NATIONAL LEAGUE OF CITIES

CENTER FOR CITY SOLUTIONS AND APPLIED RESEARCH

Trends in Smart City Development

About This Publication

Research for this guide and the original draft of the document were completed by graduate students at the American University Department of Public Administration and Policy. Contributors include Reena Shrestha, Cynthia Castro, and Fletcher Smith. These students worked in partnership with Brooks Rainwater and Nicole DuPuis at the National League of Cities (NLC) to conduct an analysis of smart city implementation across the country and around the world. The final report was prepared by Nicole DuPuis and Elias Stahl at NLC.

The National League of Cities is the nation's oldest and largest organization devoted to strengthening and promoting cities as centers of opportunity, leadership, and governance. NLC is a resource and advocate for more than 1,600 member cities and the 49 state municipal leagues, representing 19,000 cities and towns and more than 218 million Americans. NLC's Center for City Solutions and Applied Research provides research and analysis on key topics and trends important to cities, creative solutions to improve the quality of life in communities, inspiration and ideas for local officials to use in tackling tough issues, and opportunities for city leaders to connect with peers, share experiences and learn about innovative approaches in cities.

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Trends in Smart City Development

CASE STUDIES AND RECOMMENDATIONS

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Foreword

Cities are ever-changing; the dynamism of the urban environment is a microcosm of the societal interactions that we have built throughout history.

Technology has always been a critical force deeply intertwined with the evolution of cities. From the first human settlements millennia ago to the industrial revolution to today, technological breakthroughs have impacted the buildings we use, the way we get around, and how we live, work, and play in the urban space.

Now, as we are on the cusp of further rapid shifts in cities precipitated by technology, it is worth imagining what the connected smart city of the future will look like – and the associated impact it will have on our everyday lives.

Take a typical day in the life of a community member in this hypothetical future who wakes up in their connected house with artificial intelligence automating everything from temperature preference to light levels to health monitoring and more – and scale it to the city at large.

Cities are beginning to, and will continue to, integrate technological dynamism into municipal operations, from transportation to infrastructure repair and more. The back ends of these systems are not always apparent to the end user – but as the integration of smart cities technologies becomes more visible in our everyday lives, we could begin to see large scale changes in our cities.

Autonomous vehicles on our roadways and the data that they provide could create environments where traffic lights become obsolete, traffic itself becomes a thing of the past, and cities can once again be for people rather than cars, as different modes of transportation work in tandem and communicate with each another. Wi-Fi hotspots at scale like we are already starting to see in New York with LinkNYC could help transform the way we access information and help alleviate the digital divide.

Thinking even further out, we can imagine that security protocols like facial recognition technology could help transform building security in cities, making entrances and building design more fluid as we move away from the need to usher people through front doors. Similarly, as we move toward greater usage of shared vehicles, we can move away from parking either below buildings or on streets, enabling cities to recapture land for people and allowing developers to reduce the costs of buildings since parking garages will become an unnecessary expense.

Energy sources could be completely renewable in the smart city of the future as well, with technology paving the way for better integration into our cities and thereby helping to create a cleaner environment for everyone. At the same time, the smart city of the future can be safer with streetlight networks that use embedded sensors to detect gunshots or flash their lights during emergencies – and the further integration of these systems will allow cities to collect information from sources such as smart water, electric, and gas meters.

All of this is predicated on the premise that technologies can help make people's lives better in cities. At the end of the day, technological developments will enhance our urban experience – but they also risk leaving more people behind. To this end, we must be deliberate in the development of smart cities and imbue equity as a primary goal so that the city of the future is a city for everyone.

Cities are focused on these goals right now, and they are beginning to think about how these systems can be integrated to create feedback loops that improve operations and enhance the experience of community members. Fully connected smart cities are coming, and we want to help cities prepare for their arrival and provide local leaders with best practices in this arena.

The National League of Cities (NLC) is pleased to share with you Trends in Smart City Development, which presents case studies and discusses how smart cities are growing nationwide and globally. It is our hope that this report will spark conversation and action among city leaders about how to incorporate these strategies into their own communities.

NLC's Center for City Solutions and Applied Research strives to strengthen communities, transform and improve cities, and assist city leaders. We do this by knowing and learning about cities, identifying and sharing promising city practices, fostering effective solutions and innovation, and challenging city leaders to lead.

We wish to thank the cities who participated in this study. Created with our partners at the American University Department of Public Administration and Policy, this guidebook is meant to be a resource for cities as they lead the way forward in this exciting and ever-evolving space.

Brooks Rainwater
Senior Executive and Director
Center for City Solutions
National League of Cities

INTERNET OF THINGS IN CONNECTED CITIES

Every consumer product and piece of infrastructure increasingly has the ability to sense surrounding stimuli, to communicate with other devices and people, and to draw on the computing and storage power of the cloud. This phenomenon has been dubbed the **internet of things**. The more smart devices and sharing platforms there are, the more data is generated about consumer's preferences and habits. But what does this mean for cities? Smart cities are employing the same technology to connect their disparate utility, infrastructure, and public service grids, generating real-time aggregate data. This, in turn, can help cities manage their programs and services more effectively and gauge their impact immediately. The city of the future is an interconnected one, where devices communicate with one another in a constant stream of data that provides real-time information to the public and to the municipality.

1 TRANSPORTATION CONGESTION SENSORS
Smart transportation systems use sensors to detect congestion and bottlenecks in traffic patterns. They also rely on cameras to enforce speed and traffic infractions. In doing so, these tools gather real time information that can be used by city DOTs to make mobility networks safer and more efficient.

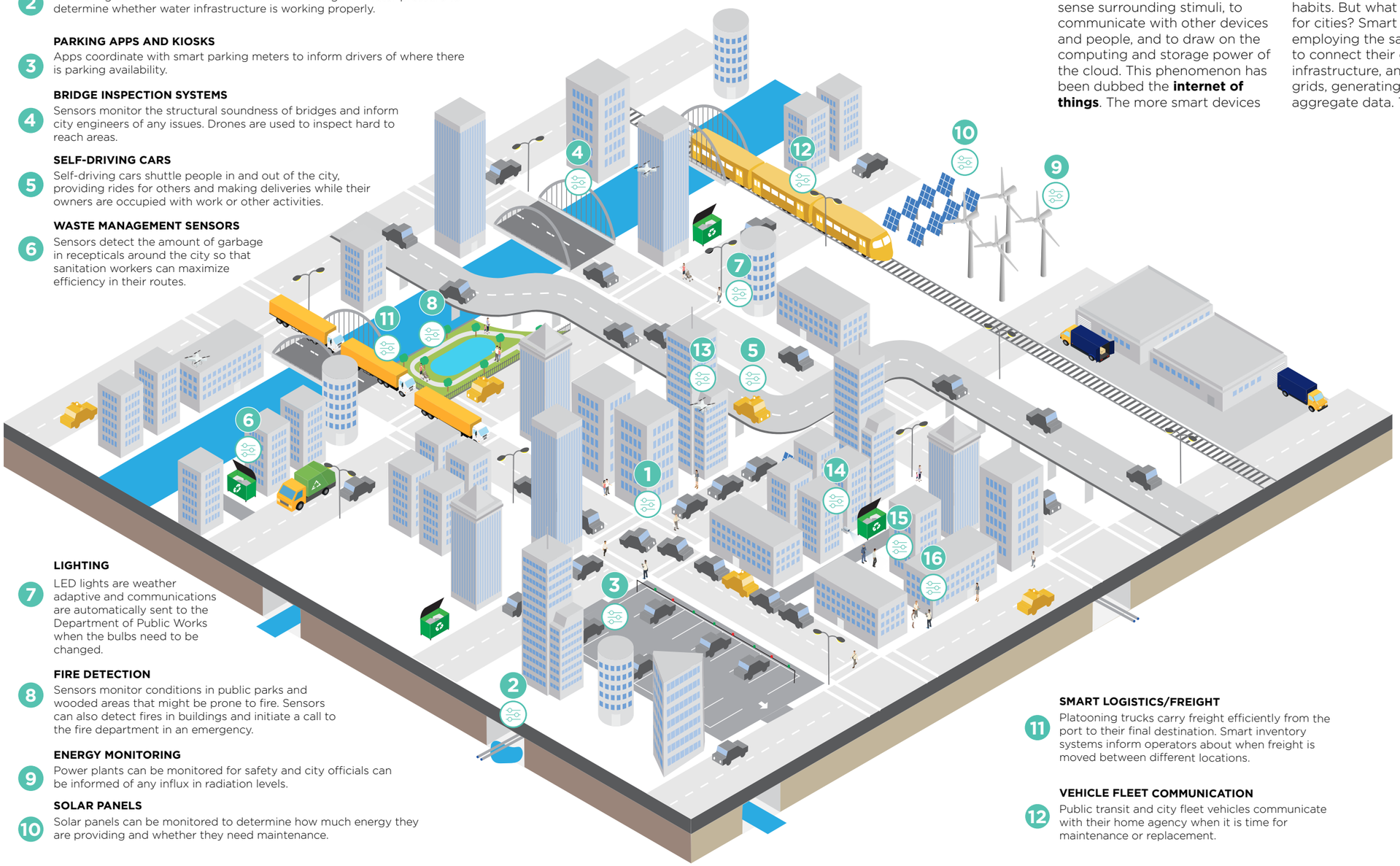
2 WATER AND WASTEWATER MONITORING
Monitoring devices can detect leaks as well as changes in water pressure to determine whether water infrastructure is working properly.

