American Planning Association
Planning Advisory Service
Creating Great Communities for All

PAS REPORT 599

SMART CITIES
INTEGRATING TECHNOLOGY, COMMUNITY, AND NATURE

Petra Hurtado, PHD, with Benjamin G. Hitchings, FAICP, and David C. Rouse, FAICP

The American Planning Association will lead the way to equitable, thriving communities by creating unique insights, as well as innovative and practical approaches that enable the planning community to anticipate and successfully adapt to the needs of a rapidly changing world.

Since 1949, the American Planning Association's Planning Advisory Service has provided planners with expert research, authoritative information on best practices and innovative solutions, and practical tools to help them manage on-the-job challenges. PAS Reports are produced in the Research Department of APA. Joel Albizo, FASAE, CAE, Chief Executive Officer; Petra Hurtado, PHD, Research Director; Ann F. Dillemuth, AICP, Editor. APA membership includes access to all PAS publications, including PAS Reports, *PAS Memo*, and *PAS QuickNotes*. Learn more at planning.org/pas. Email: pasreports@planning.org

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ABOUT THE AUTHORS

Petra (Stieninger) Hurtado, PHD, is the research director at the American Planning Association, heading APA's research programs and foresight practice. In this role, she is responsible for expanding a future-focused research agenda and advancing planning practices that assist communities in navigating change. Her areas of expertise and research include urban sustainability, smart cities, emerging technologies, and environmental psychology. Prior to joining APA, she worked as an advisor, planner, researcher, and educator in the global urban sustainability arena. She holds a PhD in urban planning from the Vienna University of Technology, where she teaches on urban sustainability and environmental psychology. Additionally, she has been a guest lecturer at Loyola University Chicago, University of Maryland, the Harvard Graduate School of Design, and the Universidad Tecnológica de Bolívar. She has authored and co-authored multiple books, research papers, publicly funded reports, and articles and has presented as a subject matter expert at numerous conferences around the globe.

Benjamin G. Hitchings, FAICP, CZO, is the principal of Green Heron Planning, LLC and a member of the board of directors for the American Planning Association. A past president of the North Carolina Chapter of APA (APA-NC), he has 30 years of experience working on planning issues and has developed award-winning plans at the local and regional levels. Hitchings is the former planning director for the Town of Chapel Hill and the Town of Morrisville, North Carolina, and is a current adjunct faculty member at the University of North Carolina's School of Government. He holds a bachelor of arts from Amherst College and a master's degree in city and regional planning from UNC–Chapel Hill. In 2016, APA-NC recognized Hitchings with its highest honor, the Philip P. Green Distinguished Service Award.

David C. Rouse, FAICP, ASLA, is a consultant, educator, and author with over 40 years of experience in urban and regional planning and design. From 2013 to 2019, he served as managing director of research and advisory services for the American Planning Association, where he supervised programs and initiatives such as Green Communities, Planning and Community Health, the Sustaining Places Comprehensive Plan Standards, and Planning for Autonomous Vehicles. Prior to joining APA, Rouse was a principal at the planning and design firm Wallace Roberts & Todd in Philadelphia, where many of his projects were recognized with professional awards for excellence. Areas of expertise include comprehensive planning, parks and open space planning, green infrastructure, and planning for emerging technologies. Rouse holds a master's degree in landscape architecture from the University of Massachusetts–Amherst.

ON THE COVER

Pedestrians scroll through directory listings on an IKE interactive kiosk in the Inner Harbor neighborhood of Baltimore (Mark Moyer)

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PREFACE

The American Planning Association (APA) is proud to publish *Smart Cities: Integrating Technology, Community and Nature*, a new resource to help planners make good use of the rapidly expanding suite of digital tools serving our cities and towns.

While this isn't the first (or last) publication on smart cities, we believe it's unique because it provides a practical framework for understanding and applying the concept from the planning perspective, which is intrinsically forward-looking, holistic, people-centric, and rooted in social justice.

Over the last decade, we've experienced unprecedented growth in the development and day-to-day use of digital technologies. For many of us, not a day goes by that we don't (perhaps unknowingly) interact with at least one. COVID-19 has quickened the pace of innovation, led to greater utilization, and cast a new and more critical focus on advanced technologies, such as artificial intelligence (AI).

Some will see smart cities and their underlying technologies as a fad or distraction or, worse, a harbinger of new and greater harm to vulnerable communities. Others envision the potential for good if approached with an eye toward not just efficiency and opportunity, but also ethics and equity. The last thing we want to do is repeat or compound the mistakes of the past.

Here's where planners—and APA—come in.

Planners are uniquely educated and experienced in the art and science of land use and public engagement to help communities envision and create better futures for all. Their knowledge, skills, abilities, and values are both complimentary and essential to the constructive advancement of smart cities and the realization of their potential. Planners have an opportunity to learn how to plan with and for smart cities, implying both a current and forward-looking role.

APA's foresight practice revealed a gap between the potential impacts of smart city technologies and the planning profession's awareness, understanding, and appreciation of them. We believe we need to mind this gap to ensure the continued relevance of planning, the desirability of planning as a career and, most importantly, the well-being of all communities in a dynamic and unpredictable future.

It's our hope you'll find this resource helpful in understanding the smart city concept and its relevance to planning, now and in the future. And most importantly, we hope you'll see how you can help shape the inevitable change that will occur because of what Microsoft CEO Sayya Nadella calls the "digitalization of everything."

We're confident that your future, the future of planning, and the future of our communities will be the beneficiaries.

Joel Albizo, FASAE, CAE
Chief Executive Officer
American Planning Association

Smart Cities

Integrating Technology, Community, and Nature

PAS Report 599 shows how smart cities can equitably integrate technology, community, and nature to enhance livability, sustainability, and resilience while fostering innovation, collaboration, and participatory co-creation.

Smart city initiatives must be supported by:

Policies & Plans
People-centric policies and holistically integrated plans create equitable and sustainable smart city outcomes.

Network Infrastructure
A city is only as smart as its network infrastructure, which supports the internet-enabled technology that powers smart cities.

Cybersecurity
With the rise of cyber-attacks, no internet-enabled device is safe without cybersecurity, and smart cities must account for this at scale.

Digital Processes
Like policies, digital processes are key to maximizing efficiency and improving predictability in smart city performance.

EXECUTIVE SUMMARY

Today, big data, the internet of things, and artificial intelligence are spurring a digital revolution, changing entire societies, economies, and built environments. Advances in digital technology affect almost every aspect in life.

The concept of "smart cities" is a development of this era. It includes not just the operation of a city and related processes, systems, and communication streams, but also the practices planners use to make plans for a community, collect and use data, and implement their plans. If deployed in the right ways, state-of-the art technologies can help planners resolve the myriad challenges they are facing in their communities, big or small.

But for many planners, "smart city" is just a buzzword that does not connect with their community goals and is not part of their vision or toolkit. This is something that needs to change.

In this digital era, it is vital that planners learn about smart city concepts and how they can use these technological innovations so their communities can benefit from them instead of being harmed by them. Adjusting planning processes to this digital environment and adding new tools, relevant skills, and knowledge to the planner's repertoire will be crucial for planners to stay relevant and evolve in this era of digital transformation. This PAS Report provides guidance for planners on how they can do this.

WHAT IS A SMART CITY—AND WHY SHOULD PLANNERS CARE?

This PAS Report defines a "smart city" as follows:

A smart city equitably integrates technology, community, and nature to enhance its livability, sustainability, and resilience, while fostering innovation, collaboration, and participatory co-creation.

A smart city should deploy technological innovations in a thoughtful and efficient manner to resolve existing and future challenges. It should take advantage of technological progress to create great communities for all while protecting the environment, mitigating climate change, and considering future generations, independent of the size of the city or community.

This report makes the case that planners should be key players in helping to implement this smart city ideal. The smart city needs a plan, and integrating smart tech into achievement of the city's vision is crucial. The planner together with the community members create the vision and goals, while the technology expert provides the path to achieve them. Problems must be defined first so technology can create solutions.

It is especially important to integrate planning principles and ethics into the ways smart cities are being developed. Too many examples exist where new technologies resulted in inequalities in society. Smart city solutions must be implemented equitably to solve problems holistically. Planners must understand smart technologies and how they can be used to resolve community challenges, and they need to communicate community goals to technology partners so smart city tech can help achieve those goals instead of creating disruptions or adding additional challenges.

At the same time, while planners are used to thinking and planning over the long term, the pace of change has been accelerating. This acceleration and a constantly changing environment create additional challenges.

A lack of preparedness and agility can result in new technologies causing severe disruption. Combining long-range visioning with future literacy—being able to imagine plausible futures and understanding the role of these plausible futures in the community context—can help to minimize these disruptions. And to enable planners to respond more rapidly to change, planning processes need to be more agile.

The digital era and the related digital transformation of communities into smart cities offers an unprecedented opportunity to improve the quality of life for all. If done the right way, smart cities provide the potential to correct planning mistakes from the past and make cities more equitable and resilient than ever before. This PAS Report prepares planners to get involved, connect with the smart tech sector, learn about and prepare for smart technologies, and start spearheading the development of smart cities.

ELEMENTS OF THE SMART CITY

For a smart city to be successful, it needs a solid foundation. A fundamental piece of this foundation is the integration of smart city technologies and processes into plans and policies. This report offers guidance to help planners integrate smart city considerations within community planning documents and policies. Other foundational elements include modern information technology infrastructure that can support smart city applications and the needed safeguards to protect these infrastructure systems from cyberattacks, and digital governmental platforms and processes that embrace systems thinking and cross-departmental collaboration.

The report offers a framework of three distinct but interconnected smart city "ecosystems" to help planners better understand smart city systems:

- **Gov tech** is the use of technology to increase the efficiency of municipal operations and services. This ecosystem represents public-sector stakeholders (municipal government, local public agencies, and regional, state, and federal entities).
- **Civic tech** is the use of technology to increase public engagement, participation, and co-creation, making government more accessible to residents and vice versa. This ecosystem represents civic-sector stakeholders (the people who live, work, and play in the city or community, community groups, and nonprofit organizations).
- **Urban tech** is the use of technology to improve the built environment and urban infrastructure to serve the needs of people, businesses, and government. This ecosystem represents private-sector stakeholders (technology companies, entrepreneurs and tech developers, investors, and businesses).

The report also describes the three elements that must be integrated to create a truly smart city:

- **Technology.** Smart city technology is rapidly evolving, providing a wide variety of functions and applications that can be used to make cities more efficient, livable, and sustainable. These applications are applied in many different performance domains, including transportation and mobility, energy, water, public health, and safety and security.
- **Community.** Open government and civic tech empower individuals to create changes in their own communities based on their personal experience and available data. To support this shift toward participatory co-creation, planners must help create such opportunities, provide transparency to increase trust, reduce biases, support innovation, create inclusive processes, allow for feedback loops, and enhance digital literacy.
- **Nature.** Technology alone cannot provide for all the needs of a community's members. Nature—land, water, air, flora, and fauna—is our essential life support system and will be increasingly important in the era of smart cities. A smart city incorporates natural systems into the built environment to provide mutual benefits for people and ecosystems, while using data and digital technologies as tools to optimize the performance of these systems in delivering these benefits.

The key to a truly smart city is the integration of all its components in the real world—and also in the digital world. A truly smart city combines the foundational elements, the three ecosystems, technology applications in different performance domains, community participation and co-creation, and nature. All these components generate data points that can be mirrored into a digital version of the city, which ultimately can evolve into a smart city digital twin (SCDT). SCDTs can be used to simulate, predict, optimize, and test policy options; visualize plans for better civic engagement; and improve decision-making processes. Eventually, the SCDT will become a state-of-the-art planning tool for the planner's toolkit.

