participate in future smart city projects. The city has also partnered with entities in the technology sector. As mentioned previously, Longmont partnered with companies like Verizon to help them implement smart infrastructure around the city. The city is currently working with Tetra Tech to develop strategies around future smart city projects. This consultation is especially helpful to Longmont's goal of creating a better strategic framework around smart city project implementations. Another strategy Longmont used is to cultivate a close relationship with its

citizens. The city accomplished this in several ways. First, the city invested money and resources in creating the country's largest membership makerspace. The city not only funded this project but has also stayed in touch with the space over the years to take advantage of new ideas and to continue to promote innovation across the city. The city also engaged its more technically savvy residents by hosting a city hackathon to help tackle some of the city's problems. Longmont stated its best strategy has been meeting with citizens directly, finding out what they want, and figuring out how best to provide them with that service. The city indicated it would honestly like to begin to use many of the smart city projects to make its citizens more independent of them. By this Longmont meant, it hopes to use the medium of smart technologies to give its citizens more autonomy and power to access the resources they need to do what they want. For this to occur, the city found the best strategy is to create a strong network of citizen engagement so that it can learn not only what services citizens want, but also what services citizens are willing to use. By doing this, Longmont states that they have a better sense of what to invest in. The best example of this is Longmont's fiber network. Longmont was able to gauge its citizens feelings about this project. The city found out that the number of citizens willing to pay for it was greater than the cost to fund it. They then were able to confidently implement the project. Longmont citizens now get to enjoy incredibly fast, city provided internet at less cost than what people in Denver pay. Longmont indicates there are actually some benefits of being a city of its size. The city stated its small size gave it an agility that larger cities lack. What it meant by this is its size gives it the agility to be build deep relationships within its communities and figure out what services the citizens want. Its size gives the flexibility to plan and implement smart city projects faster as well. Longmont believes all of these strategies are backed up by an innovative and

entrepreneurial spirit that is unique to its city and helps them successfully embrace these new technologies.

Palo Alto, CA

Pal Alto is a city in California that sits inside of Santa Clara County. It is also located within the San Francisco Bay area. Palo Alto has a population of 67,024 residents (U.S. Census Bureau 2016) and is home to one of the top universities in the nation, Stanford University. Palo Alto is also the birthplace of Silicon Valley, an area within the San Francisco Bay area that is famous for its high concentration of successful high-tech companies and as a major incubator for high-tech companies. Palo Alto is home to several major high-tech companies such as Google, Facebook, Hewlett-Packard, Tesla, Skype, and many more.

While implementing smart city projects, Palo Alto faced a litany of problems and challenges with which it had to contend. Palo Alto highlighted three major issues it faced implementing smart city technologies. The first major problem cited was the need to place smart city project implementation within the greater architecture of the city's priorities. What Palo Alto meant was that one of the main jobs in managing its city is prioritizing what projects and services to work on while still providing basic city amenities such as functioning roadways, libraries, parks, etc. Palo Alto stated while being an affluent community, it still does not have the resources that a New York City or a San Francisco has to invest in new smart city technologies. The city said that because of its community and budget size, there is a general reluctance to put significant tax payer money into smart city projects, since many are still very experimental. Due to these concerns, Palo Alto found it was usually prioritizing other, more proven projects over

smart city projects. Beyond just the financial barrier, Palo Alto mentioned that it lacked the staffing resources of larger cities. Palo Alto indicated larger cities can build individual teams whose sole job it is to focus on smart city technology implementations. Smaller cities on the other hand, do not usually have that kind of resource luxury. The second problem discussed was its belief that the smart city technology market is still rather immature. This overall "lack of maturity" within the smart city marketplace lends itself to an increased feeling of reluctance that were mentioned in problem one. Palo Alto stated while there are a lot of great vendors out there with very good products, many of these projects are still new and unproven. This immaturity comes with a certain overhead that Palo Alto feels makes it harder to invest in these projects at times. The third and final problem that it mentioned was the very concept of using technologies as the driving force to solve city problems is a relatively new concept. Palo Alto also stated many of the strategies on how to deploy these technologies is still unknown, so it is difficult to convince many department directors to adopt some of these projects. Palo Alto indicates if it is going to commit more resources to smart city projects, more mature implementation strategies need to be developed and more training of these concepts needs to be given to department directors across the city government.

Regardless of the challenges, Palo Alto has still been a strong proponent of smart city technologies, boasting over 250 implemented projects. Some of its most successful projects include: open data systems for resident access; a public accessible GIS data; upgraded permitting software; the implementation of enterprise level wi-fi across all city facilities; a new information back-up system on the cloud; and an Interactive Voice Response (IVR) system for its utilities. Palo Alto's success with smart projects can be attributed to the abundance of resources it has at its disposal as well as its drive to test out and implement these projects.

Palo Alto has relied on multiple different strategies and partnerships to implement its smart city projects. The city is a unique case as compared to the other cities in this group thanks to the high number of major tech companies that reside within its limits. Palo Alto has been able to take advantage of its proximity to these tech vendors. In exchange for helping install some of its smart city projects, Palo Alto has offered itself as a living lab for some of these companies to test their technologies. The city enjoys using this strategy since it allows it to tap into the experienced staff and ideas of these companies. This strategy has even allowed Palo Alto to implement some of these technologies at a reduced price or for free, saving money for the tax payer. The city has been able to leverage its reputation as one of the most successful tech hubs in the world to attract vendors to test their technology within its city limits. Outside of partnering with vendors, Palo Alto has also been able to leverage Stanford University as a resource. It indicates some smart city projects lend themselves more to collaborating with a university because they are too risky for companies or too experimental. In these cases, Stanford will usually acquire a grant and then Palo Alto will open the city up to them to use as a test case. Another important resource that the city leverages is its size. Due to its smaller size, Palo Alto is better able to communicate with its citizens. This communication helps it better figure out what problems can be solved with smart city technologies and what solutions would be accepted by its citizens. The city also leverages its interaction with civilians through city sponsored hackathons. Palo Alto also states since it has a smaller bureaucracy, it takes less time to implement these projects which is a benefit to both the citizens and the vendor partners. The community's smaller size also makes the results of its projects easier to observe, and the effects of these projects occur faster, which is another aspect that is a positive for vendors working with Palo Alto. Palo Alto's success with smart city implementation can be directly linked to how the city has leveraged its

aforementioned resources and strategies. The city hopes to continue implementing these smart technologies into the future.