3 PARKING APPS AND KIOSKS
Apps coordinate with smart parking meters to inform drivers of where there is parking availability.

4 BRIDGE INSPECTION SYSTEMS
Sensors monitor the structural soundness of bridges and inform city engineers of any issues. Drones are used to inspect hard to reach areas.

5 SELF-DRIVING CARS
Self-driving cars shuttle people in and out of the city, providing rides for others and making deliveries while their owners are occupied with work or other activities.

6 WASTE MANAGEMENT SENSORS
Sensors detect the amount of garbage in receptacals around the city so that sanitation workers can maximize efficiency in their routes.



7 LIGHTING
LED lights are weather adaptive and communications are automatically sent to the Department of Public Works when the bulbs need to be changed.

8 FIRE DETECTION
Sensors monitor conditions in public parks and wooded areas that might be prone to fire. Sensors can also detect fires in buildings and initiate a call to the fire department in an emergency.

9 ENERGY MONITORING
Power plants can be monitored for safety and city officials can be informed of any influx in radiation levels.

10 SOLAR PANELS
Solar panels can be monitored to determine how much energy they are providing and whether they need maintenance.

11 SMART LOGISTICS/FREIGHT
Platooning trucks carry freight efficiently from the port to their final destination. Smart inventory systems inform operators about when freight is moved between different locations.

12 VEHICLE FLEET COMMUNICATION
Public transit and city fleet vehicles communicate with their home agency when it is time for maintenance or replacement.

13 DRONES
Drones can be used for law enforcement and firefighting, as rural ambulances, for infrastructure inspections, and for environmental monitoring. Commercial uses include precision farming, aerial photography, and in the near future, package delivery.

14 SURVEILLANCE CAMERAS
Cameras ensure security by monitoring activity in areas that are not frequented by public safety officers. Areas that are not open to public access can be monitored to keep unauthorized personnel out.

15 BODY CAMERAS
Public safety officers can wear body cameras that capture footage of interactions between themselves and city residents to ensure safety for both parties.

16 WEARABLE DETECTION
Cities can build in smartphone and wearable detection sensors so that people can be an active part of the internet ecosystem, communicating with the city, and with each other.

17 BROADBAND INFRASTRUCTURE
A reliable internet ecosystem is the glue that holds the internet of things together.

Executive Summary

This report examines the meanings and practices associated with the term 'smart cities.' Smart city initiatives involve three components: information and communication technologies (ICTs) that generate and aggregate data; analytical tools which convert that data into usable information; and organizational structures that encourage collaboration, innovation, and the application of that information to solve public problems.

Hence, a smart city is a city that has developed some technological infrastructure that enables it to collect, aggregate, and analyze real-time data and has made a concerted effort to use that data to improve the lives of its residents. Such an effort should include explicit policy recommendations regarding 'smart' infrastructure and data, a functioning administrative component, and some form of community engagement.

To better understand smart cities in practice, this report outlines smart city initiatives in five cities. For each city, the report focuses on the organization of the initiatives, the policy and administrative components guiding the initiatives, and community engagement around smart development. The findings are summarized here:

- **Chicago, IL:** In 2012, Chicago Mayor Rahm Emanuel signed the city's open data policy. It created an open data platform and mandated cross-functional collaboration, all managed by the Department of Innovation and Technology. That policy and the administrative structure it created positioned the city to partner with universities and the private sector on sensor projects like the Array of Things, which aims to collect and disseminate real-time data, thereby catalyzing innovation in the city.
- **Philadelphia, PA:** In 2011, Mayor Michael Nutter issued an executive order establishing the Office of Innovation and Technology (OIT) of Philadelphia. The creation of this office allowed for city leaders to have a more hands-on approach to ICT initiatives in the city. City oversight as well as partnerships with private and public entities has moved Philadelphia toward many smart city concepts.
- **Charlotte, NC:** In 2011, Envision Charlotte was established as a public-private collaboration (PPC) to help the city sustain its accelerating population growth. As a new organization, Envision Charlotte is currently working on ways to reduce energy use in commercial buildings through behavioral changes.
- **San Francisco, CA:** San Francisco has a history of strong leadership interest in making the city smart and sustainable through environmental and transportation improvement measures. Furthermore, San Francisco's OpenData initiative, launched in 2009, supports smart cities initiatives that aim to meet greenhouse gas reduction goals and improve and increase public transportation service.
- **New Delhi, India:** New Delhi is in the initial planning stages of its smart cities initiative, which is part of the broader overarching goal of India's smart cities program that ties into the United Nation's Sustainable Development Goals. The city is following the lead of the nation's existing environmental policy and land pooling policies.

While ICT infrastructure makes the technological aspects of smart development easier, the organizational components remain challenging. Cities should work to lay the groundwork for smart development. Establishing the necessary policies (such as open data and e-governance policies) and administrative capacity (for example, a department for innovation and technology) in advance will better position cities to take advantage of these new technologies.

Rather than looking for solutions first, cities should consider the outcomes they want to achieve. They should find out what their residents and local businesses want to see happen, and turn those desires into clearly defined objectives before proceeding with smart initiatives. A city's existing comprehensive, transportation, and sustainability planning documents can help guide the establishment of goals. Conversely, smart cities can help to accelerate the goals outlined in those documents. Looking to other cities for frameworks and best practices can also provide valuable guidance, but not a set of instructions.

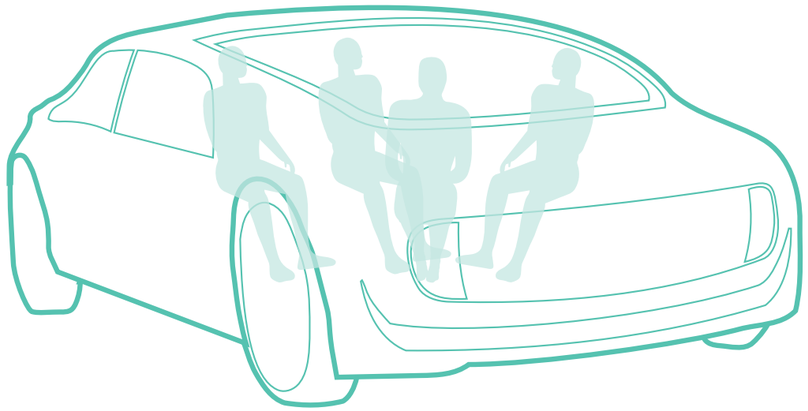
Leveraging technology to improve the sustainability and equity of cities is a powerful idea with enormous potential. Those ambitions, however, should be tempered by realism. Cities should critically examine smart city technologies and the rhetoric that surrounds them. Cities should be mindful, too, of the organizational challenges that accompany smart city implementation. Functional silos, the challenges of cross-sector collaboration, and political gridlock will not disappear with the arrival of these new 'smarter' systems. If these challenges can be overcome, then smart city development can prove beneficial.

Introduction

Improvements in information and communications technologies (ICTs) have made possible decades-old visions of smart cities where democracy and city management are guided by ICT-generated data.

According to the International Data Corporation (IDC), the digital universe (the amount of digital information created and replicated in a year) increased by 62 percent in 2009, reaching 1.2 million petabytes in 2010. By 2020, the IDC estimated that the digital universe would be 44 times larger than in 2009. Connectivity has also grown. Business Insider estimated that there were 1.9 billion devices connected to the internet in 2013, and that the number would grow to 9 billion by 2018. This growth in data and connectivity makes it possible to imagine a world in which real-time information can be gathered, analyzed, and used to influence public policy and the built environment in new, 'smart' ways.

For all of their promise, some believe that smart cities remain conceptually vague and undefined. Though generally understood to mean the use of new technologies and data platforms to improve the functioning of cities, there are also concrete policies and practice shifts involved. That is, in part, because the concept of 'smart cities' is not limited to one system. Smart cities implementation and adoption involves a paradigm shift, in which cities commit not only to using a new technology to act more efficiently, but also to changing their policies and operating procedures in a way that supports their goal. Smart city adoption can comprise many different solutions to many different public problems. Smart cities systems also often involve actors from each sector – public, private, and nonprofit – forming partnerships and working together on innovative ways to improve city life.