PLANNING IN THE ERA OF SMART CITIES

The interdisciplinary nature of planning and the variety of skills planners can bring to a team makes planners perfectly suited to spearhead and lead the development of smart cities and their integration into all systems of a city. This report highlights the need for planners to add additional skills, processes, and tools to their repertoires to make use of the benefits of new technologies.

When planning *with* smart cities, planners can use smart city applications to enhance data collection and data analytics and to better inform plan making and implementation decisions. But they must understand how data is collected through these applications, where the data comes from, what is included and what is missing in that data, how to ensure data privacy, and how to address data gaps to ensure everyone is included and no one is left behind. All available and relevant data can be integrated into one platform, which can ultimately be used for the creation of a smart city digital twin, a virtual version of the city. Planners can then use that data to visualize and test the potential impacts and consequences of plans and policies in the virtual world. They can use virtual and augmented reality, among other technologies, to share these experiments with community members, foster community engagement, and spur interest among community members to co-create.

When planning *for* smart cities, planners can use existing and new skills and processes to integrate smart city strategies into holistic plans and use smart city applications to achieve community goals. These include soft skills related to community facilitation and engagement, as well as technological knowledge and know-how on how smart city applications can be implemented equitably and sustainably. People-centric, agile, and technologically advanced competencies include strategic foresight and design thinking. Planners can use these and other skills to facilitate the connections between the needs, goals, and challenges of community members and the available technological solutions to result in equitable smart city outcomes.

SMART CITY IMPLEMENTATION

All cities strive to manage governmental operations, infrastructure, and facilities effectively and efficiently, and all can benefit from the application of smart city approaches to achieve these goals and help create more livable and sustainable places. This report explains the three primary approaches used by local governments to implement smart city applications.

A *project-driven approach* consists of a local government using a smart cities application to help solve a particular community problem or improve a community service. But without a bigger-picture approach, these one-off initiatives can have limited impact beyond their immediate application and represent missed opportunities to contribute to the development of a larger, more impactful smart cities ecosystem.

With an *incremental approach*, local governments use individual smart cities projects as pilot initiatives not only to solve immediate problems, but also to begin developing greater smart cities capabilities. Adaptive and opportunistic, this approach provides an opportunity to test and build capability over time, spreading out the cost of investment, facilitating identification and engagement with potential partners, and allowing for the tracking and integration of advances in smart cities technologies and system development techniques.

For communities that wish to pursue a more integrated, holistic strategy to smart cities development, a *holistic-city* approach establishes a comprehensive smart cities vision that is consistent with community goals, maps out a nimble and integrated action plan, and then works to implement it. Each smart cities initiative occurs within this framework and contributes in a strategic and intentional way to the development of a larger smart cities ecosystem. While more challenging and resource-intensive to implement, this approach enables a more transformative use of smart cities technologies to increase the intelligence and efficiency of services and functions throughout a local government. This PAS Report offers recommendations for how planners can help create this overarching smart city vision and plan as well as integrate smart city considerations into everyday planning practice.

SMART CITY OPPORTUNITIES AND CHALLENGES

Smart cities can provide many opportunities for improvements in cities and communities—but they can only be successful if they are implemented equitably, allowing access for all, and without compromising the safety and privacy of all community members.

This report describes how equitable implementation of smart city applications can improve operational efficiencies of a city by connecting the city directly to its residents, connecting people to people, and interconnecting infrastructure systems; reduce natural resource consumption and environmental pollution, providing a better quality of life and healthier communities, while mitigating climate change; and create financial efficiencies through collaboration with the private sector, experimenting, and prototyping. Smart city technologies offer the opportunity to fill certain gaps in existing systems or services in a city. Planners can use the data collected by smart city applications to inform planning and policy decisions. And cities can leverage their data, using it as a currency to negotiate with third-party vendors and partners in exchange for services and insights.

But while smart cities offer many opportunities to make cities better and improve residents' quality of life, challenges need to be resolved for smart cities to be truly smart. The report touches on the unresolved questions of how data will be sorted, managed, and shared—and the growing threat of cybersecurity. Cities also face the threefold challenges of the "digital divide": digital literacy, access to devices, and the provision of broadband infrastructure. And planners must understand the problems of data gaps, data bias, and the resulting inequitable outcomes that can be compounded when artificial intelligence makes decisions with algorithms that use incomplete datasets. Finally, funding is needed to help local governments innovate and support the transition from pilot projects to city-wide implementation and integration in equitable ways that benefit all population groups.

LOOKING AHEAD

Smart cities are a product of the digital era we live in today. Planners need to become a driving force of this revolution and embrace meaningful innovation. The question is not whether planners should plan for smart cities, but rather how they can do so equitably and sustainably. Smart technologies offer myriad opportunities to enhance the quality of life in communities, if planned and implemented in the right ways.

The world around us is changing and the planning profession needs to evolve with these changes. This may mean adding new processes, tools, and planning competencies; it may also mean a reinvention of what planners do and what their roles are supposed to be. While the goal of planning remains the creation of great communities for all, the path to get there can be improved and made more effective and inclusive by using state-of-the-art technology.

The deployment of smart city technologies will happen with or without planners. However, planners are needed to integrate these technologies into a holistic community vision, to ensure equitable and sustainable implementation and operation, and to create solutions that benefit all community members.

The digital era provides opportunities like never before. This PAS Report offers planners a guiding document to help them embrace these innovations and create smart cities to benefit community members, improve local government operations, correct planning mistakes from the past, and shape a better future of livability, sustainability, and resilience for all.

CHAPTER 1

INTRODUCTION

The age of the "Smart City" is upon us! It's just that, we don't really know what that means. Or, at least, not yet.
– Boston Smart City Playbook

Many cities around the globe claim to be the "smartest city in the world." Numerous planning and consulting firms offer their "smart city" services. Technology companies provide solutions for "smart" infrastructure, "smart" homes, and "smart" transportation. But it is not always clear what "smart city" really means. For many planners, "smart city" is just a buzzword or a utopian idea that does not connect with their community's goals and is not part of their vision or toolkit. This is something that needs to change.

Today, advances in digital technology affect almost every aspect in life: how people live, work, shop, play, and move around town; how businesses connect with their customers; how we communicate with one another; and even how people make decisions on what jobs to apply for or with whom to go on a date. Though this digital era began only two decades ago, it has been accelerating at an unprecedented pace.

The second half of the twentieth century was called the "information age," with its shift from traditional industries to an economy that is based on information technology. Today, big data, the internet of things, and artificial intelligence are spurring a digital revolution (Helbing 2015), changing entire societies, economies, and the built environment. These changes are prompting the digital transformation of communities.

The concept of "smart cities" is a development of this era. It includes not just the operation of a city and related processes, systems, and communication streams, but also the processes planners use to make plans for a city, collect and use data, and implement their plans.

But "smart" is not just a showy label for big cities that deploy high-tech solutions. Smart cities are a product of the evolution of an ever more digitalized world and a logical consequence of technological innovation. If deployed in the right ways, state-of-the art technologies can help planners resolve the myriad challenges they are facing in their communities, big or small.

In this digital era, smart cities should be the state of the art of planning practice. It is vital that planners learn about smart city concepts and how they can use these technological innovations so their communities can benefit from them instead of being harmed by them.

Adjusting planning processes to this digital environment and adding new tools, relevant skills, and knowledge to the planner's repertoire will be crucial for planners to stay relevant and evolve in this era of digital transformation. The American Planning Association seeks to identify skills gaps in all areas of planning (including skills to accommodate technological innovations) and provide education and training to advance the state of the art of planning and to prepare planners for a changing world. This PAS Report provides guidance for planners on how to adjust to the smart city movement and how to play a leading role in related developments.

WHAT IS A SMART CITY?

There are many different definitions of the term "smart city." Currently, every city that tries to become a smart city, and any company or organization that is involved in smart city-related activities, has its own definition of what "smart city" means.

The term "smart" originated in the information technology sector as an acronym for self-monitoring, analysis, and reporting technology (SMART); it was related to the monitoring of computer hard disk drives. Its use spread among other sectors in the context of objects and machines

DIGITIZATION, DIGITALIZATION, AND DIGITAL TRANSFORMATION

The terms *digitization*, *digitalization*, and *digital transformation* are common in the context of smart cities, but oftentimes they are confused with each other. While all three describe the transformation of something analog to something digital, they have distinct meanings.

Digitization is the conversion of information from an analog form to a digital form. For example, a text (handwritten or typewritten) on a piece of paper can be digitized to a text saved on a computer. A zoning map on paper can be digitized to a zoning map saved on a computer.

Digitalization is the conversion of processes or roles from an analog form to a digital form, including business operations, social interactions and behaviors, and business models. Examples include using digital technologies such as email or chat instead of regular mail or the telephone, or providing an automated online plan review permitting program through which the required documents can be uploaded and are automatically processed.

Finally, *digital transformation* is about the customer and the transformation of an entire (business) strategy that allows for more agility and puts customer-driven change at its core. It requires overall organizational change and the implementation of a series of digitalization projects. For example, the digital transformation of cities would entail a holistic, people-centric approach to smart cities, adapting to the needs of the individuals of a community, changing the overall operational strategy of the city, and allowing for co-creation, while using digital technologies. The Smart City 4.0, as described in Chapter 2, explains what that would look like.

that can self-monitor, analyze, report back, communicate with us and with each other, and have the power to change people's behaviors.

The term "smart city" is derived from the types of technologies that are being deployed in such a city, mainly "smart tech" or information and communication technologies (ICT). Hence, in most cases the definition of "smart city" focuses on the use and implementation of smart technology.

However, this definition makes the deployment of a smart city sound like a futuristic concept only big, well-resourced cities will be able to tackle. And more importantly, it does not take into account important factors and opportunities that can be pursued when planning for smart cities.

The purpose of a smart city should not be the implementation of smart technology for technology's sake. Rather, a smart city should deploy technological innovations in a thoughtful and efficient manner to resolve existing and future challenges. It should take advantage of technological progress to create great communities for all while protecting the environment, mitigating climate change, and considering future generations, independent of the size of the community.

The potential uses of smart tech or ICT in cities are almost limitless. They include technologies that improve service quality and process efficiency, innovations that allow for better communication streams between different urban stakeholders (government, community members, and private-sector companies, among others), and technologies that empower these stakeholders to co-create and experiment. These myriad applications have the potential to support planning goals such as climate change mitigation and adaptation, equitable access to health services, inclusive engagement, and others.

This PAS Report defines a "smart city" as follows:

> **A smart city equitably integrates technology, community, and nature to enhance its livability, sustainability, and resilience, while fostering innovation, collaboration, and participatory co-creation.**

Achieving this goal will require a continuous commitment to learn, a willingness to innovate and adopt, the ability to build trust and gain an understanding of the community and its individuals' needs, and openness to collaborate with all stakeholders to evolve and thrive. This report will suggest approaches to how a truly smart city can be achieved, while considering challenges that may be outside of the control of planners.

WHY SHOULD PLANNERS CARE ABOUT SMART CITIES?

Planners help communities navigate change and prepare for an uncertain future. In a world of accelerating change and disruption, this task is becoming ever more complex. It has been especially difficult to keep up with the pace of technological innovations.

For planners to stay relevant in this digital age and to continue to spearhead urban development processes, it is important that they learn about new technologies and understand how they can use innovative approaches to improve the well-being of their communities. The world continues to change. So do the challenges we face—and the tools that can help to solve them.

The Smart City Needs a Plan, Not Just a Technology

As the quotation that begins this chapter reports, "the age of the smart city is upon us." Smart cities are being developed across the world—in some cases without the involvement of planners. Suddenly, "tech giants" such as IBM, Alphabet, or Cisco are involved in activities historically defined as a planner's job.