Portland, ME

Portland is a city within the state of Maine inside Cumberland County. Portland has a population of 66,937 residents (U.S. Census Bureau 2016) and is the most populous city in the state of Maine. Portland is home to a handful of colleges including the University of Southern Maine, University of New England, the Maine College of Art, and the University of Maine School of Law.

The city of Portland faced certain issues when attempting to implement its smart city projects. One of the greatest challenges faced is the city's lack of available resources. This not only includes financial resources, but also labor resources. Portland indicates it does not have the financial or labor resources to invest into big smart city projects or projects that are untested and riskier. One of the city's biggest concerns regarding smart city investment is that if it ties up resources into a risky project that does not pay off, then it will have excluded itself from future project opportunities. Portland believes this lack of resources is a major difference between how it and larger cities consider which projects to invest in, as larger cities can take more risks. While Portland says that this does not make them risk adverse, it certainly means that they have to be careful with their decisions. Portland states it does not have the quality of resources of some of the bigger cities. For example, Portland really admires the smart city projects Pittsburgh has implemented, citing the main reason being the leadership of Carnegie Mellon University. While Portland has a couple local universities, none of them are as technically focused as a school like

Carnegie Mellon. This makes it hard for Portland to leverage these schools for smart city project implementation. Another issue that Portland has had to deal with is the lack of political structure and political support around some of these projects. The city cites it has only recently been given the chance to fully pursue smart city projects. Portland states that previous city leadership were less convinced about the use of smart technologies and restricted its funding around these types of projects. Portland has also run into issues with state regulations. Recently, Portland has attempted to pilot autonomous vehicles in the city, but the state Department of Transportation (DOT) has no framework for implementing this kind of technology. Furthermore, officials within the state government have voiced concern about testing this new technology in their state and have rejected previous legislation regarding its approval. Portland feels that this rejection by the state has prevented them from being as innovative as other cities throughout the US. Much of the state's hesitation is based on the fact that many of these technologies are unproven and novel. As of writing this report though, the Maine State Legislature has passed a bill requiring the state to create a working group to help implement pilot projects around AVs (autonomous vehicles). The bill was introduced by a member of the Portland delegation and became law without the governor's signature. While Portland's move to support AV technology has shown its willingness to embrace novel ideas, it has reported that this process can be difficult at times. This is especially true when it comes to the smart city marketplace. This is because Portland feels that this marketplace is still relatively immaturity. By this, it means that vendors are constantly pitching new technologies to implement, but all of the technologies have a degree of uncertainty attached. Few ideas or technologies within the smart city industry are truly standardized making the decision to implement any of them tough. The city also stated that the smart city marketplace is very fast paced, meaning that new technologies are always coming out and changing. This

adds an extra degree of difficulty when trying to decide which smart city projects to fund. Portland is concerned about the hidden costs that come with many of these projects. This includes a degree of hidden implementation and maintenance costs that it must consider. These extra costs add to the uncertainty and risk of these projects and make planning and funding them more difficult. The final major issue Portland has dealt with is the concerns of it citizens. The city states that when implementing some of its sound measuring and monitoring equipment, a segment of its constituents voiced concerns about their privacy. These citizens worried that they were being spied on and even went so far as to contact the American Civil Liberties Union (ACLU). This leeriness has also accompanied other smart city projects and has sometimes made the adoption of these technologies more difficult.

Despite these issues, the city of Portland has been able to successfully implement a diverse set of smart city technologies. One of their most recent and successful smart city projects has been the implementation of LED streetlights through much of the city. Within the last few years, the Maine state legislature has given Portland the ability to buy its light utilities from the Maine power company. Portland took advantage of this opportunity to buy back its streetlights and update them to LED lights. These lights are connected using an advanced control system giving it the ability to dim the lights and track energy expenditure. These lights also come with the ability to attach different sensors. Portland wasn't allowed to attach these sensors before, because of utility rules that prevented them from attaching anything but lights and light controllers to utility owned poles. Portland will be able to get around this rule now with their city owned poles. The city also plans on attaching these sensors to other city owned infrastructure such as buildings and traffic signals. Behind the scenes, Portland implemented some in house data analytics technologies to help make better data driven policy decisions. Other city

management projects include: smart dashboards (within city hall and the police department), a new smart radio system for emergency services, and a set of tracking sensors for its vehicle fleet. Another technology that the city has deployed is smart traffic sensors to help better manage the flow of traffic. Portland has also implemented some smart sustainability processes as well, including the installment of EV (electric vehicle) charging stations and solar panels. The city tried using smart technologies to engage citizens. One example is with the installation of electronic information kiosks around the city to inform the citizens of local news and events. The city created an app that residents can use to report problems. Portland has some smart city technologies lined up for the near future. One of them is the implementation of sensors that count people using a certain intersection. The city hopes to use this technology to improve the flow of traffic. The city has been in talks with some vendors about installing a citywide fiber network. Currently, Portland is working with a vendor to create an ambitious parcel level map that would not only show how much electricity is being used by a building, but also what kind of energy they are using (oil, gas, renewable). Portland hopes that these future projects will be as successful as previous projects. The city is very eager to take advantage of the new, smart city technologies and implement them into its city's infrastructure.