The emphasis on innovation also means that how we define smart cities changes continuously. When Cisco Systems helped South Korea turn Songdo into an automated urban environment in 2009, radio frequency identification (RFID) technology was cutting edge. By 2012, with the rise of smartphones, RFID was considered somewhat outmoded. Similarly, investment in municipal broadband was enough to make LaGrange, GA, the "Intelligent Community of the Year" in 2000, but is not enough to qualify it as a smart city today. The technology used in smart cities is often new or evolving, and prone to rapid change and development.

The overarching objectives, however, and the policy and administrative components required to realize those objectives, are more durable. Though RFID cards may no longer be the best way to forge a digital connection, enhancing that connection is still the purpose of much smart city development. Cities interested in developing smart programs and embracing the smart city paradigm shift will need to consider how to initiate and govern those programs, address the concerns of their citizens, and cope with a rapidly changing environment.

To better understand the smart city trend, this report will offer five case studies detailing the ways in which specific cities are implementing smart city projects including: Chicago, IL; Philadelphia, PA; Charlotte, NC; San Francisco, CA; and New Delhi, India. These case studies will focus on what the initiatives are, how they are organized, structured, and administered, and how the community has been engaged in their development and implementation. Examined together, the cases will provide lessons for other cities considering smart city programs.

This report offers five case studies detailing the ways in which specific cities are implementing smart city projects including:

Case Studies

Chicago, IL

Chicago has decidedly embraced smart city principles. As Mayor Rahm Emanuel's top tech lieutenant put it, Chicago wants to become "the most data-driven government in the world."

One initiative that aims to make that aspiration real is the Array of Things (AoT) project. The AoT is a network of sensors (called nodes) that will be mounted on streetlight traffic signal poles, where they will measure temperature, barometric pressure, light, vibration, carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, ambient sound intensity, pedestrian and vehicle traffic, and surface temperature. Forty-two nodes were scheduled for installation during the summer of 2016, with a total of 500 to be deployed by the end of 2018.

The stated goal of the project is broad and ambitious. It aims to, "measure the city in sufficient detail to provide data to help engineers, scientists, policymakers and residents work together to make Chicago... healthier, more livable and more efficient."The connection between the sensor network and healthier, more efficient city life, however, is an open question. The immediate goal of the project is to collect data, aggregate it in a central server, and make it publicly available. Charlie Catlett, the project lead, thinks that providing this data to the public will inspire people to create "all sorts of applications taking advantage of the data." Not everyone in Chicago, however, is convinced that these applications will be as valuable to the city as hoped. As The Chicago Tribune put it, it's unclear whether this, "will lead to meaningful improvements in urban life... or just enrich big tech vendors." Adie Tomer, a fellow and expert on smart infrastructure at the Brookings Institution's Metropolitan Policy Program, cautioned that claims of digital infrastructure investment leading to improved quality of life or economic performance are untested. Given that nodes are only now being deployed throughout the city, there isn't yet any evidence to evaluate the program's outcomes. It will, however, be evaluated nine months after the initial installation and every 12 months from that time on.

Policy

Chicago has been laying the policy groundwork for its smart city development for a while. In 2012, Mayor Emanuel issued an executive order establishing the city's open data policy. The order was intended to empower residents by providing them with information they need to participate in government, solve problems, and promote social progress and economic growth. To make the data public, the order required that an online data portal be created and maintained (the same portal that will be used for the AoT data).

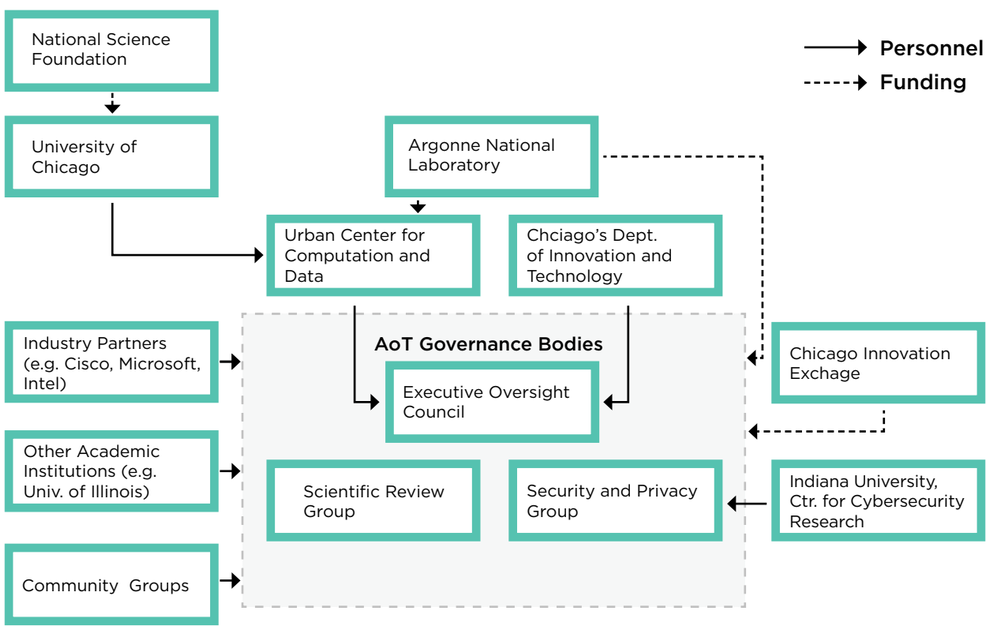
This executive order laid the groundwork for managing the data generated through sensor projects. It established transparency and open government as key commitments for the city. It also delineated what, when, and how data should be made public, and instituted reporting requirements to increase municipal accountability. Having those policies in place put the city in a stronger position to partner on smart city sensor projects.

The AoT has also had to establish some of its own policies. A privacy policy, for example, details how data with personally identifiable information (PII) will be managed and secured. PII will not be made public, but may be contained in data used to calibrate and test the machines. Any such data, however, will be housed in a secure facility and access will be restricted. This emphasis on privacy extends to the design of the nodes themselves. Images collected by the sensors will be processed into numerical data within the node itself, and the image data will be deleted.

Administration

Whether or not it improves city life, the AoT is instructive in how it was organized and developed. The project is a partnership among Argonne National Laboratory, the University of Chicago, and the city government, with input and support from an array of other universities and private corporations, such as AT&T, which will provide the wireless network to transmit the data (see Figure 1). The project is funded in part by a $3.1 million grant from the National Science Foundation, part of the White House's investment in smart city development. Argonne National Laboratory has already invested over $1 million in internal research, while the Chicago Innovation Exchange invested an additional $150,000. Besides providing administrative support, the city funds the installation of the nodes and provides the small amount of electricity needed to run them.

Figure 1: AoT Policy Field Map



The University of Chicago and Argonne National Laboratory will be the program's operators, responsible for the design, development, repair, replacement, and support of the nodes, while the city will provide oversight, policy guidance, and some technical support. An Executive Oversight Council (EOC), co-chaired by the Commissioner of the City's Department of Innovation and Technology (DOIT) and the Director of the Urban Center for Computation and Data at the University of Chicago, will be responsible for overseeing the program. There will also be a Security and Privacy Group (SPG) to advise the EOC and a Scientific Review Group (SRG). Thus, the partnership between the city and non-governmental actors is not just one of funding, but will include hands-on support and oversight.

In addition to laying the policy groundwork for programs like the AoT, Mayor Emanuel's open data executive order also developed the administrative capacity needed to manage the city's smart initiatives. The order made the DOIT responsible for overseeing the open data policy. To administer it, the mayor designated a chief data officer at the DOIT, mandated that each agency designate open data coordinators, and created an Open Data Advisory Group to assess compliance and help agencies decide what data should be made available to the public. That administrative structure provided Chicago the personnel it needed to engage with the AoT.

The open data policy also precipitated Chicago's SmartData project, which was designed to "analyze and aggregate data, identify trends and offer problem-solving predictions." Operated by the DOIT, the SmartData project looked through department workflows in Chicago for areas where predictive analytics could add value. Importantly, the analytics dashboard that the DOIT created and shared with all departments in the city was built to be open source and available to any interested city. Bloomberg Philanthropies provided a $1 million grant to the project with the explicit goal of it spreading to other cities.

The AoT project is not the only smart city initiative being deployed in Chicago. City Digital, an endeavor of UI Labs, is deploying their own sensors to monitor flooding and create virtual maps of the cables and pipes beneath the city. Between those two projects and the city's existing open data policy, Chicago meets some of the smart city criteria, but not all. It has the capacity to generate and publicize data, but is relying heavily on external actors to put the data to use.