There is a variety of reasons for why planners may not be the main points of contact or those spearheading the development of smart cities. In some cases, private-sector tech companies approach the mayor's office directly with their ideas, and decisions are made independent of existing plan documents such as the city's comprehensive plan. Or technology companies respond to requests for proposals from a city's chief information officer or the public works department, and a lack of cross-departmental collaboration or sharing of information and data leaves planners out of the loop. This suggests that technology companies do not see planners as the ones who have the expertise or the authority to implement their innovations, and that planning may be perceived as a barrier to instead of an enabler of smart cities.

In many of these cases, the conversation about smart city projects or pilots does not start with the problems that need to be resolved or the goals and vision of a city that need to be achieved, but with the technology that will be purchased and implemented. This can result in severe shortcomings, such as a lack of planning principles and ethics in the implementation of smart city projects. The goal of the planner is to plan for the common good. The goal of companies like Alphabet is to plan for data and ultimately the profit that can be made from selling that data. Additionally, in some cases, smart city projects are being executed as pilot projects in isolation from other programs within a city, which makes it harder to create holistic solutions everyone in the city can benefit from. From a planner's perspective, technology companies lack the holistic, city-wide view planners bring to the table.

Technology needs to have a purpose. This can be the resolution of a specific problem, such as smart traffic management to decrease congestion and additionally reduce greenhouse gas emissions. It can be the improvement of processes, such as using real-time data through crowdsourcing. And it can be to achieve the city's vision and certain goals set to support that vision.

Integrating smart tech into achievement of the city's vision is crucial. The planner provides the vision and goals, while the technology expert provides the path to achieve them. Problems must be defined first, and the technology must provide the path to get to solutions.

It is specifically important to integrate planning principles and ethics into the ways smart cities are being developed. Too many examples exist where new technologies resulted in inequalities in society. For example, digitalization leaves behind people who do not have access to the internet or cannot afford connected devices. Access to transportation systems such as transportation network companies, shared bicycles, or shared scooters requires a credit card and a smartphone and therefore excludes unbanked people, the very young, and potentially the very old, among other population groups. Smart city solutions must be implemented equitably to solve problems holistically.

Planners need to stay on top of urban innovation while collaborating with the companies and local government departments that provide these technologies. For a successful collaboration between planners and the tech sector, it is imperative for planners to understand these technologies and how they can be used to resolve community challenges. Additionally, planners need to communicate community goals appropriately to technology partners so smart city tech can support their implementation instead of creating disruptions or adding additional challenges.

A notable example of a global city that has embedded smart tech into its vision is Vienna. Its *Smart City Wien Framework Strategy* (updated in 2019) is a holistic, city-wide strategy that uses the United Nations' Sustainable Development Goals as its foundation and simultaneously serves as the sustainability strategy for the city. Vienna's experience is discussed in the sidebar on pp. 16–17.

To sum up, the integration of smart technologies into plans is important to ensure they have a purpose, support

FREQUENTLY USED TERMS IN THE CONTEXT OF SMART CITIES

Planners should be familiar with the following terms, which are frequently used in the context of smart cities and are used in this report.

- **Information and communication technologies (ICT)** "may be defined as the convergence of electronics, computing, and telecommunications. It has unleashed a tidal wave of technological innovation in the collecting, storing, processing, transmission, and presentation of information that has not only transformed the information technology sector itself into a highly dynamic and expanding field of activity—creating new markets and generating new investment, income and jobs but also provided other sectors with more rapid and efficient mechanisms for responding to shifts in demand patterns and changes in international comparative advantage, through more efficient production processes and new and improved products and services" (CIOWiki 2021).
- **Big data** can be described through the 5 Vs: volume, velocity, variety, veracity/validity, and value. It is characterized by a huge volume of information (data) that is processed at high velocity (almost continuously and in real time) and that is derived from a variety of data sources (and therefore, mostly unstructured). The veracity or validity of the data is important. Transparency about where the data comes from and awareness of potential data gaps can lower the risks of incomplete datasets. Additionally, the data must be truthful and accurate. And finally, big data is only useful if it can create value—if it can be transformed into meaning (Zweig 2019).
- **Internet of things (IoT)** "encompasses everything connected to the internet, but it is increasingly being used to define objects that 'talk' to each other. Simply, the Internet of Things is made up of devices—from simple sensors to smartphones and wearables—connected together" (Burgess 2018).
- **Artificial intelligence (AI)** "enables computers and machines to mimic the perception, learning, problem-solving, and decision-making capabilities of the human mind" (IBM Cloud Education 2020). AI has been in development since the 1950s. However, due to the availability of big data and increased computing power, the AI market has grown substantially over the last decade and is expected to grow globally at a compound annual growth rate of 42.2 percent from 2021 to 2027 (Future Today Institute 2021).

the city's goals, and contribute to a holistic vision for the city. Planners are the ones who can ensure that this happens.

Planning Needs to Be More Agile

While planners are used to thinking and planning long-term for changes such as climate change, technological innovations, and demographic shifts, the pace of change has been accelerating. This acceleration and a constantly changing environment create additional challenges for planners.

For instance, throughout the last decade, cities have been disrupted by transportation network companies such as Uber and Lyft. Instead of supporting them as an innovative solution that offered the potential to close certain gaps in the transportation network (if implemented equitably), many cities across the globe were at a loss as to how to accommodate them and therefore prohibited their services completely.

During the COVID-19 pandemic, many recognized that most cities were not built for physical distancing or shelter-in-place mandates. Sidewalks were too narrow, parks and green spaces were not available to all, public transit was perceived as unsafe to use. Conventional planning processes would not have helped to solve these issues in a quick and simple way; it would have taken months, if not years, to establish shared streets, open streets for outdoor dining, and implement other solutions. The quick implementation of these measures was made possible through emergency orders, not planning processes.

A lack of municipal preparedness and agility can result in new technologies causing severe disruption. Combining long-range visioning with *future literacy*—being able to imagine plausible futures and understanding the role of these plausible futures in the community context—can help to minimize these disruptions. And to enable planners to respond more rapidly to change, planning processes need to be more agile.

In this context, planners may benefit from adopting processes that are used in faster-paced industries, such as the technology sector. The success and rapid innovation in the ICT industry are possible because of the agile methods used in this industry. Planners—and the planning profession as a whole—can benefit from working to implement smart cities in collaboration with smart tech companies. Smart cities and their potential to collect data through their applications can help planners to work with real-time data, monitor, and adapt in a timely manner. This report offers planners some ideas on how to adopt new processes and methodologies.

Additionally, such collaboration will allow for more experimentation and piloting of new innovations that can help to prepare for the new, while keeping the city-wide vision in mind—as described in Vienna's smart city strategy. Increased preparedness for future changes and agile processes will enable planners to proactively prepare for the future instead of retroactively adjust and adapt to disruptions when it is too late.

The digital era and the related digital transformation of communities into smart cities offers unprecedented opportunities to improve the quality of life for all. If implemented in the right way, smart cities provide the potential to correct planning mistakes from the past and make cities more equitable and resilient than ever before. Therefore, it is crucial that planners get involved, connect with the smart tech sector, learn about and prepare for smart technologies, and start spearheading the development of smart cities.

ABOUT THIS REPORT

The goal of this PAS Report is to provide guidance on how to plan *with* smart cities and on how to plan *for* smart cities. The concept of planning *with* smart cities focuses on the use of smart city applications as planning tools that enable planners to collect real-time data, allow for more agility, and provide the ability to act, make corrections, and adjust in real time. The concept of planning *for* smart cities emphasizes the importance of a people-centric planning process that integrates technological innovation as a solution to a variety of community challenges.

The report describes where smart cities are today, what can be expected for the future, and most importantly, how planners can become future-ready for these developments. The report further explains what makes a city smart and explores the related impacts on communities and the roles of the people who live in a smart city.

The role of the planner in the development of smart cities is currently not clearly defined. This report discusses the current role of planners, and it explains how planners can better collaborate with the technology sector and lead smart city developments to benefit their communities. It describes how combining the existing skills and tools planners bring to the table with new methods and approaches can ensure equitable and sustainable outcomes in this digital era.

Smart cities provide incredible opportunities for cities, communities, and the planning profession to thrive and become nimbler and more future-proof, if implementation happens in the right way. However, planners risk making the same mistakes in the digital world that they made in the analog world. This PAS Report addresses these challenges and suggests solutions for how they can be overcome.

The target audience for this PAS Report is all planners who want to be able to help their communities navigate the accelerating pace of change and prepare for a future that will be more technology-driven, as well as smart city aficionados of any level. Readers will have a better understanding of what smart cities are and how planners can play an active and important part in their equitable and sustainable implementation.

Chapter 2, Evolution of Smart Cities, describes the evolution of smart cities, including their history, present state, and future considerations. It explains some of the milestones on the path from Smart City 1.0 to 4.0 and provides several case study examples.

Chapter 3, Integrating Technology, Community, and Nature, introduces the elements of a smart city, including its foundation, available technologies, the role of the community in a smart city, and the integration of nature in smart cities. It describes the three ecosystems of a smart city (gov tech, civic tech, and urban tech), and it explains the connection between the real-world smart city and its digital platform.

Chapter 4, Planning in the Era of Smart Cities, summarizes skills, processes, and methodologies planners need to be able to plan with and plan for smart cities. For the concept of planning with smart cities, it explains some of the needed skills related to data analytics, handling of real-time data, and experimentation in the virtual space. For the concept of planning for smart cities, it describes the importance of technology knowledge and the right practices that can allow for more agile planning processes.

Chapter 5, Planning Approaches for Smart City Implementation, covers the implementation of smart cities. It suggests different approaches on how to get started and move from single pilot projects to a holistic smart city strategy while collaborating with the tech sector and the members of the community, and it further highlights how smart city considerations can connect with planners' everyday work.

Chapter 6, Smart City Opportunities and Challenges, summarizes some of the opportunities that smart cities provide and explains why it is important for planners to become smart city experts when trying to create sustainable, resilient, equitable, and livable communities. The chapter explains efficiencies that smart tech can create in cities, how information and communication technologies can balance out deficiencies from the analog world, and how planners can take advantage of the smart city and the data that can be mined from it. Additionally, the chapter outlines some of the challenges that arise with smart city implementation and the related use of data while offering solutions and best practices on topics such as the digital divide, data protection and data privacy, biased data and data gaps, and public-private sector collaboration models and related funding.

Chapter 7, Looking Ahead, concludes the report with an outlook on how planners need to adjust and upskill to make smart cities successful. It also gives a look-ahead on what this may mean for the future of planning, how planners can continue spearheading urban development, and what a redefined role of the planner may look like. Enjoy the adventure!

THE SMART CITY WIEN FRAMEWORK STRATEGY 2019–2050

Vienna's smart city strategy combines the three elements, or dimensions, of a truly smart city as defined by this PAS Report: technology, expressed as innovation; community, expressed as quality of life; and nature, expressed as resource conservation (Figure 1.1). Each of these dimensions has specific principal goals attached. Together, they formulate the holistic vision for the city.

A comprehensive city-wide strategy, *The Smart City Wien Framework Strategy 2019–2050* is based on the 17 UN Sustainable Development Goals (SDGs), with a focus on how new technologies and innovations can benefit people. It acknowledges that all three dimensions are interlinked and cannot be developed or improved in isolation. The main goal is: "High quality of life for everyone in Vienna through social and technical innovation in all areas, while maximising conservation of resources" (Figure 1.1; Vienna 2019).