The city of Portland reported its success in implementing these projects comes from some of the strategies and resources it was able to use. One of the most beneficial resources its was able to take advantage of is industry partnerships. Portland took advantage of industry expertise and financial support in implementing many of its smart city projects. One example is with the company Tyler Technologies, who partnered with the city to design and install an in-house data analytics system. Portland is also partnering with a consulting company to better identify appropriate strategies for planning its smart city projects. One of Portland's most potentially

beneficial partnerships is with a company from New Jersey. This company is currently in talks with Portland to install fiber into the city free of charge if the city lets them use Portland as a testing ground for a new installation technique. This deal would be favorable to Portland as it not only saves tax payer dollars, but also provides beneficial technology to its citizens in addition to being able to leverage this in attracting new businesses. Portland believes there is a roll for these private/public relationships and sees it as a great way to secure funding for smart city projects. The city has also partnered with a university. While most of Portland's local universities are not technically inclined enough to help with any smart city project implementation, the city has partnered with a spinoff company from Carnegie Mellon University to install smart traffic light sensor technology. Although Portland has to pay for this technology, Portland believes that this project and the expertise of the company that is behind it is well worth the cost. Another strategy Portland uses is its effort to collaborate with its citizens. Portland believes that it is essential to have a solid connection with its citizens to better understand what services they want and how smart technologies can provide those services to the citizens. The city tries to involve its citizens by rolling out information and communications technology (ICT) that can better connect the people to their city officials. The city also tries to reach out to businesses to see how they can better provide services to help them. Portland states one of its main goals is to introduce technologies that provide information and resources to private citizens and businesses on a regular basis. This connection with the public is important because it helps Portland be more transparent with its citizens when implementing a new technology. This is crucial to the city to help lessen the concerns of citizens and better insure that these technologies will be used. One of the final strategies that contributes to Portland's success is making sure that there is a champion within the local government that is continuously pushing for these ideas. The city indicated that

the presence of this person within its local government has been paramount to the success it's had in getting these projects approved. As previously stated, Portland had some issues in the past with convincing other government officials to invest resources into these projects. Having someone who is constantly researching and pushing smart strategies to these critics is incredibly important when trying to change their minds. Portland has also been looking into alternative funding strategies for their smart city projects. For example, the city's streetlight project is structured as an Energy Performance Contract and funded through a private financing company using a municipal lease. The city also has a solar project funded using a power purchase agreement. Portland claims that it will continue to look into innovative ways to get its smart city projects done.

Queen Creek, AZ

Queen Creek, Arizona is a town that straddles the line between Maricopa and Pinal counties. The town has a population of 33,649 (U.S. Census Bureau 2016) and is located just southeast of Phoenix, Arizona. Queen Creek is home to the Communiversity at Queen Creek, a satellite educational center of Rio Salado College. Queen Creek is also considered a "drive through" community as around 50,000 vehicles of non-residents pass through it each day.

The town of Queen Creek cited multiple obstacles and concerns that they had to face when implementing their smart city projects. One of the first obstacles Queen Creek discussed was its access to sufficient funds. Queen Creek claimed that one of the hardest parts of funding these smart city projects was deciding on how to prioritize these projects when considering other city matters. There is only so much money that the city council has for funding, and once the

primary services (police, fire department, etc.) get their funding there is usually not enough left to tackle resource intensive smart city projects. Another issue the city faced was attracting companies to test out smart technologies within the community. Queen Creek believes this reluctance from companies to finance projects in its city comes from the fact that it has such a small population. The town states that companies feel as if there is not much financial incentive to bring smart technologies into Queen Creek because of its small size. Many of these companies instead, go out to other nearby cities such as Phoenix to take advantage of the larger customer base. Queen Creek believes that it is not being used to the fullest capacity as a living lab by these companies. As a small city, Queen Creek does not have access to any major educational institutions they can leverage as an innovation resource. The final two challenges Queen Creek faced while implementing smart city projects deals with staffing and training. The first issue Queen Creek faced was time and resource constraints when it comes to training its staff for these projects. The second issue Queen Creek faced was that the implementation of some of these smart city technologies slowed the growth of hiring town employees.

While facing those challenges has been difficult, the town of Queen Creek managed to implement a series of successful smart city technologies. One of the most recent technologies implemented is an online permitting and development review software system called Accela. This system allows residents to submit permitting requests from anywhere at any time. In return this system allows government resources to be more flexible, be on demand, and helps decrease the amount of paper work created. The final area that Queen Creek implemented smart technologies into is infrastructure. One of its most successful smart infrastructure projects has been their current implementation of a fiber network throughout their town. Queen Creek also recently passed a bill that would allow cellular companies to utilize town right-of-ways as

installation points for small cell technologies. Queen Creek has already been in talks with multiple cellular companies about installation procedures and is excited about the prospect of constructing its 5G infrastructure. The last major smart city project that Queen Creek has is an intelligent transportation system (ITS). Queen Creek developed the ITS in collaboration with its neighboring counties and relies on it to handle the immense amount of drive-through traffic that commutes through the community every day.

Queen Creek made use of a variety of different strategies and resources to implement smart city projects. One of the most cohesive and effective plans was to create a "Corporate Strategic Plan" that guides how it approaches implementation of these technologies. To be specific, the plan is a 5-year plan enacted by Queen Creek's town council to help spur economic development. Technology makes up a major part of this plan and smart city projects are represented within that section. Queen Creek claims that by creating this plan, its IT department has a better chance of convincing the town council of funding the smart city projects. In a sense this plan stands as a mandate that helps reaffirm Queen Creek's dedication to smart city projects and will help it follow through with the implementation of the projects. Queen Creek states it generally takes a "shovel ready" approach when it comes to smart city implementation. Queen Creek tries to stay away from the cutting edge of smart city technology because its budget does not allow it to take risks on new technologies. This means that the town always have a set amount of resources stored away that is specially dedicates towards a smart city project when the opportunity arises. Another strategy that the city of Queen Creek uses is they are big believers in training their staff. As was mentioned previously, one of the challenges with smart city projects that Queen Creek faces is that it can sometimes replace the need for a previous city job. To make sure that this does not cause massive layoffs of city workers, the city of Queen Creek funds

training programs for their staff to help them better adapt to the technologies that are changing their jobs. The final strategy that Queen Creek uses to implement smart city projects is that they make sure to maintain a close connection with their constituents. One of the ways Queen Creek does this is by distributing a biannual public poll to their citizens to get feedback on how they are doing. Furthermore, Queen Creek leverages social media to make sure that it is are being transparent as to what projects the town is currently working on. The town also has an app that citizens can download and use to send direct comments or complaints to town officials. Queen Creek beliefs that they really shine in regard to employing this strategy. The town thinks that the concerns and opinions of their citizens are taken into account when considering a new smart city project so that they know for sure that what is implemented is wanted and will be used. Beyond these strategies, Queen Creek believes that there are some benefits that come with implementing smart projects as a smaller town. Since there is less bureaucracy to deal with, their city can be more flexible and quick with approving and implementing smart projects. Queen Creek says that it leveraged this benefit before to incentivize companies to install smart technologies into their town with positive results. The companies that have worked with Queen Creek said they liked working with them because of this flexibility. Queen Creek hopes to further leverage these characteristics and strategies so they can be better utilized by businesses and implement more smart city projects in the future.