Community Engagement

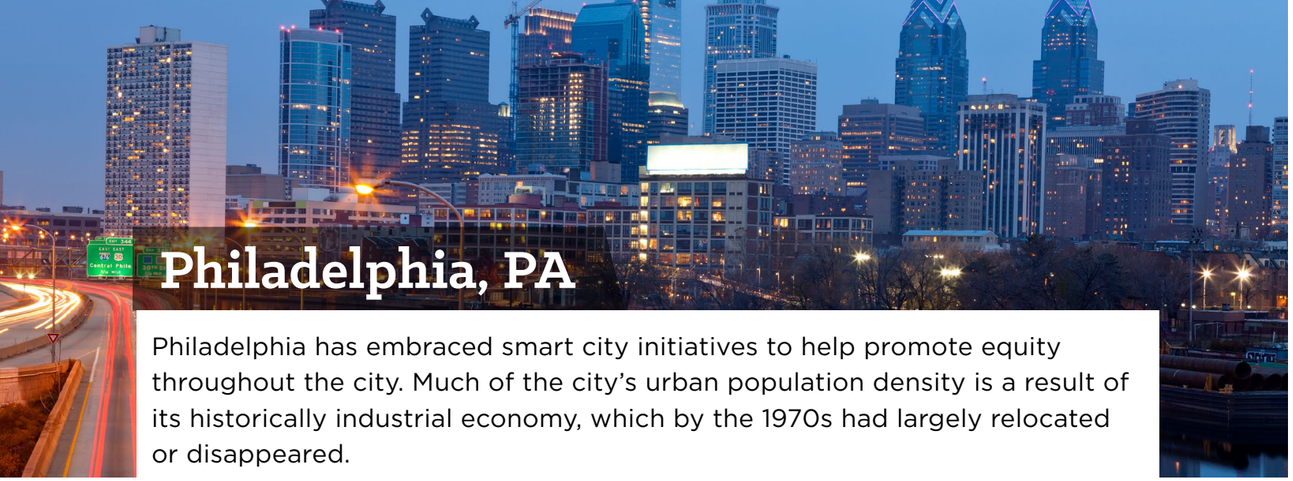
The concern over privacy is not limited to project managers. There is still a question of how the community will respond to the sensors monitoring their neighborhoods. Lee Tien, a senior staff attorney at the Electronic Frontier Foundation, likened sensor projects to increased surveillance and wondered how much force such privacy policies will really have if the police, for example, request information that would violate them. The project managers are aware that concerns like these could be an issue. As part of their governance document, they've included provisions for community outreach in any areas where nodes might be placed. That outreach includes meeting with aldermen and women and community leaders, and holding community meetings with residents. In addition, they plan to hold workshops to, "introduce concepts, ranging from environmental science to electronics design to data analytics, to neighborhood youth."

The city's Smart Communities initiative includes a digital literacy and outreach program that increased rates of broadband adoption and internet usage, including job search[es] in the city's nine predominately African-American and Latino low- and middle-income neighborhoods. Between 2008 (when the program was implemented) and 2013, those neighborhoods in the initiative saw a 13 percentage point increase in internet usage.

While this program does not necessarily demonstrate high-tech delivery, it works to increase connectivity in the city, making it more likely that the resources developed through projects like the AoT will be utilized by and accessible to all city residents.

The Internet of Things

As wireless, Bluetooth, and sensor technology has become increasingly sophisticated and inexpensive it has moved from being found exclusively in expensive hi-tech products such as computers and cell phones to increasingly low-tech, even analog, items such as thermostats, coffee makers, and even toys. Together with the advent of cloud networked computer, which has minimalized the need for physical storage and computing power in a device, the devices around us are undergoing a conceptual reinvention. Every consumer product or piece of infrastructure increasingly has the ability to sense surrounding stimuli, to communicate with each other, and to draw on the computing and storage power of the cloud. This phenomenon has been dubbed the Internet of Things (IoT). Essentially, the seismic change that the internet brought to computers is now extending itself beyond computers to increasingly simple and inexpensive devices. Market incentives for this shift are high. The more smart devices there are, the more data is generated about consumer's preferences and habits. But what does this mean for cities? Smart cities are employing the same technology to connect their disparate utility, infrastructure, and public service grids, generating real-time aggregate data. This in turn can help cities manage their programs and services more effectively and gauge their impact immediately. Sensors installed on water pipes can detect leaks and communicate them to the water utility instantly. Smart parking meters can notify parking agents when they are timed out, as well as residents when a space is free. Smart infrastructure communicating with its utilities is just a one-sided exchange. Increasingly, as autonomous vehicles and drones fill city streets and skylines, smart cities will invest in infrastructure to vehicle (I2V) technology, where traffic lights and public infrastructure communicates with the smart devices around them. The city of the future is an interconnected one, where devices communicate with one another in a constant stream of data that provides real-time information to the public and the municipality. As this trend accelerates, innovative cities will become more efficient, open, and responsive to their residents.



Philadelphia, PA

Philadelphia has embraced smart city initiatives to help promote equity throughout the city. Much of the city's urban population density is a result of its historically industrial economy, which by the 1970s had largely relocated or disappeared.

This downturn left Philadelphia with a high poverty rate. Since then, city officials have been challenged by balancing the needs of residents, "left behind by post-industrial economic restructuring and aggressively transforming Philadelphia into a competitive node in the globalized economy." According to the Center City District's 2015 annual report, Philadelphia ranked second in urban density to Midtown Manhattan. With high urban density and a poverty rate of 25.8 percent, Philadelphia still struggles with issues of income disparity and building an inclusive municipal economy. Much like many older, developed cities in the U.S., Philadelphia officials are looking for new ways to manage urban growth during an era of tight budgets and often conflicting priorities.

Policy

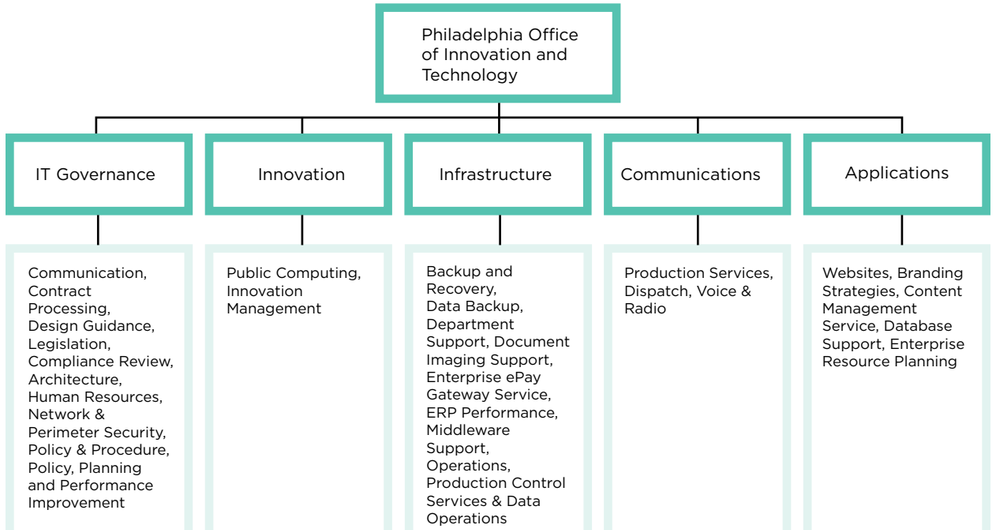
In 2011, Mayor Michael Nutter issued an executive order establishing the Office of Innovation and Technology (OIT) of Philadelphia. OIT's mission is to oversee all ICT initiatives for the city of Philadelphia. By creating this office, city officials hope to improve the effectiveness of any ICT initiatives in meeting the needs of the city. The OIT focuses on five branches of ICT: IT governance, innovation, infrastructure, communications, and applications. Within those branches are sub-branches that promote specific tasks and goals. Figure 2 outlines the structure of the OIT.

Administration

Additionally, Philadelphia is using ICTs within the Philadelphia Police Department (PPD) to develop preventative measures that will lower the city's crime rate. The "Smart Policing Initiative" (SPI) or "SMART" (Strategic Mapping Analysis Response and Tactics) is the city's effort to collect and analyze data on crimes within the city. The program looks at where crime is occurring in the city (also known as hotspots) and attempts to determine why. This data collection allows the city to use its limited resources on areas where they will have the biggest impact on reducing crime.[1] With grants provided by the Bureau of Justice Assistance (BJA), the program uses data analysis, including analytical models, GIS mapping, and predictive analysis to identify these hotspots so that a targeted response can be deployed to these areas faster.