In addition to the three dimensions, the strategy is structured into 12 thematic fields with specific goals. However, the strategy emphasizes the need for cross-sectoral and cross-thematic projects and collaboration to achieve its goals. Examples of thematic fields and specific goals include the following:

Figure 1.1. The three dimensions of the Smart City Wien Framework Strategy *(Vienna 2019)*

- ***Mobility and transportation***: Currently, over 70 percent of Vienna's passenger transportation is taking place by either walking, biking, or public transit. The goal is to achieve 85 percent eco-friendly transportation by 2030.
- ***Digitalization***: By 2025, Vienna will digitalize and fully automate all processes and services where possible. The goal is to use digital tools and artificial intelligence to conserve resources and improve the quality of life.
- ***Environment***: Over 50 percent of the city's territory is green space. The goal is to maintain green space and ensure a distribution of green space in line with population growth. Additional goals focus on the conservation of biodiversity, environmental protection, and the support of sustainable local and regional food systems.
- ***Healthcare***: This theme includes goals regarding healthcare facilities as well as goals to promote health literacy and seek solutions for health risks from climate change.
- ***Social inclusion***: Vienna has a long history of affordable housing and leads globally with its inclusive, publicly subsidized homes. Over 60 percent of the population of Vienna lives in subsidized housing, a model that provides a healthy social mix. Vienna is committed to continue this model in connection with innovation for resource conservation and efficiency.
- ***Education***: A city can only be smart if its residents know how to take advantage of its applications. Therefore, Vienna supports digital education and vocational trainings for all, so everyone can be successful in this digital era. These trainings will additionally reflect changing job profiles and related necessary skills. The goal is to make Vienna's residents and workforce future-proof. The city will leverage its strong information and communication technologies sector, including research institutions and private-sector companies, to achieve this goal. Collaboration of all stakeholders is key to provide training. A specific initiative under this goal is the establishment of a city-wide network of *Bildungsgrätzl* (learning communities) by 2030.
- ***Participation***: Vienna encourages everyone to participate in the planning and implementation of its smart city vision. Opportunities for engagement and participation will therefore be visible and accessible to all. Urban labs and pilot districts are available to try out new technologies, innovate, and co-create.

TECHNOLOGICAL AND SOCIAL INNOVATION

The priorities of Vienna's Smart City strategy are equity and inclusion of different social groups; accessibility and affordability for all; participation and locally tailored solutions, including citizen co-creation; and the social component of innovation, which is to help and support everyone in this transition to the new.

To support social innovation as a form of citizen co-creation, the city established "social innovation labs" as central public contact points to share information, support the innovators, and

connect them with the right government agencies and initiatives.

Additionally, Vienna provides open government data and transparency of its processes and actions, so everyone can co-create or participate in existing processes. The city fosters experimentation and provides living labs and pilot districts to try out new technologies in long-term collaborative research projects with real-time data.

One example is the Aspern Smart City Research project in the Aspern Seestadt neighborhood, the largest smart city living lab in Europe. It is a multistakeholder research effort in which research institutions and private-sector companies collaborate with residents to create innovative solutions for energy efficiency, smart grids, and other challenges. A pilot for a self-driving bus, Vienna's auto.Bus, has been in operation in this neighborhood since June 2019 (Figure 1.2).

Roadmap for Implementation

A strategy can only be successful if it gets implemented. Therefore, Vienna elaborated a roadmap for implementation, emphasizing two key aspects:

- The need to enable a steady and constant evolution of the strategy
- The importance of providing the needed space for new innovations and an openness and a willingness to question established ways of doing things

Vienna acknowledges that digitalization affects all aspects of a city and the people who live in it. In its strategy, the city addresses related challenges such as data privacy and transparency, ethical and moral boundaries for artificial intelligence, and equitable distribution of benefits and opportunities resulting from technology innovations that need to be resolved. Additionally, the city understands the many opportunities coming out of this digital transformation that may provide innovative solutions for current and future challenges, create new ways for public participation and engagement, and make certain processes and services easier to improve the quality of life.

Vienna recognizes that little adjustments here and there won't be enough. For Vienna, "Smart City Wien means rethinking the city," a process that combines "creativity, imagination, and expertise" (Vienna 2019). Additionally, it requires openness to change and the willingness and ability to let go of old behavior and consumption patterns.

Implementation will be handled through an integrated approach that focuses on synergies between thematic fields and objectives through cross-departmental plans and projects. Through this approach, conflicting objectives and priorities can be identified and resolved. Regular monitoring mechanisms will allow for agile updating and adapting to new innovations.

The *Smart City Wien Framework Strategy* provides long-term, high-level guidance and orientation for short-term programs and actions. The dialogue between all stakeholders is key in this approach. All activities under this strategy are supported by the Smart City Wien agency that coordinates projects, gives advice, functions as a liaison for partnerships and networking activities, supports communication, and provides support to the smart city government structure.

Figure 1.2. Vienna's self-driving auto.Bus (Manfred Helmer/Wiener Linien)

CHAPTER 2

EVOLUTION OF SMART CITIES

New technologies have transformed societies throughout human history. Smart cities and the "fourth industrial revolution" emerged from the digital revolution, as described in Chapter 1, and are the latest manifestation of this phenomenon in our society.

The first industrial revolution spanned the second half of the 18th and first half of the 19th centuries, when innovations such as the steam engine and railroads marked the transition from muscle to mechanical power. The late 19th and early 20th centuries witnessed the emergence of the second industrial revolution, an era of mass production made possible by electricity, inexpensive fossil fuels, and invention of the assembly line.

The third industrial revolution, commonly called the computer or digital revolution, began in the 1960s with the development of semiconductors and mainframe computing, followed by the rise of personal computing and the internet in the closing decades of the century (Schwab 2016). The fourth industrial revolution has emerged from the digital revolution during the first two decades of the 21st century. It is characterized by big data, the internet of things, and artificial intelligence—the hallmarks of smart city technology.

The decreasing durations of these industrial revolutions—from a century for the first to a few decades or less for the third and fourth—is an indication of the accelerating pace of technological advancement. It is impossible to predict with any degree of certainty how our society will be transformed by the technologies of the future. Regardless of the future direction of technological change, the challenge for planners is clear: to help communities prepare for and manage that change to achieve sustainable, resilient, and equitable outcomes.

This chapter begins with a brief history of smart cities from their origins towards the end of the 20th century to the present day. It then describes several stages, or generations, of smart city development that are still evolving. It concludes with thoughts about the further evolution of the smart city movement, including a future vision for smart cities. Fundamental to this vision is the need to put people, not technology, first to support community values and serve community needs.

A HISTORY OF SMART CITIES

The beginnings of the smart city movement can be traced back to the development of computer analytical capabilities during the third industrial revolution referenced above.

In 1974, the City of Los Angeles' Community Analysis Bureau used IBM-360 mainframe computers to develop a database of 550 social and physical factors for census tracts throughout the city. Referred to as "A Cluster Analysis of Los Angeles," the goal of this project was to inform policy and action to alleviate poverty and address blight (Vallianatos 2015). The ultimate vision of the project's creators was to create a "control panel" that would provide real-time data to urban policy decision makers, which proved not to be possible with the technology of the time. The project is nevertheless significant as an early technological application led by planners, one that foreshadowed the use of big data and establishment of online data portals (of which Los Angeles' GeoHub is a good example) by contemporary smart cities.

The origins of the "smart city" date back to 1994, when Amsterdam established *De Digital Stad* (DDS), which translates to *The Digital City*. DDS was a "free-net" (a model also used in the United States and Canada at the time) designed to provide easy access to the internet and to improve communication between the government and residents. The initiative ended in 2001 when its municipal subsidy was discontinued, although volunteers carried on with its purpose and materials associated with DDS were later incorporated into the permanent collection of the Amsterdam Museum (de Vries et al. 2015; Alberts et al. 2017).

Amsterdam has continued as a leader in the smart cities arena. In 2009, it launched the Amsterdam Smart City platform, a public-private partnership encompassing gov-

ernmental agencies, knowledge institutions, companies, and foundations (Kuyper 2019). The online platform is organized around six main project areas: infrastructure and technology; energy, water, and waste; mobility; circular city; governance and education; and citizens and living (Smith 2017).

Enabled by increasing computer processing power, the pace of smart city development has accelerated in the 21st century. Technology companies such as Cisco, IBM, and Siemens developed and marketed software platforms and applications using sensors, networks, and urban analytics to help cities operate more efficiently and sustainably. Table 2.1 (p. 21) identifies several examples of these initiatives. Two "new smart cities"—the Songdo International Business District in South Korea (see the sidebar on p. 25) and Masdar City in Abu Dhabi, United Arab Emirates—were initiated in 2005 and 2006, respectively.

During this period, other cities such as New York, Singapore, Vienna (see the sidebar on pp. 16–17), and Barcelona, Spain (see the sidebar on p. 27), emerged as further leaders in the use of smart city technology within existing urban environments. At the national level, China started a pilot smart city initiative in 2013 that by 2019 had grown to 749 projects located in approximately 290 cities—the largest such initiative in the world (Wong 2020). In 2015, India launched a "Smart Cities Mission" for 100 cities "to provide core infrastructure and a decent quality of life to citizens, a clean and sustainable environment and application of Smart Solutions" (Ministry of Urban Development 2015).

In 2020, Saudi Arabia announced four "giga" projects—Neom, Qiddiya, Red Sea Project, and Amaala—during the lead-up to the G20 leaders' summit (McKeown 2020). Ranging from 334 to 28,000 square kilometers in size, these are touted as the most ambitious projects to date using smart technology in combination with conservation of natural landscapes to increase sustainability.

Smart new cities such as Songdo, Masdar City, and others sponsored by national governments are advancing the use of technological applications (typically provided by tech companies) to increase sustainability and conserve natural resources. As top-down projects developed on greenfield sites, however, they do not meet the definition of a smart city proposed by this PAS Report:

> **A smart city equitably integrates technology, community, and nature to enhance its livability, sustainability, and resilience, while fostering innovation, collaboration, and participatory co-creation.**

By contrast, a number of established cities around the world, such as Barcelona and Vienna, are moving in this direction as part of the ongoing evolution of the smart city movement. In the United States, cities large and small are beginning to adopt community-centric smart city approaches, as demonstrated by the example of the Town of Gilbert, Arizona (see the sidebar on p. 26).

THE EVOLUTION OF SMART CITIES

Smart city commentators have postulated that the evolution of the smart city movement consists of three or more stages or generations of development. According to Boyd Cohen, a researcher in sustainable development and smart cities, these generations are Smart Cities 1.0 (technology driven), Smart Cities 2.0 (technology enabled, city led), and Smart Cities 3.0 (citizen co-creation) (Cohen 2013).

In Smart Cities 1.0, cities adopt smart city solutions without really understanding the implications for residents. This generation corresponds to the initial development and marketing of smart city applications by technology companies based on the operational efficiencies and performance improvements they promise to bring. In Smart Cities 2.0, forward-looking municipal leaders and administrators determine the role of technological innovation in shaping the city's future. In Smart Cities 3.0, which Cohen believes to be the future of the movement, local governments and community members collaborate to determine how technology can best serve community needs.

A management development professor and curator at Amsterdam Smart City, Herman van den Bosch identifies three stages of smart city development that are differentiated largely by the extent of public involvement (van den Bosch 2018). Smart City 1.0 emphasizes the use of advanced technology to address selected urban problems, corresponding to the top-down approach promoted by technology companies. South Korea's Songdo International Business District, described in the sidebar on p. 25, is an example.

Smart City 2.0 begins with the identification of urban problems for application of technological tools in consultation with community members. However, community engagement in Smart City 2.0 is limited, reaching a small minority of the overall population. Van den Bosch identifies Sidewalk Labs' plan for Toronto's Quayside as an example.