Seat Pleasant, MD

Seat Pleasant is a city within the state of Maryland and inside Prince George's County. It is a city with a population of 4,769 residents (U.S. Census Bureau 2016) and sits near the Capital

Beltway right outside of Washington, DC. The city of Seat Pleasant does not have any institutions of higher learning within its city limits, but it is in close proximity to top universities throughout the state of Maryland and within the District of Columbia. In recent years, Seat Pleasant has come to embrace the idea of smart city planning, coining itself with the moniker, "A Smart City of Excellence".

The city of Seat Pleasant, Maryland faced a lot of obstacles in its journey to becoming a leading smart city hub. One of the first obstacles Seat Pleasant reported was with their revenue. Like nearly every other city in this report, Seat Pleasant thinks that one of their greatest barriers to attempting and incorporating new smart city projects is lack of resources. Seat Pleasant believes that its problems with revenue is mostly based on the fact that their population is much smaller than most cities in the US. Because of this lack of revenue, Seat Pleasant is forced to seek resources outside of the city if it wants to implement these technologies. Seat Pleasant also cited that most venture capital money generally goes to states such as California, New York, and Massachusetts meaning that it is harder for it to tap into that particular resource. The second major obstacle Seat Pleasant reported was making sure the city had "citizen buy in" when implementing these new technologies. Seat Pleasant said that it is critical to gain citizen involvement as early as possible, so you can better understand what they want. However, getting this interaction is not always easy. McKinsey Consulting Group (2017) found that citizen satisfaction with the quality of key government services was "less than have that with most non-state providers, such as banks or utilities". Because of this, Seat Pleasant must be more conscious of how to connect with its constituents. The third major obstacle Seat Pleasant reported was that there was difficulty in adopting some of these technologies into the government's internal framework. The city has said that they continue to work hard to infuse these technologies into

the day to day operations of their personnel to increase this adoption. The fourth and final problem that Seat Pleasant reported involved the make-up of the relationships within the smart city marketplace. Seat Pleasant feels that for a long time, vendors have been driving the conversation around smart city implementation. This is because these vendors usually have more of the resources and experience on their side and are generally the ones approaching the cities to buy their products. Seat Pleasant hopes to change this dynamic for themselves so it can have their citizens be the driving force behind the implementation of innovative technologies within their city. In doing so, the city not only hope to improve the success of their projects, but also the lives of their citizens.

Despite these obstacles, Seat Pleasant has made remarkable strides in the implementation of smart city technology throughout the city. At the heart of Seat Pleasant's advancements in smart city technology lies their Intelligent Operations Center (IOC). The IOC is a cloud-based platform that provides a holistic operational view of the city across all departments. The goal of this technology is to facilitate collaboration in and across departments for decision making, coordination of events, coordination of resources, and processes to yield efficiency in each of those areas. Seat Pleasant thought that this technology was important, because they saw cities around the U.S. with a lot of single IoT solutions. Seat Pleasant saw that these cities were missing a certain interoperability within and across different departments. Seat Pleasant thought that it was necessary for them to implement this IOC to prevent this fragmentation of resources and data and to help provide better quality of service to their residents. One of the second biggest smart city projects that Seat Pleasant plans to implement is their video analytics system for traffic management. One of the main functions that this system is used for is capturing license plates. Seat Pleasant hopes that using this license plate capturing system will help them better

catch criminals who are crossing the jurisdictional boundary between them and neighboring Washington, DC. While this technology has not been installed within the city yet, the project is on Seat Pleasant's list of planned city projects. The next smart city project that Seat Pleasant is implementing in their city is the installation of an array of sensors to help them better provide information and services to their citizens. One set of sensors the city has been looking at is smart trash can sensors. These sensors would help alert city waste management workers when a trashcan is ready to be picked up, so they do not waste resources driving around all day looking at each trash can. Another set of sensors that Seat Pleasant has been piloting are weather sensors that they can attach to their city vehicle fleet. These sensors keep track of the conditions on the road as well as the vehicle's location via GPS. This data would be continuously transmitted back to the IOC where it could be organized and used to make a map of the conditions of roads throughout the city. In the near future, Seat Pleasant is also hoping to install air quality sensors throughout the city. The city plans to use these air quality sensors to detect the levels of carbon dioxide within the city throughout the day. The city would then pass that information on to their citizens to help them make better choices about when they should go outside to do activities or to see if there are correlations between test scores in school and carbon dioxide concentrations. These ideas are still in their earlier stages though. The city of Seat Pleasant has also been working with the Harrisburg University in Pennsylvania to implement blood pressure measurement machines throughout the city's government buildings to help provide smart health programs to their workers. The final project that Seat Pleasant mentioned was their Seat Pleasant municipality app. This app was created to help citizens better connect and communicate with their city. It allows citizens to file complaints and comments about the city. Seat Pleasant is very proud of their app and has reported a 98 percent decrease in city response time to public issues.

Seat Pleasant hopes to continue to implement even more sensors and smart city technologies so it can build a completely connected and transparent city.