As of 2013, out of the 38 police departments around the United States that have implemented SPI, Philadelphia has been among the most successful at lowering crime rates. Philadelphia's high crime areas have seen a drop in the crime rate since the implementation of SPI through the application of data analysis and an organizational change within the PPD. Although hotspot policing has been part of the PPD since the late 1990s, recent adaptations of analytical methods, such as GIS, have provided the PPD with a new way to look at existing data. As of 2014, the PPD had trained 26 police officers as analysts.[2]

Figure 2: Philadelphia OIT Structure



City officials in Philadelphia have also partnered with outside sources to help research and implement smart city initiatives. In 2015, experts from Drexel University and the University of Pennsylvania's Institute for Urban Research joined the MetroLab Network as participants in a White House initiative to make universities and their local cities partners in using technology to solve the challenges that face growing urban areas.[3] The MetroLab Network is supported by a $1 million grant from the MacArthur Foundation that will focus on 60 smart city projects starting in 2015. Research universities have the "physical and human resources to help their cities meet complex urban challenges through undertaking research, development and deployment of innovative projects at a lower cost."[4] This network of partnerships focuses on sharing data, analytics, and innovative new practices. Pairing universities with policy makers provides a cost-effective way of implementing smart city initiatives within a city.

According to Charles Haas, head of the Department of Civil, Environmental and Architectural Engineering at Drexel,

the university "has had a long history of working with agencies of the City of Philadelphia to apply knowledge and skills to help contribute to solutions to challenges that face the city."[5] In collaboration with the city of Philadelphia, Drexel and the University of Pennsylvania will focus on incorporating technology and analytics to improve existing public service infrastructure, to measure the impact of new infrastructures (to include green infrastructure), and to address inclusive economic development.

The University of Pennsylvania is also partnering with the city of Philadelphia to promote data collection via geospatial technologies that are used to visualize, measure, and analyze the earth's features. The technologies include GPS, GIS, and remote sensing (RS). The OIT provides GIS services that help "develop and deliver state-of the art.... technology and services to the enterprise (citywide)."[6] GIS Services Group (GSG) provides city officials with the technology to help develop, deploy, and maintain spatial data, as well as provide 30 geospatial web services. With over 200,000 hits daily, the city's geospatial web services and applications provide relevant information on urban development and have broad applications for Pennsylvania's businesses and nonprofits.

Community Engagement

Another initiative that the OIT is working towards is Philly311, which will open the lines of communication between Philadelphia residents and the government. Philly311 uses social media and phone applications as a forum to communicate with citizens in real time.[7] An example of this communication includes city leaders using Twitter to communicate to citizens about traffic patterns. As Philadelphia's urban population continues to grow, Philly311 has the potential to improve communication between public officials and residents.

Charlotte, NC

Over the past decade, Charlotte has undergone tremendous growth. According to the U.S. Census Bureau, Charlotte saw the 10th largest increase in population among large cities.

Charlotte grew by 17,695 people from July 2014 to July 2015, resulting in a total population of 827,097[8,9]. While most large cities such as New York, Boston, and Chicago are seeing slow or negative growth, Charlotte has become a hub for major corporate expansions as well as an expanding suburban population. With vast amounts of rural area, warmer weather, and lower costs of living, southern cities such as Charlotte present not only opportunity for business owners but also a more hospitable environment for families aiming to move away from larger, overpopulated, and older cities.

Much of Charlotte's economic success is attributed to being the second biggest banking center in the country behind New York City. Charlotte hosts the headquarters of Bank of America, as well as major regional operational facilities for a number of other institutions, including Citi, Ally Financial, JPMorgan Chase, and Wells Fargo. New jobs are quickly being added to Charlotte as these banking institutions contribute to a wider economy in financial services. [10] With an increase in available jobs, there has been an influx of younger people moving to Charlotte for education and employment opportunities.[11] The city is currently facing the pressures of population growth, and is focusing on ways to sustain this growth.

Policy

Unlike other cities, where the city government plays a large role in many smart city initiatives, city leaders in Charlotte have taken a more hands-off approach. Instead of actively collecting data and constructing metrics, the municipality has embraced a market-oriented and facilitative role, aiming to "encourage independent actions from a wide range of participants."[12] The city of Charlotte intends to use outside resources to educate citizens on how their behaviors contribute to problems such as energy waste, and how they can change those behaviors.[13]

Administration

One smart initiative is Envision Charlotte, a non-profit public private collaborative organization established in 2011 and funded by grants from the Department of Energy. Envision focuses on using sustainability to promote economic development. Created by partnerships between Duke Energy, Cisco, and Charlotte Center City Partners, Envision Charlotte aims to help "accelerate [initiatives] fueled by civic and corporate leaders committed to further transforming the city into the country's most sustainable core."[14]

In a statement about partnering with Envision, Cisco Chairman and former CEO John Chambers said, "as cities all over the world experience significant population growth, the need to sustainably balance social, economic, and environmental resources becomes even more paramount... Cisco believes that technology can transform how the world manages these energy and environmental challenges."

Envision's first initiative was a partnership with Duke Energy to focus on reducing energy use in Charlotte's Center City. The project's primary focus is on reducing wasted energy consumption in commercial buildings within Charlotte's downtown area through innovative technologies that encourage energy efficiency and changes in consumer behavior.[15] As of late 2015, the program successfully reduced power usage in participating buildings by 8.4 percent and saved more than $10 million.[16]

Although fairly new, Envision has already impacted Charlotte. From partnering with Duke Energy on this initial project, Duke Energy has been able to commercialize "Smart Energy in Offices" (SEiO). By "adopting a team mindset and fostering ownership -- two key elements in any successful work environment- SEiO makes it simple... for property managers, building operators, and tenants to minimize workplace energy use."[17] SEiO will help teams reduce energy waste with the following steps:

1. Provide accessible information about energy use in buildings, load factors, historical trends, and how to interpret the information
2. Institute goals and opportunities through "Energy Action Plan"
3. Create campaigns, games and other initiatives to motivate individuals to become "Smart Energy Workers"
4. Receive recognition in the community as their building advances through "Levels of Achievement"[18]

Community Engagement

Envision Charlotte has also been a model for other cities in the United States to engage their residents to change their behaviors and to promote sustainable communities. A spin-off group called Envision America will help other cities learn from the Charlotte campaign. As of 2016, ten cities were selected to kick off Envision America initiatives and to attend workshops that will bring together city leaders, smart city experts, and corporate partners to learn about the successes of Envision Charlotte and to start facilitating project planning and implementation.

San Francisco, CA

San Francisco is a worldwide tourist destination that houses some of the world's largest financial institutions and is known as a city of innovation and technology.

In 2011, San Francisco was declared the Greenest City in the U.S. and Canada Green City Index and the Cleantech Capital of North America.[19]Like other cities, San Francisco's leaders want to make the city safer, more affordable and equitable, and reduce its emissions footprint. Unfortunately, the dramatic population growth San Francisco has witnessed for the past decade has raised the cost-of-living to one of the most expensive nationally and strained the city's infrastructure and governance. For this reason, San Francisco has led the way in incorporating sustainable, innovative, and ambitious strategies to accelerate its smart city adoption.

In pursuit of this goal, San Francisco focuses on using technology to make building operations more efficient, reduce energy use, streamline waste management systems, and improve transportation systems, all of which contribute toward greening the city. The city aims to achieve zero waste by 2020, become carbon-free by 2030, and meet transportation-related demand by creating a safer and more efficient transportation experience for everyone. To achieve these goals, San Francisco uses a three-pronged approach that addresses both policy and administrative challenges and works to actively engage the community in all of these initiatives.

Policy

To achieve its zero waste goal, San Francisco displayed great political determination in passing a raft of legislation,[20] including Resolution Setting Zero Waste Date, the Mandatory Recycling & Composting Ordinance, and the Mayor's Executive Order Enhancing Recycling and Resource Conservation. The city also provides online tools using open source software and an open data model to provide localized and accurate results.[21] To complement these policies, the city partners with like-minded organizations to develop new programs and create a culture of recycling and composting.