Smart City 3.0 takes community engagement to the next level, engaging large numbers of residents and stakeholders in defining urban problems and developing initiatives to ad-

TABLE 2.1. MILESTONES IN THE HISTORY OF SMART CITIES

Year	Initiative
1994	Amsterdam establishes De Digital Stad.
2005	South Korea launches the first phase of the Songdo International Business District, a new smart city developed from scratch on filled land.
2006	The Government of Abu Dhabi in the United Arab Emirates initiates Masdar City, a new smart city designed as a hub for clean tech industries.
2008	IBM introduces the Smarter Planet initiative to harness the potential of "a whole new generation of intelligent systems and technologies" (IBM 2011). A $50 million Smarter Cities campaign followed in 2009. In 2011 IBM registered the trademark "smarter city."
2009	Dubuque, Iowa, partners with IBM on an initiative called Smarter Sustainable Dubuque, with the goal of creating an international model for the use of technology by smaller cities to increase sustainability (Wood 2013).
2009	Cisco launches the Smart+Connected Communities initiative as a digital platform for cities to improve economic, social, and environmental sustainability (Chakrabarti 2011).
2011	The first Smart City Expo World Congress is held in Barcelona, attracting 6,000 visitors from over 50 countries.
2013	China announces an initial group of 90 pilot smart cities, districts, and towns. Additional groups of smart cities are announced in subsequent years.
2013	Microsoft unveils the CityNext initiative, which it calls "a people-first approach to innovation that empowers governments, businesses, and citizens to shape the future of their cities" (Mlot 2013).
2014	Singapore launches its Smart Nation Initiative.
2015	India initiates a Smart Cities Mission for 100 Indian cities.
2016	Esri (purveyor of ArcGIS software) starts a Smart Communities initiative to promote use of geospatial technology by governments of all sizes to "make the lives of their citizens better" (Esri 2021). Esri subsequently develops software applications such as the ArcGIS Hub and ArcUrban as tools for creating smart cities.
2016	Columbus, Ohio, wins the $50 million Smart City Challenge sponsored by the U.S. Department of Transportation and Vulcan, Inc. The goal is to demonstrate how an intelligent transportation system can use emerging technologies to promote equitable access, increase economic opportunity, and improve quality of life (Columbus 2021).
2016	Google announces a new Alphabet enterprise, Sidewalk Labs, as an "urban innovation company that tackles cities' greatest challenges" to "help developers build more sustainable, innovative, and equitable places around the world" (Sidewalk Labs 2021).
2017	Alibaba launches City Brain, an initiative that uses big-data computing and artificial intelligence to manage urban systems such as transportation, health, and tourism. Initially deployed in Hangzhou, China, to reduce traffic congestion, City Brain had been implemented in 23 Asian cities as of September 2019 (Alibaba Clouder 2019).
2017	Sidewalk Labs wins a contract to plan and build Quayside, a site on Toronto's downtown waterfront, as a smart urban redevelopment. The plan prompted strong citizen opposition, largely due to data privacy concerns, and was abandoned by Sidewalk Labs in 2020.
2020	Saudi Arabia announces four planned "giga" projects, which are touted as the most ambitious projects to date using smart technology in combination with conservation of natural landscapes to increase sustainability (McKeown 2020).

Sources: GlobalData Thematic Research 2020, others as cited

dress them. The role of the municipality is to facilitate the use of digital technology and create the necessary infrastructure for implementation. Van den Bosch identifies Amsterdam and Barcelona (see the sidebar on p. 27) as emerging Smart City 3.0 examples. He concludes by proposing that the term "Smart City" be replaced by "Inclusive City," based on four interconnected characteristics: wellbeing, circularity, justice, and digital connectivity (van den Bosch 2018, 156).

ESI ThoughtLab is an economic consultancy that has conducted research on the global development of smart cities. Based on a survey of 167 cities worldwide, ESI ThoughtLab identifies three stages of smart city development similar to those postulated by Cohen and van den Bosch (ESI ThoughtLab 2021, 58). Smart Cities 1.0 pilot solutions offered by tech suppliers. They often see technology as an end, rather than a means for meeting the needs of community members. Smart Cities 2.0 focus on digital solutions to achieve their social agenda and improve services for residents. They often lack the support of all community members, many of whom may be left out of decision making. Smart Cities 3.0 are attuned to sensitive social and digital issues. They include community members in decision making and strive to act on their behalf.

ESI ThoughtLab further identifies a fourth stage of development—Smart Cities 4.0—in which cities use technology, data, and community engagement to achieve the United Nation's Sustainable Development Goals (SDGs) (United Nations n.d.) (Figure 2.1).

Comparing the stages of smart city development identified by Cohen, van den Bosch, and ESI ThoughtLab to the definition proposed on p. 20, it is apparent that the ideal smart city—Smart City 4.0—uses technology as a tool to serve the needs of people, community, and to encourage co-creation; and to enhance livability, sustainability, and resilience with the SDGs as the guiding principles. Vienna's *Smart City Wien Framework Strategy,* which is based on the 17 SDGs, demonstrates these fundamental characteristics (see sidebar on pp. 16–17). Planners have an important role to play in helping cities achieve the potential represented by Smart City 4.0.

Figure 2.1. The UN's 17 Sustainable Development Goals (United Nations)

SMART CITIES OF THE FUTURE

Several barriers must be overcome to move towards the ideal of Smart City 4.0. In a survey of government officials in 100 smart cities worldwide, the following were the most frequently cited obstacles to realizing the potential benefits yielded by smart city technology (ESI ThoughtLab 2019):

- Gaining support of citizen and other stakeholders (cited by 52 percent of cities surveyed)
- Ensuring that the speed of development keeps up with business and citizen needs (47 percent)
- Complexity of procurement (44 percent)
- Keeping pace with technological change (37 percent)
- Policy and regulatory barriers (36 percent)
- Managing cybersecurity/data privacy (36 percent)

The 30 North American cities surveyed ranked "gaining support of citizens and other stakeholders" significantly higher than average (67 percent).

Similarly, a public opinion survey conducted in the United Kingdom revealed that almost 68 percent of respondents did not know what a smart city was and that 24 percent found the concept "worrying, due to a lack of available information on the topic" (ATG Access 2018). These findings indicate the need to meaningfully engage residents and stakeholders if the ideal of Smart City 4.0 is to be realized.

Utopia or Dystopia?

The debate on the smart cities of the future has tended to gravitate between two extreme scenarios, which can be characterized as "sustainable city utopia" or "megacity dystopia" (Cathelet 2019; Hemel 2018; KFV 2019; Nenciu et al. 2016).

In the utopian scenario, people have access to smart city technology and data; they (rather than corporations or government) determine how technology is used to resolve priority needs and issues; data privacy is assured; and the results are healthy, inclusive, sustainable, resilient, and equitable communities. In the dystopian scenario, there is closed access to technology and data to benefit the socioeconomic elite; the use of technology prioritizes economic growth over sustainability; and the digital divide exacerbates inequality between the rich and much larger urban poor populations.

The smart cities of the future will likely fall somewhere between these two extremes. The challenge for planners and policymakers is to set the direction and continually move towards the former rather than the latter. Table 2.2 presents key variables that will influence the outcomes.

TABLE 2.2. KEY VARIABLES FOR SMART CITY OUTCOMES

Variable	Extremes
Governance	• Top-down versus bottom-up
Data	• Closed access versus open access • Surveillance versus privacy
Technology	• Technology in control versus people in control • Technology as the end versus technology as the means
Priorities	• Economy first versus sustainable development • Exclusion versus inclusion

Fundamental questions to consider in planning the smart cities of the future include: Who does technology serve? What are the objectives? Who (or what) is in control? And how can smart city technology be leveraged to serve people in inclusive ways that support community values and help realize social, environmental, and economic goals? This report offers guidance to planners in helping their communities find the answers to these questions.

A Future Vision for Smart Cities

As smart cities evolve, a holistic approach to their development and the integration of all systems, sectors, and stakeholders has become ever more important to ensure equitable, inclusive, and sustainable solutions and to achieve the definition of a truly smart city. Smart City 4.0 represents a model for this. Chapter 5 of this PAS Report will explain how planners can plan for and implement this ideal version of a smart city in their communities.

In addition to its implementation in the real world, the future of the ideal smart city encompasses the integration of all systems, sectors, and stakeholders in its digital version and the concept of planning with smart cities. Big data from almost any movement, flow, or activity in a smart city can be used to inform planning processes and improve decision making about a community's needs, challenges, and future vision. However, the data needs to be integrated into a single platform and data siloes need to be avoided, as will be further explained in Chapter 3.

This data platform combined with artificial intelligence can recreate the entire smart city as its ultimate virtual manifestation: a smart city digital twin (Hurtado and Gomez

2021). More information on smart city digital twins (SCDTs) will be provided in Chapters 3 and 4.

CONCLUSION

A central premise of this PAS Report is that smart city applications need to be expanded and harnessed in the service of people to realize sustainable, resilient, and equitable outcomes, and to address big issues, such as climate change and public health. This will require not only applying technology to improve performance in smart city domains such as energy and mobility (described in Chapter 3), but also addressing key variables related to governance, access to and control of technology and data, and equity and inclusion. For smart cities to realize their full potential, their final stage of evolution will be a complete integration of systems in the real world and a complete integration of data in the digital world (i.e., a digital twin).

To help cities ensure that the ways in which they adopt smart technology will lead them towards the Smart City 4.0 ideal, important questions about which planners can lead community conversations include the following:

- How can smart cities benefit communities that planning and policy have historically excluded or disadvantaged, such as lower-income populations, people with disabilities, people experiencing homelessness, the elderly, and other groups that may have little or no access to digital technology?
- How can the use of smart city technology be broadened to positively affect the various systems that contribute to socioeconomic inequality and related disparities in health outcomes, vulnerability to natural disasters, and the like?
- How can smart city technology be leveraged to make our communities more socially, economically, and environmentally resilient?

The next chapter will describe the components of a smart city in more detail.

SONGDO: A SMART NEW CITY

South Korea's Songdo International Business District is a smart new city under development on 1,500 acres of reclaimed waterfront land in Inchon, about 22 miles from Seoul (Figure 2.2). Conceived in 2001 with its initial phase launched in 2005, Songdo was originally planned to contain 80,000 apartments, 50,000,000 square feet of office space, and 10,000,000 square feet of retail space by 2015. Development is ongoing.

Promoted as the "world's smartest city" with "ubiquitous technology," Songdo has millions of sensors embedded in streets, electrical grids, water and waste systems, and buildings that monitor, respond to, and predict the flow of people, energy, and materials (Townsend 2013). With a target of cutting greenhouse gas emissions by two-thirds compared to similarly sized cities, its sustainability features include, among others, over 20 million square feet of LEED-certified buildings, electric vehicles and charging stations, a state-of-the art water recycling facility, and a pneumatic waste disposal system.

Commentators observe that Songdo has yet to realize its initial promise, despite its advanced technology. Growth has been slower than anticipated, with the business district about 70 percent built out and the population at one-third of the original target of 300,000 residents after 15 years of development (Poon 2018). The city contains an extensive network of green spaces and bike trails, but its unfinished landscape is dominated by streets as many as 10 lanes in width and clusters of identical residential high-rises, lacking the diversity, activity, and character of cities that evolve organically over time. While Songdo was planned with an extensive transit system, automobiles remain a primary mode of choice. Some residents report difficulty making social connections and an overall lack of a sense of community (Poon 2018).

These issues reflect the top-down approach used to develop Songdo as a greenfield project on filled land over former coastal wetlands. Critics argue that this approach emphasized technology without adequately accounting for people and their needs (Niedhart 2018).