Seat Pleasant is an extremely interesting example of a city that has fully embraced the idea of the smart city and is attempting to incorporate these ideas in everything it does. To do this, Seat Pleasant has used a multitude of different strategies and resources. One of the most crucial resources that Seat Pleasant relies on is its close partnership with IBM. In talking with Seat Pleasant, it is obvious that the city has taken full advantage of its opportunity to work with IBM. Seat Pleasant states that it proactively approached IBM with the idea of partnering with their city to create a smart city package designed around them. By creating this partnership, Seat Pleasant has been able to take advantage of IBM's vast amount of resources, knowledge, and reputation to help them better implement their city's smart projects. One of the greatest benefits Seat Pleasant said it received from this partnership is the financial resources they receive for helping sell IBM's smart city package to other small smart cities. The city said that it become a living example of the benefits of smart technologies. It did this by promoting and participating in what IBM refers to as the "shared services business model". The model operates as a "cost sharing mechanism" that allows smaller municipalities (with smaller budgets) share in the benefits of innovative solutions at a fraction of the cost. Through this business model, Seat Pleasant is offering access to the IOC through a subscription-based model. In addition to the benefits the IOC can bring to cities, the shared services approach allows cities within the plan to collaborate and co-create solutions to common problems. Furthermore, Seat Pleasant said that they have benefitted from the training and experience that IBM has provided. In fact, Seat Pleasant has even hired some IBM team members and integrated them into their city staff to assist with the implementation of these projects. Beyond just working with IBM, the city of Seat

Pleasant has also worked with other smaller vendors to help with smart project implementation. Many of these smaller vendors have also approached Seat Pleasant and provided their services for free in exchange for using the city as a living lab. The city of Seat Pleasant has also had the opportunity to leverage universities as a resource. Seat Pleasant states it proactively approached the University of Oklahoma to see if it wanted to use the city as a living lab. The University of Oklahoma turned out to be very interested because of the city's reputation for smart city implementation and its deep level of public engagement. These qualities made Seat Pleasant a perfect candidate for testing smart technologies. The city was also approached by Harrisburg University in Pennsylvania to do smart city research. These university partnerships are significant, because they allowed Seat Pleasant to tap into a wealth of advanced resource knowledge without having to use any of their own funding. It is also important to point out that this is another example of Seat Pleasants strategy of being proactive about smart city implementation. Because Seat Pleasant does not have the university resources of its own, it made the proactive choice of reaching out to other research universities and offered their city as a living lab in exchange for their research. Another valuable resource Seat Pleasant took advantage of was state and federal resources. At the federal level, Seat Pleasant received a grant from the United States Department of Agriculture (USDA) to implement a smart emergency control center in their city. They also received other grants from the federal government to help implement smart technologies that would improve the health of minority citizens in their community. Seat Pleasant has also taken advantage of other organizations with their state. They have been in close collaboration with the Innovation Village Baltimore project. The project was created to help create innovation districts across the US and Baltimore is the center for Maryland's program. Both Seat Pleasant and this organization have worked together to explore

different strategies on how to implement smart technologies into areas to accelerate their economic growth. The final strategy that Seat Pleasant uses is developing a strong connection with its constituents. The city claims that they have taken a "constituent obsessed" approach when engaging their citizens with smart city projects. Seat Pleasant reports that this is crucial for them, because they want to make sure that the technologies they are investing in are going to be used by their citizens. The city of Seat Pleasant tried cultivating this relationship in many ways. First, Seat Pleasant created a department within their government that is solely dedicated to connecting with its citizens. The name of this department is the Public Engagement Department. Furthermore, Seat Pleasant worked closely with citizen leaders to create data security and privacy policies to help alleviate public concern. One of the last ways Seat Pleasant tried to connect to their citizens is by making sure that they maintain transparency about what they are working on. The city says this transparency and engagement has not only alleviated the concerns of their citizens but has also enticed both universities and businesses to test their technologies within the city. The universities and businesses are eager to test their technologies in cities where they can get valuable feedback. Overall, the city of Seat Pleasant thinks that they've been able to overcome many of the disadvantages of their city's size and even take advantage of some of its benefits. The city believes that its smaller size is advantageous because the lack of a large bureaucracy leaves them more flexible to implement smart city projects on a faster time scale. The city also believe that their size gives them the ability to provide a more controlled and fleshed out testing environment for any entities looking to pilot their projects. Seat Pleasant is a prime example of a city that has taken full advantage of the resources and strategies at its disposal to find success within the world of smart cities.

Discussion

Research Question #1: How do smaller cities, towns, and communities implement smart city technology?

This study has shown that smaller cities, towns, and communities implement smart technologies by leveraging the resources described in the Quadruple Helix Model. While smaller cities do make use of every entity within the Quadruple Helix Model, it should be noted that these cities leverage some of these entities more than others. For instance, because of the resource restrictions of many state and city governments, smaller cities tend to rely on industry entities a lot more for funding. Smaller cities also rely more on the industry entity for their knowledge and innovations, because many of these smaller cities do not have major universities within their region. While smaller cities do rely a lot on industries for help implementing their projects, they leverage their citizens a great deal as well. One of the most striking benefits small cities have when comparing them to larger cities, is that smaller cities have a much better and more intimate connection to their citizens. This is mostly because their communities are vastly smaller and more concentrated, allowing the officials of these governments to be more connected with their people. This close connection with their constituents allows smaller governments to get more accurate sense of what their people want and want smart technologies they will be willing to use. This is extremely important, because it is critical to know what is pertinent to these users so that you are not wasting resources on technologies that will never be used (Carayannis et al., 2017). Furthermore, this shows that within the Top-down/Bottom-up model, smaller cities are inclined to leverage both top and bottom entities for a project but are likely to start the project planning and design phase from the bottom entity. This is because these smaller

cities are better able to connect with their citizens (bottom entity) and because their lack of funding resources requires them to be sure a project will be used. Smaller cities are also better able to leverage their own local government entity, because of their smaller size. While the government entity is defined as a more centralized, top-down entity (Hagel, 2008), smaller cities have the advantage of having less centralized cities. This is because, smaller cities have dramatically smaller bureaucracies than larger cities do. This allows these cities to be faster and more flexible with how they implement new technologies and engage in industry partnerships. While most cities interviewed for this project reported being smaller and more flexible made it easier to engage in industrial partnerships, a few cities also reported that their size could be a deterrent to these relationships. This is because industry entities are looking to work in cities where they can get the biggest return on investment. Since smaller towns have smaller populations, some companies do not consider them for their projects. Many of the smaller cities that were interviewed felt that they were being underutilized because of this. As the field of smart city technologies grows, I believe that smaller cities will become a valuable resource when it comes to piloting innovative technologies. This is because they are much more flexible, more manageable, faster, and better connected to their "users" than larger cities.

Research Question #2: What problems do smaller smart cities face?