To reach San Francisco's goal of becoming carbon-free by 2030, the city has implemented a comprehensive set of incentive programs to improve the performance of new and existing buildings. Various technology applications have helped enhance these programs. For example, the San Francisco Energy Map is a tool that tracks solar and wind installations across the city. Residents or businesses can go to the website to see their roof's solar potential and access rebates. Likewise, the Honest Buildings program helps buildings save energy using a software platform. The online portal informs property owners, managers, and

tenants about their building's performance and provides the most effective energy efficiency strategies to help them reduce utility costs.[22]

Muni Forward is a project that takes a holistic view of transportation in San Francisco by making the system smarter. Using the 1973 Transit First Policy, which gave priority to public transit vehicles on San Francisco streets, along with improved technology and infrastructure, San Francisco aims to make getting around safer and more reliable. Muni Forward is replacing transit signals in San Francisco with new signals that can detect an oncoming Muni train or bus and hold the green light, allowing the transit vehicle to make it to the next stop faster, reducing traffic congestion, and improving reliability. The city has also created a state-of-the-art Transportation Management Center (TMC) to improve communication with Muni bus and train drivers, helping it monitor and improve transit services. Finally, the radio communication system was modernized and incorporated with an Intelligent Transportation System (ITS).

These are only some examples of how San Francisco is becoming a smart city leader by using technology to improve its public services. None of these smart city initiatives would have been possible without the city's open data platform, San Francisco OpenData. San Francisco OpenData is the city's open data portal and a product of the official open data program that was launched in 2009.[23] DataSF is the city's one-stop website for government data. The open data legislation requires city departments to make all non-confidential datasets under their authority available on DataSF. DataSF uses transportation data to improve transportation needs and commute times, and to help meet greenhouse gas reduction goals. The platform also provides an app for Muni bus or train commuters that lets commuters buy Muni tickets and plan their trips.

Administration

San Francisco's smart city programs are quite ambitious and require strong partnerships between public agencies and the private and non-profit sector. With its strong leadership, the city is attempting a collection of pragmatic and effective policy reforms. The San Francisco Municipal Transportation Agency (SFMTA) and the San Francisco Department of the Environment are playing prominent roles in the city's smart city initiatives and have cross cutting goals of improving San Francisco's transit while pursuing environmental goals like zero carbon. The city plans to implement Muni Forward in phases to optimize financing and minimize service disruption. On November 4, 2014, San Francisco voters approved Proposition A, which included $150 million in funding to design and build Muni Forward projects. Future funding is expected from other sources for a combined total funding of $230 million.[24] SFMTA also manages SFpark to improve parking in the city by collecting and distributing real-time information about available parking spots.

Community Engagement

The city's Open Data Policy highlights the social and economic benefits of increased government efficiency and civic engagement.[25] Making data publicly available is a great way for cities to engage with their communities. SFMTA proactively solicits community input and shares its plans, data, and success widely and visibly. SFMTA uses its interactive performance dashboards to collect feedback and track its progress in meeting the goals and objectives outlined in its strategic plan. SFMTA also uses the 'capital improvements' map to inform the projects and programs across the city. Likewise, the San Francisco Department of the Environment put its mission into action by mobilizing communities. To meet its 2020 goal of zero waste, it continues to develop new programs and expand community outreach. The agency believes that community engagement enables city staff to better understand barriers and challenges to zero waste and carbon free programs, create or adjust programs, and plan for the future.

Another smart city initiative Mayor Ed Lee introduced is the Living Innovation Zones project. The project helps businesses transform prototypes into products and services by designating zones throughout the city where businesses can use city assets to demonstrate new and emerging technologies. The project provides innovators with a real-world setting to test new ideas, evaluate next generation technologies, and collect data about impact. It also encourages businesses to engage in advancing the city's sustainability goals, promotes efficient government, and ensures a better quality of life for San Francisco residents, all while educating the public about innovative solutions in the process.[26]

Mayor Lee's leadership supports San Francisco's sustainability goals by developing the city's Cleantech, transportation, energy, waste, built environment, and other sectors for maximum effectiveness and environmental benefit.[27] With so many smart city initiatives on the ground and the city's reputation for being technologically innovative, it is unsurprising that San Francisco is a global leader in smart city development

New Delhi, India

New Delhi is the largest commercial center in northern India. The population of Delhi has increased rapidly over the past decade, reaching 18.6 million in 2016, and it is expected to grow another 40 percent by 2020.[28]

At this rate of accelerated urbanization, the government is under tremendous pressure to deliver public services like transportation, water, electricity, and affordable housing. In the past two decades, Delhi's urban area has almost doubled, leading the average commute to increase from 8.5 kilometers to 10.4 kilometers.[29] Distant city residents rely on automobiles, contributing to traffic congestion, rising greenhouse gas emissions, air pollution, and poor public health. Without the right design and planning by the city, existing problems of congestion, traffic, pollution, and safety will only metastasize and worsen.

The government of India has historically promoted various urban development initiatives, such as the Integrated Development of Small and Medium Towns (IDSMT) program in 1979 and the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2005. However, many urban development goals have barely been met. Due to either economic, technological, or political reasons, only a few local governments have been able to take sufficient steps towards implementing best practices and meeting these goals in their cities.[30]

Policy

After more than 40 years of studies into a rail-based mass transit system, Delhi Metro Rail Corporation (DMRC) was established in 1995 and began construction on October 1, 1998.[31] The Delhi Metro project became the first railway project in the world to be certified for carbon credits for reducing greenhouse gas emission by the United Nations.[32] To improve the train system's efficiency, DMRC partnered with Google India (through Google Transit) in 2010 to provide free train schedule and route information to commuters through mobile devices with Google Maps.[33] By the second-half of 2016, DMRC is planning to provide free high-speed broadband internet to its 2.7 million passengers.[34] Commuters will then be able to access real-time information regarding train location, approach, and destination, and navigate between different lines. The Delhi Government plans to introduce a Common Mobility Card2016, which will allow riders to access Metro trains, Delhi Transportation Corporation buses, and cluster buses.[35] Delhi Metro is an excellent example of a city transportation system that gradually adopted smart city systems.

As the country's government changed in 2014, an emphasis was placed on the use of smart principles for improving conditions in existing towns and cities across the country.[36] In June 2015, the Smart Cities Mission was launched as yet another attempt at enabling better living conditions and achieving higher economic growth in 100 Indian cities.[37] Prime Minister Narendra Modi saw challenges as an opportunity and introduced his smart cities initiative.[38]

In parallel to the New Delhi Municipal Council's smart city project implementation, the Delhi Development Authority (DDA) has introduced a land pooling policy to address one of Delhi's primary challenges: affordable housing to accommodate its growing population as well as to lay the infrastructure to implement ICT technology as proposed by the municipal council for the smart cities challenge grant. Besides regulating the land pooling policy, DDA is also committed to accountability and transparency by allowing the population to monitor its infrastructure projects online. All construction-related data are updated in real-time in online measurement books that then link them with a contractor's payment and customer feedback to ensure higher quality of work.[39] The system also offers a library of General Packet Radio Services of construction sites and status reports.

New Delhi residents and the local government are using social media actively during planning and implementation. In the wake of smart cities initiatives and active social media, no enabling legislation or policy has been formulated by the central government, apart from releasing a "Mission Statement and Guidelines" for the smart cities competition. Neither the national nor the local government provides any relevant applicable laws and policies for the initiative. Likewise, there is no information available to the public regarding the deployment of open data or use of specific technologies like cloud storage or big data, as outlined by the relevant policies and laws.[40] Drawing on the practices adopted by cities across the world, the Centre for Internet & Society suggests that smart cities in India should adopt robust regulatory and governance frameworks regarding technical standards, open data, and data security and data protection policies.[41] Nevertheless, India's Open Data Policy and data protection standards under section 43A of the Information Technology Act (ITA) do apply and help to ensure the sustainability and efficiency of the county's smart cities while safeguarding individual rights.

Administration

The central government approved a budget of INR 48,000 crore (USD 7.8 billion) to be spent over a five-year period (FY 2016 to FY 2020) on smart cities initiatives in 100 designated cities in India. The state and local governments are expected to equally match the central government funds. According to the Smart City Mission Statement & Guidelines (2015), India's objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment, and application of smart solutions. The focus is on sustainable and inclusive development in compact areas to create a replicable model for other aspiring cities.[42]

Among 100 cities, NDMC received a grant from the central government to foster the efficient management of urban services

through the application of technology. These services included water supply, sanitation, housing, waste management, and urban mobility. NDMC consulted with New Delhi residents on their requirement as a smart city and plans to develop smart bus stops, app-integrated cycle tracks, sensor-based smart parking, e-surveillance, including electronic tickets for traffic violations, automatic sewer cleaning machines and geo-tagging of bins. Other projects include providing Wi-Fi access points, air-quality sensors, noise-pollution sensors, and renovating Gole market.[43]

As New Delhi progresses with its smart cities initiative, the city government has tentative plans to launch an app-based air conditioned bus service. The city's Transport Department stated that the new app-based services would enable commuters to reduce wait times by reserving seats on buses. Buses operating under this service scheme will be required to install two CCTV cameras, Wi-Fi, GPS, fire extinguishers, and first-aid kits. The original announcement of this new service indicated deployment in June of 2016. However, the project is currently placed on hold while the city seeks public opinion on the project's implementation.[44]

Community Engagement

The smart cities initiative in New Delhi is in a very early stage. The mission guidelines stipulate that each city needs to prepare a Smart City Plan that comprises an area development proposal and a pan-city initiative using smart solutions for delivery of urban services. It seems a natural fit for DDA to implement a land pooling policy ahead of NDMC's smart city project. This approach gives NDMC the infrastructure to incorporate digital solutions while providing affordable housing to the NDMC residents.