Figure 2.2. Songdo International Business District, Incheon, South Korea (Fleetham/Wikimedia Commons)

GILBERT, ARIZONA: A DIGITAL TOWN

The Town of Gilbert is a rapidly growing community of nearly 245,000 residents located in the Phoenix metropolitan region. In 2012, the town established an Office of Digital Government to better connect with its relatively young, well educated, and digitally savvy population. It also developed a Digital Roadmap "as a guide for Gilbert's success as a digital town by allowing for increased internet access, open government, citizen engagement, and digital industry growth" (Gilbert 2015).

Gilbert's digital engagement programs include a mobile app hub, a regular podcast *(Government Gone Digital)*, an annual *Digital State of the Town* video production, and an open data portal hosted by Alex, a digital guide. Social media activities are coordinated across municipal departments and partners such as the Gilbert Chamber of Commerce, Chandler-Gilbert Community College, and Mercy Gilbert Medical Center.

A leader in the Phoenix region in improving citizen services through online technology, Gilbert implemented additional applications during the COVID-19 pandemic such as a text alert service, virtual building inspections, and more robust use of social media to connect with residents (Brereton 2020, Teale 2020). In recognition of its efforts during the pandemic, Gilbert received the Sharman Stein Award for Storytelling Changemakers from the Bloomberg Philanthropies' What Works Cities initiative. The award honors a city team or official that uses communications to build trust and collaboration between its government and residents (Teale 2020).

To celebrate its 100th anniversary in 2020, Gilbert adopted a new mission statement: to become the "City of the Future" and "anticipate change, create solutions, and help people and our businesses" (Gilbert Manager's Office 2021). Development of a fiber-optic network along arterial roadways that connects all town facilities and assets is a key part of Gilbert's smart city strategy (Brereton 2020). The town has piloted smart city applications such as smart water meters, adaptive signal timing, and sensor-based irrigation technology.

Gilbert is noteworthy as an early adopter of digital technology that has sustained and grown its programs over the years, which enabled it to respond quickly to the shift to remote work, municipal services, and civic engagement precipitated by the COVID-19 pandemic.

BARCELONA, SPAIN: AN OPEN, FAIR, CIRCULAR, AND DEMOCRATIC SMART CITY

Propelled by hosting the initial Smart City Expo World Congress in 2011, Barcelona was an early leader in the deployment of smart city technology. In 2013 its city council adopted the following definition of smart city: "a self-sufficient city of productive neighborhoods at human speed, inside a hyper-connected, zero emissions metropolitan area" (Zigurat Global Institute of Technology 2019).

The city developed an internet of things (IoT) sensor network with applications such as a smart LED-based lighting system, a waste disposal system that vacuums waste into underground storage bins, a smart irrigation system, air quality and noise detection, and informational kiosks (Figure 2.3). Barcelona's IoT systems have yielded benefits that include the creation of 47,000 jobs, water cost savings of €42.5 million, and generation of €36.5 million annually from "smart car parks" (Zigurat Global Institute of Technology 2019).

What is most noteworthy about Barcelona's smart city strategy, however, is its approach to e-democracy. Following the election of a new mayoral administration in 2015, the city's vision shifted from a primary focus on technology to an "open, fair, circular, and democratic city" that promoted residents' data ownership and technological sovereignty (Calzada 2018).

In 2016, the city council launched *Decidim Barcelona*, an online platform that enables community members to suggest and debate ideas and participate in decision making, thus shaping future policies. Over 40,000 residents participated in this process and approximately 70 percent of the ideas they generated were incorporated into the government's agenda. Herman van den Bosch notes that "Barcelona is the very expression of the shift towards… Smart City 3.0 by deploying digital tools to engage its citizens and to empower them to initiate the use of digital devices themselves" (van den Bosch 2018, 141).

Figure 2.3. Smart kiosk in Barcelona, Spain (smartcity.bcn.cat)

CHAPTER 3

INTEGRATING TECHNOLOGY, COMMUNITY, AND NATURE

As elaborated in Chapter 1, a truly smart city equitably integrates technology, community, and nature to enhance its livability, sustainability, and resilience, while fostering innovation, collaboration, and participatory co-creation.

This chapter describes the needed foundation to create smart cities in line with this definition. It further outlines the different "ecosystems" of a smart city—urban tech, gov tech, and civic tech—and describes how smart technologies can make infrastructure systems more efficient, and how the integration of nature in smart cities will benefit the well-being of society, the environment, and the economy.

Additionally, the chapter explains how smart technology can create a two-way communication stream between the government and the people and how it can be leveraged for co-creation. It also shares how data mined from the smart city can be integrated into one platform, which ultimately can evolve into a smart city digital twin that planners can use to experiment and prototype plans and policies.

FOUNDATIONAL ELEMENTS FOR THE SMART CITY

For a smart city to be successful, it needs a foundation it can be built upon. This foundation entails a suitable policy framework that includes regulations and guidance on how smart tech can be implemented and operated in equitable and sustainable ways. The foundation for a smart city also needs to provide the technical infrastructure systems and related security protocols that allow for a seamless and resilient operation.

Building on this foundation, a smart city needs to equitably leverage the strong connections and communications streams for the people who live, work, and play in it. Planners and their traditional skillsets are well suited to combine and coordinate these foundational elements; however, technological knowledge will also be important to generate equitable and sustainable outcomes.

Policies and Plans

One fundamental piece of the foundation of smart cities is the integration of smart city technologies and processes into plans and policies. As explained in Chapter 1, the smart city needs a plan. Crafting a vision, goals, and comprehensive approach that guides the use of smart city approaches is needed to ensure that technological innovation is pursued to support the achievement of defined community goals, and not just for technology's sake.

Innovative smart city solutions are often considered and enacted as standalone technology projects without much integration into comprehensive or functional plans. Further, smart city solutions historically have been considered an enhanced option rather than a need, which limits their impact and deployment at scale. Integrating smart city considerations within community planning documents and policies helps to ensure they will be enacted in an effective and efficient manner.

A holistic approach to a smart city requires breaking down silos between planning, policy making, technology, and community needs. This necessitates a big-picture, integrated framework, as exemplified by Vienna's *Smart City Wien Framework Strategy* (see the sidebar on pp. 16–17).

When a smart city solution is tied to specific policies and community goals, the impact and the investment both provide a framework for the launch and eventual expansion of the tech-enabled solution. Chapter 5 will provide more detail on how to create a strategic smart city plan and how to integrate smart city principles and approaches into everyday planning practice.

Network Infrastructure and Cybersecurity

A smart city starts with the basics. Smart technology solutions are needed to support the efforts of urban planners, architects, and designers. But one of the reasons why many

smart city initiatives do not move beyond an experimental phase is the lack of modern information technology (IT) infrastructure. Aging or "legacy" infrastructure is not just a roadblock to innovation, it also makes an agency, city, and the community vulnerable to cyberthreats.

Building a smart city requires an agile and flexible network foundation that can support smart city applications and the needed safeguards to protect these infrastructure systems from cyberattacks. An agile network can support scaling up or down of services and applications, allowing cities to experiment with creative solutions with a route to expansion.

Whether cities seek to provide public wifi or build a cutting-edge cloud infrastructure, the foundation must be a network that can support and secure the vast ecosystem of devices and applications. The internet of things (IoT), sensors, video cameras, social media data, and other devices provide city operators with massive amounts of data. To manage the flow of incoming raw data, process millions of data points, and use big data analytics, cities need a foundation of reliable, flexible, and secure network infrastructure and connectivity. (For more on cybersecurity and data privacy, see Chapter 6).

Digital Workflows and Processes

To plan and operate a smart city, structures and processes in local governments must become smart. This means moving from analog to digital processes (where possible, and where it makes sense) that embrace systems thinking, support cross-departmental collaboration, and encompass the following elements:

- Clear workflow definition
- Clear business case definition
- Clear location awareness strategy for geointelligence
- Creation of decision support systems
- Agile application development strategy
- Implementation of new IT strategies, such as cloud services and enterprise architecture
- Uniform data standards
- Contract language that requires delivery of digital data using the city's data standards
- Upgrades to cybersecurity

For the past decade, growth in web-based software applications has allowed local governments to move toward

TABLE 3.1. SOFTWARE OPTIONS FOR DIGITAL WORKFLOWS

FEATURES	OFF-THE-SHELF	ALL-IN-ONE	NO-CODE
Functionality	Single purpose	Multipurpose	Single purpose
Integration with other functions	Not usually	Usually	Not usually
Cost	$10s–$100s	$10,000s–$100,000s	$1,000s–$10,000s
Installation expertise	DIY	Expert needed	DIY
Installation time	Hours	Months to years	Days to weeks
Library of sample workflows	No	No	Yes
Ability to pilot	Easy	Difficult	Easy
Automated workflow	No	Yes	Yes
Project tracking	No	Yes	Yes
Ease of integrating historical data	Difficult	Difficult	Difficult
Ability to move to another vendor	Easy	Difficult	Easy
Management metrics	No	Yes	Yes
Examples	Adobe, pdfFiller	Accela, Energov, Evolve, MUNIS, ViewPoint	CityGrows, Symbium Plancheck

Sources: Hitchings 2020; Generaucos 2021; Banijimali 2021.

digitalizing workflows. A study completed just before the COVID-19 pandemic, however, found that only four percent of midsized cities had fully digitalized services (CityGrows 2020). The pandemic is only the latest of reasons to make this move toward digital workflows and processes.

In addition to writing their own code, local governments have three basic software choices for going digital (Hitchings 2020; Geanuracos 2021; Banijamali 2021):

1. **Off-the-Shelf Option**: This pre-packaged software allows forms to be disseminated in digital form and to filled out digitally by the customer, for example as a fillable PDF, but data does not get entered into a database, so manual processing is still required by the service provider. Industry experts sometimes refer to these as "dumb" forms.
2. **All-in-One Option:** This proprietary software often includes integrated functions and features that together create an internal management system. One example is a development review module used to collect fee payments that are then recorded in the organization's financial management system. The software is often customized for organizations through an extended installation process.
3. **No Code Option**: This software comprises single-purpose software applications that are not integrated with other software packages but allow users to configure and launch an online process quickly and easily. They allow service providers to create their own digital workflows and processes without the need for coding expertise, similar to how GoDaddy, Wix, or WordPress enable users to create their own websites without coding in HTML.

Table 3.1 (p. 30) shows some of the typical features and functions of each software type.

As communities prepare to move from analog to digital processes, some things to keep in mind include the importance of the following (Hitchings 2020):

- Creating a team of knowledgeable staff to lead the effort
- Talking with internal and external customers to identify system needs and desires
- Completing a software assessment to compare functions and features from different vendors
- Confirming whether the software works on mobile devices
- Checking references to find out other customer's experiences using the software
- Clearly mapping workflows
- Checking the ease of configuring the system to workflow
- Asking vendors to allow software testing during a
- trial period
- Conducting a beta test
- Educating internal and external users prior to
- system launch
- Creating a system for providing ongoing user support

While going digital can be transformative in improving service and customer satisfaction, it is not always a simple process. Organizations should manage the process carefully to minimize operational disruption and maximize the potential for a successful outcome. In California, the City of Pacifica is launching an automated review process to help staff planners conduct development reviews (Banijamali 2021). This is an evolution to watch closely as smart cities technologies continue to transform the nature of planning work.