The cities that were interviewed for this report are comparable in a series of ways when viewing them through the lens of what problems they face. These problems can be broken down into four major categories; lack of resources, lack of proper training, lack of strategy, and lack of political and communal acceptance or participation. Some of these obstacles are directly caused by the size of the city while the others are probably found throughout cities of any size. It should

be reiterated that these problems exist within the context of when these cities attempt to implement smart city projects into their communities.

The first common issue found amongst these cities was that they lacked the extra resources to put towards implementing a great deal of smart city projects. These resources include both financial and staff resources. The cities in this study stated that while they were eager to implement these new technologies, they felt their city size left them less adapt to implement as many of these projects as they wanted to. When talking to these cities, they would often cite that larger cities (New York, San Francisco, Chicago, etc.) not only had larger financial resources, but also larger citizen populations and staffs to work on these projects. Many of the cities felt that their smaller populations left them with less resources overall and made their cities less attractive to business looking to implement technologies, because of the small customer base. It seemed that cities with smaller populations generally had less local educational and industrial resources to access as well.

The second common issue was that these cities lacked the proper training infrastructure to implement these smart city projects. Many of these cities stated that they did not have many employees on hand with experience in implementing technical projects (much less smart city projects) or with dealing with large amounts of data. This problem could be related back to the previous problem. Because of many of these city's lack of funding, they generally could not afford to hire experts within the field of smart cities or implement technical training programs. Furthermore, many of these towns lacked major technology focused universities within their city's limits. This lack of local educational resources made it more difficult for these cities to find pretrained candidates for these positions. Overall, this left cities without the ability to access the university entity of the quadruple helix model.

The third common issue was that these cities lacked the proper strategies and domain knowledge to tackle some of these smart city projects. With the smart city industry being so novel, this is most likely a problem for cities of all scales. As stated in the previous problem though, employees in these smaller cities generally have less experience in coordinating technology projects nor do they have large staffs to implement these new ideas with. There was also a trend with many of these cities that since they usually lacked the funding, industrial, and educational support that bigger cities have, they were more cautious when approaching many of these new strategies. Many of these cities only felt comfortable following more proven and accepted strategies of smart city implementation than more novel ones. Overall, the novelty of the projects matched with the city's limited resources made learning and following smart city implementation strategies difficult.

The fourth and final issue found within many of these cities was their struggle introducing and integrating these technologies into the lives of their constituents and employees. Almost every city interviewed for this project claimed that they had issues convincing people within their own governments to invest time and trust into these technologies. These government employees ranged from city council officials who did not pass the proper bills to help with the implementation of these technologies to city employees who did not want to change their routines. Beyond internal cooperation, many of these cities also had issues with external cooperation from their citizens. Some of these cities claimed that they lacked enough funds to properly interact with their citizens in the way they wanted to. Other cities also reported that citizens were sometimes concerned for their own privacy and security. These citizens were concerned about the cities ability to collect data on them through these smart technologies.

Research Question #3: What technologies can these cities implement to solve these problems and create new opportunities?

From the cities that were interviewed, there were three distinct categories of technologies that were commonly implemented. Those categories are city management technologies, utility technologies, and transportation technologies. Each of these categories is made up of common technologies that were commonly implemented by many of the interviewed cities or at least planned for in the near future. While each of these categories are distinct, the technologies within them do interact with and even enhance other technologies in different categories. It should also be noted that different technologies within each individual category might serve varied purposes depending on their context. Even so, each technology should still match the broader concept of the category they inhabit.

The first category of commonly implemented technologies is city management technologies. This category of technologies has been of incredible interest to city officials across all eight of the cities that I interviewed. This category is of such interest to cities because, "An efficient city administration that provides services to its citizens and fosters businesses is essential to today's service-based economy" (Washburn and Sindhu, 2010). These city management technologies not only help organize the inward facing processes of a city's government, but also help with the city's outward facing processes. With city-wide sensors giving communities access to huge sets of data, these city management technologies are critical in helping city officials make better short term, data-driven decisions (Batty 2013). The most common technologies this study found in use are employee management systems, resource management systems, cloud services, smart budgeting software, smart city dashboards, open data, online permitting system, intelligent operations centers, and city apps. Cities find these

technologies important because it lets them become nimbler and helps them better plan for their community's future. Furthermore, some of these technologies (such as open data and the online permitting system) take the process directly to citizens. This gives them the ability to access these resources on their own terms at any time they want while freeing up more of the city's resources. A few of the cities interviewed for this report even expressed the desire to construct a fully digital town hall for their citizens to access. These types of technologies will become increasingly necessary and beneficial to cities as they find themselves dealing with more data to parse and more services to provide.

The next category of technologies that were commonly implemented by these cities is the communication technologies category. This category can be defined as technologies whose purpose in implementation is to provide services to entities within the community. This category also covers technologies that help governments provide these utilities in a more efficient and sustainable way. Every city interviewed for this paper and many other cities across the country realize that it is critical to both curb their carbon admissions while also providing an increasing amount of utility resources to their citizens (Kramers et al., 2013). To do this, these cities are investing more into these kinds of smart and sustainable technologies. The commonly implemented technologies within this category are gigabit networks, 4 and 5 G cellular infrastructure technologies, advanced emergency services communication technologies, smart utility metering, smart grids, solar PV, EV charging stations, and smart street lights. The implementation of these technologies can make cities more efficient, green, and (especially in the case of the gigabit and cellular infrastructure projects) more attractive to business. These types of technologies will play increasing critical roles in the future, as cities continue to compete to keep up with community demand for these utilities.

The third category of technologies that were commonly used throughout these cities is the transportation technologies category. Transportation technologies can be defined as technologies that assist in the movement of resources across a city and that can also help resolve congestion issues. This category of technologies is especially important because it effects a wide breath of city entities such as citizens, businesses, government officials, etc. (Taniguchi, 2014). This report found that the commonly used technologies in this category are; smart traffic cameras, vehicle fleet tracking sensors, parking space detection technologies, smart stoplights, autonomous vehicle piloting, smart crosswalks, and Intelligent Transportation System (ITS) analytics. By investing more into these technologies, a city can increase the flow of information and resources that it can handle. Better transportation will also help entities within a city connect with each other better. This in turn will make cities grow into more collaborative and innovative places. As more people begin moving into cities in the coming decades (U.N., 2010), these technologies will become crucial in helping cities create an infrastructure that can support this influx of population.