New Delhi's smart city initiative is a part of India's holistic smart cities plan that taps into the UN's Sustainable Development Goals (SDGs). A report by Price Waterhouse Coopers states that "the pillars of a smart sustainable city are completely aligned with the proposed UN's Sustainable Development Goals (SDGs) and the closer the integration of sustainability into India's '100 Smart Cities' initiative, the greater will be the linkages with the SDGs."[45] At Prime Minister Modi's request, the Asian Development Bank (ADB) has committed to support the Ministry of Urban Development in its development of smart cities on the area-based development component of the smart city guidelines.[46] ADB has agreed in principle to set aside $1 billion for extending loans to the smart city projects and the World Bank could provide up to $500 million in long-term loans.

Case Study Comparison

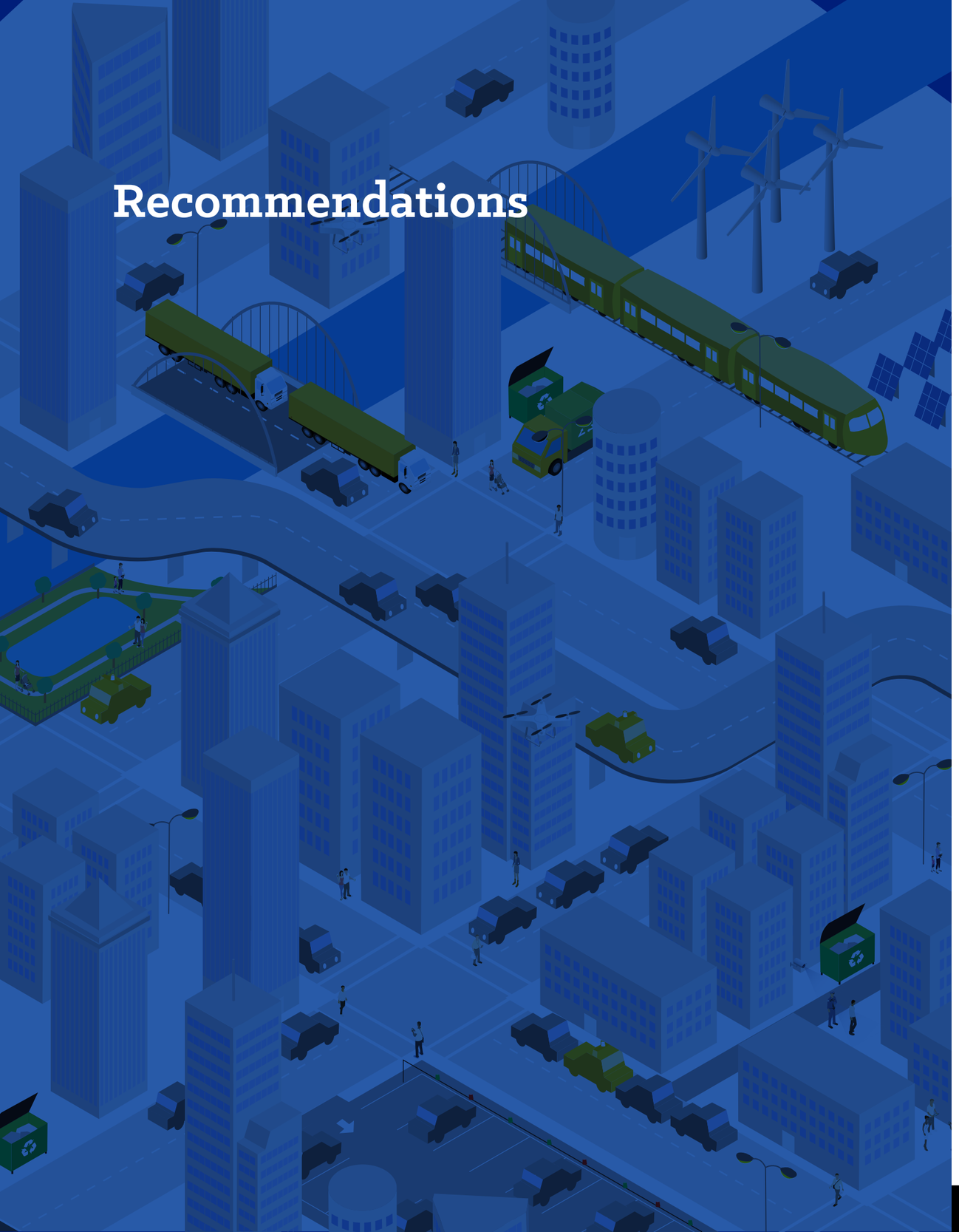
The five case studies in this report only compose a small fraction of cities implementing smart city initiatives. While the five cities cannot represent every smart city, their commonalities and differences are instructive. Table 1 highlights the similarities of each city, focusing on the policy domains covered, levels of government involved, non-governmental partners engaged, and instruments used.

Four out of the five cities focused on making data open and widely available. In Chicago and Philadelphia, for example, both mayors have signed executive orders establishing an open data policy. In addition, most of the cities are partnering with non-governmental entities, including universities and businesses, to develop smart city programs. For example, city officials in Philadelphia have partnered with the University of Pennsylvania to research different data collection systems such as GIS. Several of the cities, including Philadelphia, Chicago, San Francisco, and Delhi, also partnered with the federal government in their pursuit of smart city projects, in some cases receiving grant support for various smart city initiatives. Finally, the majority of the cities are using smart city tactics to promote sustainability and overcome challenges associated with population growth.

These case cities are using a variety of instruments to achieve their policy goals. Rather than large policy changes, Charlotte is encouraging people to change their behavior and adopt energy-saving habits. Chicago, on the other hand, is attempting to catalyze innovation by making more data publicly available. Whatever the method, all of the cities are hoping to use ICTs to improve the lives of their residents.

Categories	Sub-Categories	Chicago	Charlotte	Delhi	Philadelphia	San Francisco
Policy Domains	Open Data	✓	✓		✓	✓
	Sustainability		✓	✓	✓	✓
	Transportation			✓		✓
Administration	Designated Department or Office	✓			✓	✓
Level of Government Involvement	National	✓		✓	✓	✓
	Regional				✓	✓
	Local	✓	✓	✓	✓	✓
Non-Governmental Partners	Universities	✓	✓		✓	✓
	Private Companies	✓	✓	✓	✓	✓
Instruments	Behavioral Nudge		✓			✓
	Open Sensor Data	✓				✓
	Land Pooling			✓		
	Market Creation			✓		✓

Recommendations



The preceding case studies provide a glimpse into the on-the-ground reality of smart development. Cities are taking many different approaches to solving public problems, and there is no one-size-fits-all way to adopt and implement smart city systems. Through examination of the existing literature on smart cities and the experiences with smart development in our case cities, we have arrived at a set of general recommendations aimed to help guide other cities considering similar projects.

Recommendation 1: Cities should consider the outcomes they want to achieve.

Data collection is not an end in itself. To be useful and relevant, it needs to be analyzed. The information that results from that analysis can then drive real applications to public problems. Cities should consider what public problems they want the initiative to address and how the data collected will help address those public problems. Additionally, assessment of public problems and data collection should be derived from and tied to existing city comprehensive plans, visions, and sector planning documents.

The improvement in ICTs has made data collection considerably easier. In some of the case cities, the ease of data collection appears to have inspired cities to invest in smart initiatives without clearly defining what initiatives they seek to achieve. The challenge for cities is not a technical one of gathering or disseminating data – it's an organizational one. Cities need to consider how new data will influence public policy and what administrative capacity is needed to put the data to use.

What that use is will vary by city. Not all cities face the same challenges or are suited to the same solutions. Before investing in smart city infrastructure, cities should consider what they need, not just what other cities are doing. Small cities don't necessarily face the same problems as large cities. San Francisco's smart parking program, SFpark, for example, might be an appropriate response to congestion problems in San Francisco but would be unnecessary in smaller urban areas that don't have the same problems.

Though the conversation around smart cities has been largely driven by the private sector, it is not their job to define the city's objectives, only to provide them with the technology needed to achieve those objectives. Cities need to consider first and foremost what problems they want to solve, and then develop a model

for how smart city technology can help them achieve those ends. Furthermore, cities should rigorously evaluate smart city investments and look at an array of options before committing themselves.