In Durham County, North Carolina, the local government has committed to building its network foundation and boosting cybersecurity to support innovative smart city efforts. Since IT staff has migrated its traditional network to more modern software-defined technologies the time spent on manual management has plummeted, freeing up time for innovation and advancement (Douglas 2016). It is a similar story for the City of Corona, California, which moved toward digitalization to attract more business and support economic development (Microsoft 2017). Its investment in cloud connectivity not only helped it to be more efficient but has also helped it to be more resilient. During the COVID-19 lockdown the city's staff had the platform in place to work remotely and securely.

Additional Considerations for a Future-Proof Foundation

Policies and plan integration, a resilient network, and digital workflows are just the basics of the urgently needed smart city foundation. Looking ahead, the growing amounts of data that can be collected and analyzed in a smart city and the need for cross-sector integration require additional elements that are becoming increasingly important as part of a solid smart city foundation: interoperability, edge computing, and artificial intelligence.

Interoperability, or the ability to share and use data across different systems, facilitates the integration of all applications in one network. It helps to scale up, and it can increase the agility of the systems. Edge computing improves response times and saves bandwidth by connecting computation and data storage closer to the user application (Bigelow 2020). And ultimately, artificial intelligence (DeAngelis 2020), au-

GOING DIGITAL IN WEHO

In the City of West Hollywood, California, paper contracts would sometimes sit on desks for weeks, or even on occasion get lost. To improve, the city worked with software company CityGrows to create a digital workflow for internal contract management. In so doing, it turned a process that sometimes took months into a leaner process with a reliable seven- to 10-day turnaround time.

The new system lets users see where a contract is at all times so it doesn't get lost, and they can provide a gentle nudge to keep things moving, if needed. It also allows for multiple reviews at once.

Francisco Contreras, AICP, West Hollywood's innovation manager, notes that the city was able to draw on an existing library of workflow maintained by CityGrows to create its own customized solution and got it up and running in a matter of weeks—without the help of an expensive IT consultant (Contreras 2021). The user interface allowed regular city staff to set up the process.

When pursuing these kinds of projects, Contreras suggests that local governments not try to copy their paper process, and instead use the move to digital as an opportunity to analyze and improve existing workflows. In addition, he notes that the platform doesn't require much expertise, speeding the process of development and delivery. As a result, during the pandemic the city was able to move rapidly to digitalize priority processes, with the city council authorizing outdoor dining on Monday, staff configuring a digital workflow to review and process permits on Tuesday, and the new system being available for business owners online on Wednesday (Contreras 2021). For many local governments, that represents a sea change in the time required for project delivery.

tomation, and machine learning can help to collect, analyze, process, and make decisions based on data that would be too voluminous for humans to be able to process or analyze.

SMART CITY ECOSYSTEMS

Early versions of smart cities focused on managing, evaluating, and visualizing the vast amount of data generated by different urban systems to provide a single, simplified view of that data. The approach was to solve a problem via one technology solution, such as smart parking or smart lighting, and measure performance against factors such as energy efficiency and financial savings. This structure, however, fails to provide a holistic image of the many connections between multiple sectors and users.

The smart city of the future is one in which a foundation of secure digital infrastructure supports a database that is constantly being updated by real-time data and curated by applications and services in different sectors and by different populations. A smart city approach is incomplete unless a community implements and acknowledges the relationships and interdependency of public-private application and services.

One way to understand the structure of smart cities is to think in terms of ecosystems. Smart cities are a diverse phenomenon, encompassing numerous participants with different motivations and connected by a common interest in digital infrastructure, advanced technology, and their application to urban systems. The many different stakeholders have disparate roles and motives, and can be divided into three sectors:

- **Public-sector stakeholders** include municipal government, its elected leaders and officials, and various departments and functions that make use of smart city technology; other local public agencies that interact with municipal government; and regional, state, and federal entities that influence smart city policy and investments at the local level.
- **Civic-sector stakeholders** include residents, community groups, local institutions (e.g., universities, health care services), and nonprofit organizations with interests that may intersect with smart city issues. As the largest group of stakeholders whose welfare smart city technology should ultimately serve, residents include both the digitally connected and people who have limited or no access to digital technology.
- **Private-sector stakeholders** include technology companies that are promoting smart city investments by local

governments, entrepreneurial startups and developers of smart city applications, investors in new technologies, and the local and regional business communities. Similar to residents, the latter can be divided into two groups: businesses that actively use smart city technology and data, and businesses that have limited experience with but could potentially benefit from smart city applications.

These three groups of stakeholders align with three distinct but interconnected smart city "ecosystems":

- **Gov tech** refers to the use of technology to increase the efficiency of municipal operations and services. This ecosystem represents the public-sector focus.
- **Civic tech r**efers to the use of technology to increase public engagement, participation, and co-creation, making government more accessible to residents and vice versa. This ecosystem represents the civic-sector focus.
- **Urban tech** refers to the use of technology to improve the built environment and urban infrastructure to serve the needs of residents, businesses, and government. This ecosystem represents the private-sector focus.

These ecosystems, centered on functionality and users, represent a modern framework for understanding smart city systems. The following sections will describe each of these ecosystems and respective examples in detail.

Gov Tech

According to the World Bank (2021):

> GovTech is a whole-of-government approach to public sector modernization and promotes simple, efficient and transparent government with the citizen at the center of reforms. The GovTech approach represents the current frontier of government digital transformation. It is distinct from previous phases as it emphasizes three aspects of public sector modernization:
>
> - Citizen-centric public services that are
> - universally accessible
> - A whole-of-government approach to digital
> - government transformation
> - Simple, efficient and transparent government
> - systems.

Solutions such as digital IDs, e-payments, national data registries, better connectivity, and digital services are considered gov tech solutions. One example of a city that has embraced gov tech is Singapore, as described in the sidebar on p. 48.

Gov tech is not just about procuring or creating digital services for the community. To make digital transformation a reality and to be successful at it, decision makers and leaders need to understand the changes in management and processes required along with new technologies, as discussed above.

Civic Tech

Civic tech is often considered part of gov-tech solutions to provide transparency and engagement through new technology. But with technology becoming a part of everyday life, civic tech has slowly found its distinct place in the smart city movement, represented by community members using social media and existing gov-tech tools to organize, advocate, and connect with the government.

The Knight Foundation and the Rita Allen Foundation define civic tech as "technology used to inform, engage and connect residents with government and one another to advance civic outcomes" (Knight Foundation and Rita Allen Foundation 2017). As they further note, "Whereas GovTech is defined by the intended user (that is, government), civic tech is defined by the intended outcome. Thus, civic tech and GovTech are neither mutually exclusive nor perfectly overlapping."

Civic tech connects an open government with community action and civic innovation. Figure 3.1 (p. 34) visualizes these connections in different areas, ranging from technology that supports the use of government data and technology to create social networks, to technology that encourages collaboration and community organization or community-based options for funding.

On the open government side, open data and data transparency are key to encourage community members to use government data for innovation to improve community services. Furthermore, civic tech can support community engagement in planning processes and facilitate feedback from the community. On the civic innovation side, civic tech can help to create community forums and manage community initiatives. It can support information crowdsourcing to collect vast amounts of data to inform initiatives and decisions, and it can provide platforms for civic crowdfunding to support community projects.

Local governments recognize the ability of these tools to reach many users, but effective engagement of large numbers of the public can be challenging. Also, without metrics to measure the engagement, simply posting about new initiatives on social media or other platforms can create a false

sense of the effectiveness of such outreach. Nonetheless, civic tech has enormous potential to make planning processes more democratic and accessible.

Changing systems and related lifestyle changes result in the opportunity to actively participate in planning processes and co-create the city one lives in. Using Facebook, Twitter, or the YouTube comments function to share an opinion on a city hall proceeding or to engage with elected officials turns these social media platforms into civic-tech tools.

Code for America, a San Francisco-based nonprofit that aims at addressing gaps between community members and the government, has been helping its local government to build and maintain application and services. From criminal justice to community engagement applications, groups like Code for America have given a new dimension to civic tech.

Similar examples can be found from around the world. FixMyStreet.com from the United Kingdom is a crowdsourcing platform that allows residents to report public infrastructure issues to the local authority. It provides a running dashboard that shows the number of reports and updates on the issues. Civic tech offers community members a set of tools to create change.

Civic tech and gov tech work best when implemented together. In their efforts to digitalize services, local governments also need to provide tools and access to open data in ways that are easily accessible to community members. Civic

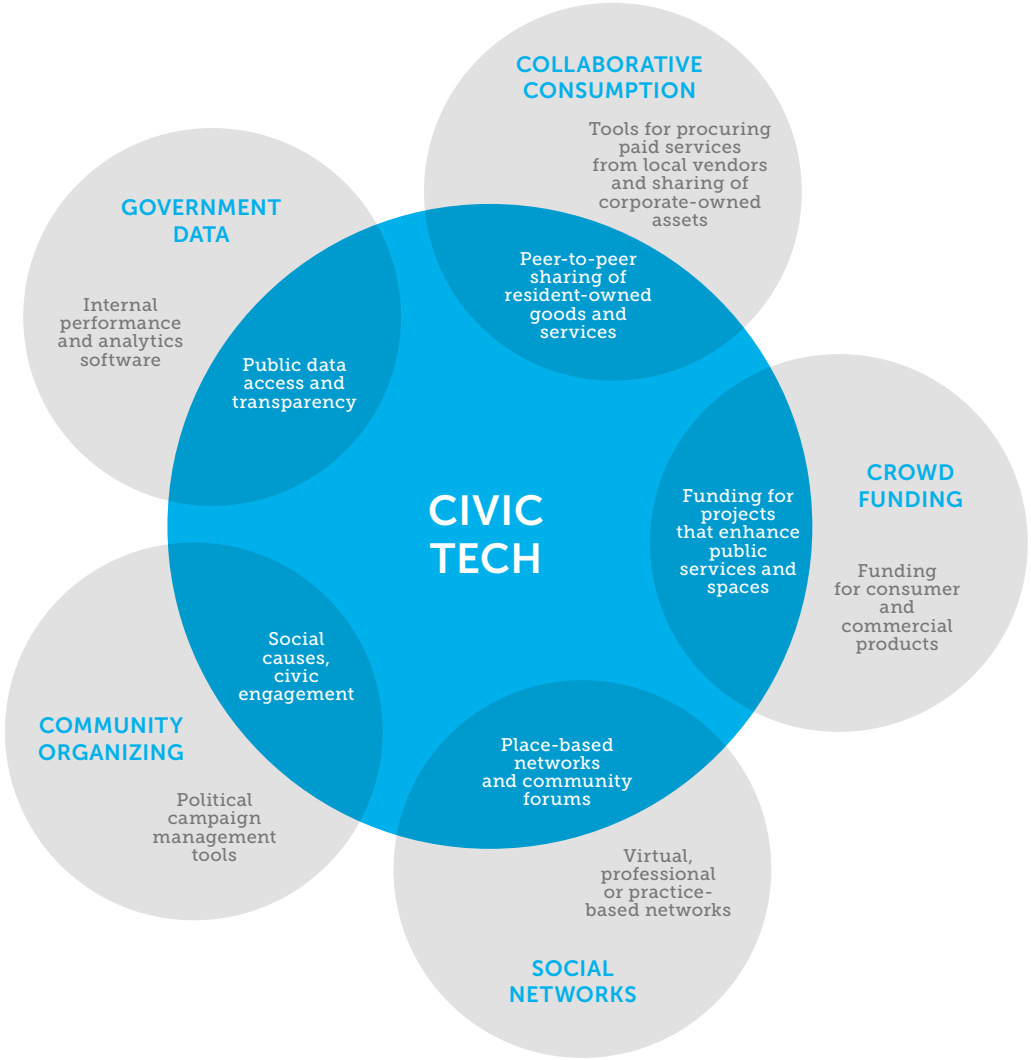

Figure 3.1. The various areas of civic tech and the connections between open government and civic innovation (The Knight Foundation (CC BY-NC-SA 3.0))

tech helps increase legitimacy by getting community members involved in decision making, while gov tech directly increases efficiency by enhancing local governments' ability to respond to this input.