Research Question #4: What strategies can small smart cities use to effectively implement these changes?

Smaller smart cities use a wide array of strategies when implementing smart city technologies. All of strategies observed during this study can be categorically summarized through the lens of the Quadruple Helix Model. Because of their smaller size and relatively small amount of resources, cities within this study stated that they had to be extra creative with the strategies they used. These cities also stated that they had to take advantage of every resource at

their disposal. This meant that they tried taking advantage of every entity within the Quadruple Helix Model they had access to.

Starting with the government, smaller cities found it critical to leverage this entity to help better fund their projects and determine what metrics to use to evaluate them with. Nearly every city that was interviewed for this project reported having used some sort of state or federal funding to implement their smart projects. Another government-based strategy that these smaller cities used was to have someone within their organization act as their smart city "champion". By this, they meant that it was important to have someone in the government always pushing for and defending the implementation of these smart city projects. Without these crucial people, the administrations within these cities may never consider smart city technologies as a viable option for city investment. These smaller cities also stated that state and federal governments were also helpful in creating guidelines and metrics for these cities to follow when implementing their projects. Furthermore, the governments of these smaller cities generally took it upon themselves to be the "middleman" between the other entities and the actual implemented projects. These smaller cities used this strategy, because they could understand and translate the needs of their population directly to industries and better facilitate their relation that way.

The next set of strategies comes from leveraging industry entities. Industry and business entities were crucial to the implementation of these smart projects. This is, because they could be leveraged as a primary provider of financial resources and expertise when implementing projects. Smaller cities leveraged these entities in many ways. One way they did is by having them train their city officials in project management skills so that they could be better at implementing these technical projects. Another way smaller cities leveraged industries was by interacting with vendors and consultants for smart city projects. This strategy was important to

use because it gave these cities access to technologies and strategies that they would not of had otherwise. The finally strategy these cities used to leverage industries was to allow them to use their region as a "living lab" for piloting innovative technologies. The idea of using cities as living labs for new technologies is a main tenant of smart city theory (Cosgrave et al., 2013). By letting industries use them as living labs, these cities were able to implement smart city technologies for reduced prices or even for no cost at all. This strategy allowed them to circumvent on of their greatest obstacles, lack of financial resources.

The third set of strategies comes from leveraging universities. Leveraging universities is useful because they are homes of innovation. Leveraging these entities to take advantage of this is an incredibly important part of the Quadruple Helix Model (Senge and Kim, 2013). Smaller cities leverage universities in a couple separate ways. The first way, is to try to use universities to entice businesses to come to a small city's region. Small cities do this by advertising the fact that their region has more skilled workers for these businesses to hire. Small cities can also leverage this skilled labor themselves by hiring graduates form these schools. The other way small cities can leverage universities is by letting them use their cities as living labs to test innovative technologies in. Allowing universities to do this provides cities with free, cutting edge technologies that their budgets wouldn't usually allow them to fund. Leveraging universities as a strategy gives smaller cities the chance to continue to stay in step or even get ahead of some of the innovations occurring in bigger cities. The best strategy smaller cities can execute to get universities to work with them is by being proactive and approaching them with the opportunity to use the city.

The final set of strategies comes from leveraging citizens. Leveraging the local population to implement smart cities is one of the strongest strategies smaller cities can employ.

This is because, the intimate connection smart cities have with their citizens is one of their greatest strengths. The cities interviewed for this project claimed that they would regularly reach out to their constituents to gauge their wants and needs. Doing this gave these cities a better idea of what smart city projects were relevant to their situations and which ones their citizens would be willing to use. The strategy of taking a user-centric approach to smart technology implementation was incredible useful for making the implementation of these projects worthwhile. Furthermore, the cities in this report claimed that the companies and universities that they partnered with were largely incentivized to come test out their projects within their cities because of these close relationships. Cities within this study also said that they would leverage their citizens technical skills as well. Most of the cities interviewed in this report said that they had sponsored hackathons to leverage this. In these situations, cities would invite citizens to submit apps or other technical projects that would help the city do their job. The submissions that won these hackathons would then be taken over, supported by, and integrated into the city itself. Most of the cities that participated in this project believed that their ability to leverage their citizen's involvement was one of the main strategic benefits that they had over larger cities.

Limitations

One of the main limitations of my study was the sample size. The sample size of this study is not completely representative of the whole of the United States nor of the world at large. Since this was only an exploratory study, only eight cities were interviewed. While the 8 that were interviewed did come from various places from across the U.S., the size of the sample is still too small for it to truly be considered representative. Furthermore, this study did not equally represent all parts of the U.S. There is a distinct lack of representation from deeper southern states, Midwestern states, and middle American states as well.

Another limitation of this project was that there was a lack of a cohesive list of smart city projects from every city that was interviewed. During each interview, interviewees were asked to list the smart city projects that they had implemented within their cities. Interviewees that could be interviewed for an hour were read a list of smart city technology categories and asked if they could recall any technologies that their city had implemented that fell within any of them. While this second question was more thorough, both question required interviewees to recall their city's smart projects all from memory. Because of this, there is a chance that some technologies were missed by this paper.

A third limitation to this study is that all the data gathered was self-reported data. This means that all the data that was gathered for this paper was taken upon trust and much of it would be difficult to verify. Furthermore, as the people interviewed for this paper were employees discussing their own work, there may have been bias towards talking about the more positive aspects of their work.

The final limitation of this study was that, this project did not provide interviewees with a common definition of what it considered smart technology. Even the industry definition of what "smart technology" is can be vague itself. Because of this, interviewees were required to rely on their own idea of what smart technologies were, which varied from interviewee to interviewee.