Recommendation 2: Cities should look for ways to partner with universities, non-profits, and the private sector.

Many of our case cities partnered with non-governmental actors. As with Chicago's Array of Things, those partnerships can cut across sectors and include a wide-range of actors. Cities can even partner with other cities on smart city initiatives.

Partnerships provide many benefits to cities. They give cities access to funding and expertise that might not otherwise be available. Many public problems are complex and can be too diverse for any single organization to tackle. That makes collaboration advantageous. Organizations are often able to do more together than they could alone.[47] Partnerships also allow cities to share the risks of development, which is especially valuable giving the evolving and often untested nature of smart city technologies. Finally, partnerships give projects continuity. Without external commitments and support, shifts in political power might cause a project to be cancelled or ignored.

That does not mean that there are not also drawbacks to collaboration. There are different organizational cultures, different missions, and different stakeholder groups that need to be negotiated and aligned for a collaboration to work.[48] For example, it is important that there be a clear, mutually agreed upon purpose or mission for the partnership. Cities should weigh the motivation and commitment of their partners. They should consider the structure and governance of the collaboration, clearly delineating authority and responsibility. Formal arrangements, regular meetings, and informed points-of-contact can help ensure that partnerships stay on track.[49] Cities should also consider how authority and responsibility will be balanced and what each partner is accountable for.[50] Taking all of these organizational pieces into account will improve the chances of a successful partnership. Furthermore, smart city partnerships come with their own set of specific considerations, such as how rights to intellectual property developed by the project will be handled and who owns the physical infrastructure deployed.

Cities need to consider the incentives and motivations of private actors. It is the job of companies in the smart city market to develop and sell technological solutions. As with the early days of e-government, cities should be cautious of unwarranted optimism and realistic about the powers of ICT systems.[51] Elected city officials should carefully consider both the public and private sector interests inherent in smart city projects, whether they align with existing goals, and whether the project they have in mind is appropriate. There can be benefits and opportunities in fairly negotiated public-private partnerships, including maximizing scare municipal budgets. Even so, city officials should not enter into these partnerships in haste, or without asking the right questions about objectives and public good.

It's been noted that "while many of the technologies offer clear benefits, the 'smart' concept itself suggests a positive and uncritical stance towards urban development."[52] Cities should look past the rhetorical dressing of smart city technologies and focus on what is appropriate for their cities. A strong administrative foundation backed by established smart city policies provides cities with both the structure they need to take advantage of public-private partnerships, and the knowledge they need to critically examine smart city proposals.

Furthermore, it is worth reiterating that smart city development should be driven by demand in cities, not top-down or by supply alone.[53] Smart cities have been criticized for "turning cities into digital marketplaces for large multinational firms, blurring the lines between public and private and concealing new forms of social and economic inequalities."[54] The smart city discourse often centers on technological questions not well understood by the public and therefore often dominated by private companies.[55] Bottom-up, democratic development would obviate some of these concerns and lead to more equitable growth.

Recommendation 3: Cities should continue to look for best practices and frameworks for 'smart city' development.

There is a lot of variability in the smart technologies being deployed. Some cities and universities are developing their own pioneering sensors, like the Array of Things nodes. Others are looking to large private firms to supply ICT solutions. The diversity in technology and the lack of agreed upon principles for redesigning the built environment presents a challenge for interested cities. The newness of smart development means that not much has been codified.

Though this report provides a window into what some cities are doing now, smart development is a rapidly changing field. Cities interested in becoming smart should continue to look for best practices and frameworks for this type of development.

Though not yet fully implemented, the National Institute of Standards and Technology (NIST), part of the U.S. Department of Commerce, is

working on a framework for smart city development.[56] The framework is designed to address two main concerns: the interoperability and portability of ICT development across cities, and the need for standard architectural principles. Their goal is to standardize enough that systems can be integrated across cities, without standardizing so much as to be an obstacle for further innovation.[57] In addition, the Smart Cities Council has developed a Smart Cities Readiness Framework that has been used by dozens of cities internationally to set a strategic direction.[58] Cities should monitor progress on frameworks like that being developed by the NIST and the SCC.

Continually keeping apprised of new developments and innovations in the smart development arena will also help cities manage the path-dependent dynamics of technological development.[59] Frameworks like NIST's can influence the way cities approach smart city development, helping them avoid being limited to the suite of proprietary technologies in which they initially invest by ensuring that those technologies can be integrated with new ones.[60]

Leveraging ICT technology to improve the sustainability and equity of cities is a powerful idea with enormous potential. Those ambitions, however, should be tempered by realism. Cities should critically examine smart city technologies and the rhetoric that surrounds them. Cities should be mindful, too, of the organizational challenges that accompany smart city development. Functional silos, the challenges of cross-sector collaboration, and political gridlock will not disappear with the arrival of ICT technology. However, if these challenges can be acknowledged and overcome, then smart city development can not only increase a city's efficiency, accountability, and transparency, but also leave behind an organizational legacy of innovation and collaboration that will continue to improve local governance.

Appendix

Definition

The conceptual uncertainty of smart cities has not stopped their advance. In September of 2015 the White House announced a smart cities initiative that will invest $160 million in federal research to help local communities tackle their challenges.

In the announcement, the White House defined smart cities as, "communities that are building an infrastructure to continuously improve the collection, aggregation, and use of data to improve the life of their residents." The Initiative aims to harness the powers of the, "growing data revolution, low-cost sensors, and research collaborations," to assist those communities.

According to the Smart Cities Council (SCC), a leading industry association, "a smart city uses information and communications technology to enhance its livability, workability, and sustainability." Smart cities have been broadly characterized as employing ICTs to solve problems in a wide range of public policy domains, including energy, waste management, transportation, healthcare, security, public administration, education, and more. ICT systems can collect, transmit, and aggregate data from the environment, allowing that data to be analyzed and put to use. ICT systems can also enable objects and environments to sense, communicate, network, and produce information, forming the Internet of Things (IoT).

As the White House Initiative suggests, smart cities are not exclusively technological, but also involve creating collaborative environments and making the human capital investments necessary to catalyze learning and innovation. Thus, smart cities have two distinct focuses:

1. leveraging ICT systems to solve public problems; and
2. developing organizational structures that encourage the spread of knowledge and innovation.

The technological evolution of ICT systems has facilitated this first focus. Global businesses like Siemens, Cisco, IBM, and Microsoft have developed and pushed technologies to support smart city development, creating a global market that's expected to grow to $1.4 trillion by 2020.

As the supply of new, smart ICT systems has grown, so have urban populations and the problems of efficiency and social sustainability. The barriers to smart city successes are often more organizational than technological. In most cases, cities need to consider the policies and administrative components that undergird, enable, and guide smart city initiatives.

For the purpose of this report, smart city initiatives are defined as involving three components: ICT systems to generate and aggregate data; analytical tools which convert that data into usable information; and organizational structures that encourage collaboration, innovation, and the application of that information to solve public problems. Hence, a smart city is a city that has developed some technological infrastructure that enables it to collect, aggregate, and analyze real-time data, and has made a concerted effort to use that data to improve the lives of residents. Such an effort should include an explicit policy for 'smart' infrastructure and data, a functioning administrative component, and some form of community engagement.

It is important to remember that being smart is a process and not an end-state. There are many steps to developing smart environments and solutions, some of which may not register as smart city initiatives. For example, expanding broadband access through community outreach or the creation of new networks increases connectivity and lays the groundwork for future smart development, but does not itself constitute smart city implementation. Other programs meet some but not all of the criteria. The development of open data policies and platforms to share existing data can encourage innovation and prepare cities to handle future ICT-generated data pools, but do not necessarily include the analytical tools necessary to qualify as smart city initiatives. Alternatively, many of these endeavors represent important steps along the way.

Case Study Methodology

The case study comparison explores how a variety of cities have approached smart city development. While considered leaders, the case cities are mostly in the early stages of the smart city system adoption. While some are further along than others, many of the programs discussed are recently deployed. NLC is not, therefore, in the position to rigorously evaluate the outcomes of these initiatives. Instead, this report focuses on answering the following questions:

- What are the initiative's objectives and instruments?
- How is the initiative funded and organized?
- What policies structure and direct the initiative?
- How is the initiative administered?
- How has the community been engaged and responded to the initiative?

Cases were selected for their diversity in size, demographics, and geography. This type of case selection ensures that the best practices implemented in these cities and described in this report will be broadly applicable to other cities interested in smart development. To answer the key questions above, we reviewed academic articles, census data, policy papers, government documents, and newspaper articles from the case cities. In addition, we interviewed two subject matter experts (SMEs) on smart cities, as well as local leaders from the case cities.

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