Further Research

Overall, there are three separate topics that stem from this paper that require further study. The first would be to look at the strategies and resources cities use to implement smart city projects based on the city's affluence. One could assume that a cities affluence has a huge effect on what resources a city has access to. It would be interesting to see how that affects the implementation of smart city projects. The second topic would be to examine how towns and cities can cultivate trust within their communities better. Throughout this paper I saw that trust and communication between a city and its citizens was an incredibly crucial resource to have. It would be interesting to explore what strategies would be effective for a city to use to cultivate that trust. The third and final would be to study the security concerns that arise when a city takes a business centric approach to smart city implementation. Within the cities I interviewed for this paper, it seemed like many of them relied heavily on businesses as a resource to implement their smart city projects. Because of this, it would be interesting to see what the security and privacy implications of this business-heavy strategy are, if any exist.

Conclusion

The findings of these interviews suggest that small cities tend to have similar problems surrounding funding, training, and overall smart project implementation strategy. These interviews also showed that when small cities do invest in smart city technologies, the technology generally falls within the category of management technologies, utility technologies, or transportation technologies. This paper also found that the most popular smart city implementation strategies these cities used were all derived from their interactions with entities from the Quadruple Helix Model. While these small cities did take advantage of many of these resources, the three most critical resources were industry cooperation, administrative support, and citizen interaction. This project shows that small cities generally have to be more creative and cooperative when it comes to smart city project implementation.

This study also provides insight into how small cities can better leverage themselves in order to implement more smart city projects. One of the key findings of this study was, when it comes to smart project implementation, there are actually some benefits to being a small city. These benefits are; close citizen interaction, less bureaucratic inflexibility, and a more controlled testing environment for piloting projects. This study also showed that small cities generally feel underutilized by industry, university, and government entities that could be using them as living labs for testing new smart city technologies. Regardless of these feelings though, all of the small cities that were interviewed expressed excitement at the idea of implementing more smart city projects. Today, over 60 percent of the U.S. population lives in cities and towns with populations less than 100,000 people (U.S. Census Bureau). It is critical that organizations pay more

attention to this demographic, not only because they are a majority of our population but, because of the incredible opportunities and partnerships they can offer the smart city industry.

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Appendix

Appendix A – Initial Email Correspondence

Hello,

My name is Ryan Theurer and I am a student at the University of North Carolina at Chapel Hill's school of Information Science. I am currently working on a thesis paper on the topic of how small and medium sized towns and cities might better implement smart city technologies into their cities. The purpose of this research study is to explore how these communities benefit from the use of smart city technologies and how best they can incorporate them into their smaller scale of design. I was wondering if you would be willing to participate in a 45 to 60 minute interview with me on your town's experience with smart city projects?

The possible risks/discomforts to you in taking part in this research are:

- You will have to share information about your town or cities smart city project work.
- Your interview will be recorded with an audio recording device. (Your identity and the identity of your town/city will be kept anonymous in the write-up of the report).

The possible benefits to you for taking part in this research are:

- Access to an article detailing effective strategies for implementing smart city technologies into small towns and cities.
- An article detailing some of the ideas other cities and towns similar to yours are employing in the implementation of smart city technologies.
- Helping progress the science of smart cities.

If you have any questions about this research or are interested in being a part of it, please contact the Investigator named at the top of this form by calling [redacted]

or [redacted]. If you have questions or concerns about your rights as a research subject, you may contact the UNC Institutional Review Board at 919-966-3113 or by email to IRB_subjects@unc.edu.

Thank you for your time

Appendix B – Interview Questions

Hello,

Thank you again for participating in our smart city study. As stated previously in my email, I have recruited you to be interviewed for this study, because you an extended knowledge in how smart cities can be integrated in small to medium sized cities. This interview will be an unstructured interview, meaning that the answers you will provide to my question will be free form. Questions not listed below may also evolve from this interview process. This interview will be conducted over the phone and will be recorded via microphone. Hand written notes will also be taken during the extent of this interview. The full interview should take around 45 to 60 minutes in total. The interviewee reserves the right to refuse to answer any questions they want to and may stop the interview at any time. Interviewees may also choose to have their interviews pulled from the project at any time before the publication of the study.

The questions are as follows:

1. What technologies have you implemented into your city?
2. What strategies are you using to implement smart city technology into your city?
3. What are the greatest obstacles that you face in implementing smart city technologies into your city?

4. If your city were larger (had more resources, population, etc.), how do you think it would affect the way you could and would implement smart city programs?
5. What benefits have you seen from implementing these smart city projects?
6. What are the issues within your city that you feel would be most conducive to being solved by smart city technologies?
7. Do you think there is an upper limit to what smart city projects your town or city can implement?
8. What do you feel is the public's view on these smart city projects?
9. How involved does your cities government what to be in the implementation of these smart city technologies? Where do businesses and the public fit in this implementation?
10. What does successful smart city implementation look like in your city or town? What is the ultimate goal of your cities smart city program?
11. Have you had any experience with any of the following categories of smart city projects:
    a. Smart mobility (parking, smart traffic, bikes, facilities for electric vehicles, smart bus, rail/train facilities, etc.)
    b. Smart energy (helping with smart consumption, load balancing, renewables, etc.)
    c. Smart food (combating food deserts, healthy options, farm-to-table, etc.)
    d. Smart health (exercising options, bike/walk facilities, smart patient technologies, etc.)

e. Smart governance (public feedback, open government, transparency, citizen governance, city apps, etc.)
f. Smart economy (with regards to budgeting, online payment options, supporting smart city projects to benefit businesses, etc.)
g. Smart tools and technologies (ICT (Information and Communications Technologies) being used, smart infrastructures, smart analytics, etc.)
h. Smart dashboards (smart decision making, disaster handling, long-term planning, etc.)

12. Can you briefly go into detail on any of the above project categories that your city has tried implementing? (failure or success, implementation strategy, biggest obstacles, greatest benefits, etc.)
13. How does your city leverage local colleges or other educational institutes to help assist in implementing smart city projects?

Appendix C – Interview Transcripts

The audio interviews for this paper were transcribed into word documents and then uploaded to lifetime library. To access these transcripts, follow the link below and access the “Honors Thesis Project” folder on the left side of the screen. The transcripts will be downloadable from there.

Link:

https://lifetime-library.ils.unc.edu/idrop-web2/home/link?irodsURI=irods%3A%2F%2Fdiamond.ils.unc.edu%3A2247%2FlifelibZone%2Fhome%2Fryantheu%2FHonors%2520Thesis%2520Project