Urban Tech

Urban tech refers to the use of technology in urban systems. Mostly driven by start-up companies, it can be defined as "technology that makes cities and urban spaces more connected, livable, and efficient" (Blackwell and Chambers 2017). The intent of urban tech is to improve quality of life in cities.

The channels through which urban tech is implemented are primarily private businesses and individual consumers, rather than government agencies. Urban tech is a rapidly growing industry and is playing a central role in shaping the future of smart cities.

Urban-tech companies focus heavily on direct-to-consumer products, as well as products for businesses and firms in performance domains such as housing and real estate, urban infrastructure systems (e.g., transportation, energy, water, wastewater, waste management), food, and public health and safety (Urban Us 2021). Examples are companies such as Uber, Lyft, and Bird in the transportation sector; Nest (which started out as a smart thermostat and was later acquired by Alphabet and developed into a brand for a variety of smart home products) in the energy and housing sectors; and Biobot (a start-up that analyzes sewage to map community health, including concentrations of drugs and COVID-19 cases) in the water and health sectors.

Urban tech is being developed and used to increase operational and fiscal efficiency and improve sustainability. Much of the focus has been on improving the performance of urban systems. Current deployments of urban tech typically take the form of pilots or programs that address a particular urban system or problem in one of these domains. The current applications of many technologies are relatively narrow and mostly focused on efficiency and environmental performance. As discussed in Chapter 1, a holistic, city-wide integration is needed to ensure an equitable deployment that can benefit everyone in the community.

TECHNOLOGY APPLICATIONS IN THE SMART CITY

Smart city technology is rapidly evolving, providing a wide variety of functions and applications that can be used to make cities more efficient, livable, and sustainable. These applications can be categorized as performance domains (i.e., areas in which technology can be used to improve outcomes).

Some of the most common smart city performance domains include transportation and mobility, energy, water, public health, and safety and security (ESI ThoughtLab 2021; McKinsey Institute 2018; Smart Cities Council n.d.).

The following sections provide examples of current applications in each of these performance domains. This list of examples is by no means exhaustive and the pace of technological innovations is hard to keep up with. What is important, however, is that in a truly smart city, all of these applications are integrated within a holistic plan for the community.

Transportation and Mobility

Smart city applications are being deployed to move people and goods more efficiently and safely while reducing greenhouse gas emissions and other environmental impacts. According to a survey of 167 global cities by ESI ThoughtLab (2021), major investment areas include real-time public transit apps, electric vehicle charging infrastructure, demand-based micro transit, mobility as a service (MaaS) apps, smart traffic signals, digital transit payments, and smart parking apps.

However, the list doesn't stop there. In 2020, APA's foresight practice identified the transportation sector as one of the planning sectors that is most affected by technological innovations, which makes it ever harder for planners to adjust and ensure all options are included in transportation plans. This development was originally spurred by the invention of the iPhone, which enabled the emergence of transportation network companies such as Uber or Lyft and micromobility options such as bike or scooter share programs. In addition, trends such as e-commerce and food deliveries, which were accelerated by the COVID-19 pandemic, increased the need for curbside management and related smart technologies.

Automation and artificial intelligence have spurred the latest innovations in the transportation field, such as autonomous vehicles (ground-based and urban air mobility) and autonomous delivery services (ground-based as well as drone deliveries). The sidebar on p. 36 highlights additional PAS resources on some of these emerging areas.

Real-time public transit apps, which provide information on the next bus or train to arrive at a transit stop or station, have become an integral part of the urban tech ecosystem. Benefits include decreased wait times, reductions in overall travel time due to changes in path choice, and increased use of transit, as well as increased satisfaction and perceptions of personal security when riding transit (Brakewood and Watkins 2019).

PAS RESOURCES: TRANSPORTATION TRENDS

Transportation is one of the planning sectors most affected by technological innovations. The following PAS resources can help keep planners up to speed.

- "Urban Air Mobility" (*PAS QuickNotes* 91). Urban air mobility (UAM) is an emerging system of transportation comprising aerial vehicles, either crewed or automated, that can maneuver in and across low-altitude air space. This brief explores how local governments, planners, and policy makers can leverage the value of these innovative vehicle technologies to prepare for the future and transform transportation systems for the public good.
- "Managing Shared-Use Micromobility" (*PAS QuickNotes* 86). Shared-use micromobility is a transportation strategy that allows users to share vehicles that are relatively low in weight and maximum speed (e.g., bicycles and scooters). This brief highlights key elements in helping shared-use micromobility support community goals and become a reliable transportation option in cities.
- *Using Drones in Planning Practice* (PAS Report 597). Drones—more technically known as unmanned or uncrewed aircraft systems (UAS) or unmanned or uncrewed aerial vehicles (UAV)—are quickly becoming indispensable tools for almost every discipline from agriculture to zoology. This report provides planners with the knowledge they need to determine whether UAS can enhance their planning practice and, if so, to take the first steps toward UAS implementation.
- *Planning for Autonomous Mobility* (PAS Report 592). Autonomous vehicles (AVs) are poised to disrupt the built environment and planning practices just as the automobile did more than a century ago. This report is a call to action for planners to develop policy solutions and infrastructure investments that ensure an attractive, people-friendly, equitable, and safe AV future.
- *Planning for Shared Mobility* (PAS Report 583). Ridesharing, carsharing, and bikesharing are some of the vehicle services made available by the new shared economy. But what are the rules of the road for these new services? This report explores how shared mobility is shaping—and being shaped by—local plans and policies.

A number of different public transit apps are available in cities across the United States and worldwide. Examples include CityMapper, Transit, and Moovit's One Mobility App.

Electric vehicle (EV) charging infrastructure is being deployed to support the replacement of internal combustion vehicles with zero-emission EVs (Figure 3.2). As more EV charging stations are installed in cities, they can become distributed data hubs that provide information on charging behavior. Among other applications, this information can be used to understand how energy resources and roads are being used and to determine future charging station locations (Enel X 2020).

In San Diego, smart charging stations with dynamic pricing are being deployed by San Diego Gas & Electric to incentivize charging activities during times of high renewable energy supply (IRENA 2019).

Demand-based microtransit offers flexible routing and scheduling of minibus vehicles shared with other passengers. Public transit agencies are using online platforms for real-time response to demand and to integrate scheduled trip requests simultaneously. Benefits include better matching service to demand, reducing the cost of and emissions generated by fixed-route vehicles, and increasing transit availability for underserved communities (Vik Hansen 2021).

The Capital District Transportation Authority (Albany, New York), Central Ohio Transit Authority (Columbus, Ohio), Denton County (Texas) Transit Authority, and Los Angeles Metropolitan County Transportation Authority are examples of U.S. transit agencies that have launched demand-based microtransit initiatives (American Public Transportation Association 2021).

Mobility as a Service (MaaS) refers to the integration of different travel options into a single mobility service accessible on demand. New mobility services include ride hailing and sharing, micromobility options such as e-bicycles and e-scooters, car sharing, and various forms of fixed and flexible route transit. Among other features, MaaS offers users a simple user interface across different web-enabled devices, the ability to locate to identify a range of transport options, and a single digital payment mechanism. Benefits include increased user mobility and accessibility to different travel modes, thus reducing reliance on single-occupancy vehicles; decreased air pollution and greenhouse gas emissions; and improved availability, reliability, and affordability of public transit (Wray 2019). MaaS can also provide data back to cities to help them plan future mobility improvements (Wray 2019).

MaaS is an emerging concept that is at varying levels of development in cities around the world. Los Angeles' TAP Card and San Francisco's Clipper Card are examples that integrate multiple public transit operators in each region through a common payment system. These services are being extended to make other mobility modes such as scooter-share, ride-share, bike-share, and parking accessible through a mobile app (Cole 2019).

Smart traffic signals use data from devices such as sensors and cameras to monitor, learn, predict, and respond to traffic demand by adjusting signal timing for prevailing conditions. For example, the City of Atlanta and Georgia Institute of Technology implemented adaptive signal timing as part of the North Avenue Smart Corridor, a demonstration project launched in 2017 to improve traffic flow and safety and reduce emissions caused by vehicular congestion along a 2.3-mile corridor. As part of the project, adaptive signal timing leverages artificial intelligence, thermal imaging, and video cameras for real-time response to pedestrians and cyclists (who do not need to press any buttons) while factoring in vehicle types, speeds, and queues to maximize efficiency (Applied Information 2018). In many European cities, smart traffic signals recognize public buses and switch to green when one is approaching an intersection, prioritizing public transit for better service during high traffic times.

Smart parking refers to the use of real-time data and guidance for drivers to reduce search time and vehicle emissions while maximizing parking space utilization. For example, Cologne (the fourth largest city in Germany) experiences CO_2 emissions, to which inner-city traffic is a major contributor, that regularly exceed European Union norms. To address this issue, the regional energy supply company RheinEnergie AG implemented a parking management system to optimize

Figure 3.2. EV charging stations can collect data while supporting the use of zero-emission EVs (Alphotographic/iStock Unreleased/gettyimages.com)

parking space usage and reduce unnecessary search time. The system includes sensors installed on existing light posts that display real-time information to guide drivers to the closest available parking space (Cleverciti Systems 2020).

Energy

Energy efficiency is another domain in which smart city technology is being used to improve performance. Examples include smart grids, meters, buildings, and streetlights.

The conventional energy grid consists of a network of transmission lines, substations, transformers, and other components that delivers electricity from power plants to end users. The **smart grid** integrates two-way digital communications technology with conventional grid components, thus enabling the network to monitor and respond to changes in demand by users in real time (Figure 3.3). Benefits include more efficient transmission of electricity, quicker restoration of electricity after power disturbances, reduced operations and management costs, reduced peak demand, and increased integration of renewable energy systems (U.S. Department of Energy, Office of Electricity n.d.). The smart grid also allows for customers to generate energy (e.g., through solar panels on the roofs of their houses) and feed that energy into the grid.

Smart grids are an essential component on the path toward net zero energy, 100 percent renewable energy, or similar energy goals. When it comes to balancing times of peak energy consumption and times of low energy generation with renewables, smart grids combined with innovative storage technologies are key.

The smart grid is being implemented by utilities across the nation at varying rates of adoption. It is anticipated that digital networks will eventually lead to greater levels of information exchange between utilities and their customers, as well as the convergence of the electric grid with other infrastructure systems such as buildings, transportation, and telecommunications (U.S. Department of Energy 2018).

As digital replacements of conventional (analog) meters, **smart meters** (also referred to as advanced metering infrastructure, or AMI) allow for automated transfers of information between buildings and utility providers. This information can be routed through energy management applications to track and adjust energy usage (for example, operation of household appliances during periods of lesser demand when prices are lower). As of 2019, U.S. electric providers had installed approximately 94.8 million smart meters, of which about 88 percent served residential customers (U.S. Energy Information Administration 2020).

Smart buildings use building automation systems (BAS) to enable automated building operations and control. Whereas heating, ventilation, air conditioning (HVAC) and other conventional building systems operate independently, smart buildings connect these systems through digital networks to optimize operations and whole-building performance. According to the International Energy Agency (IEA 2020), the building and construction industries combined are responsible for over 30 percent of global energy consumption and nearly 40 percent of carbon emissions. It has been estimated that smart buildings with integrated systems can realize 30–50 percent savings in existing buildings that are otherwise inefficient (King and Perry 2017).

Smart streetlights can fulfill multiple purposes. Connected through a network that is monitored and controlled

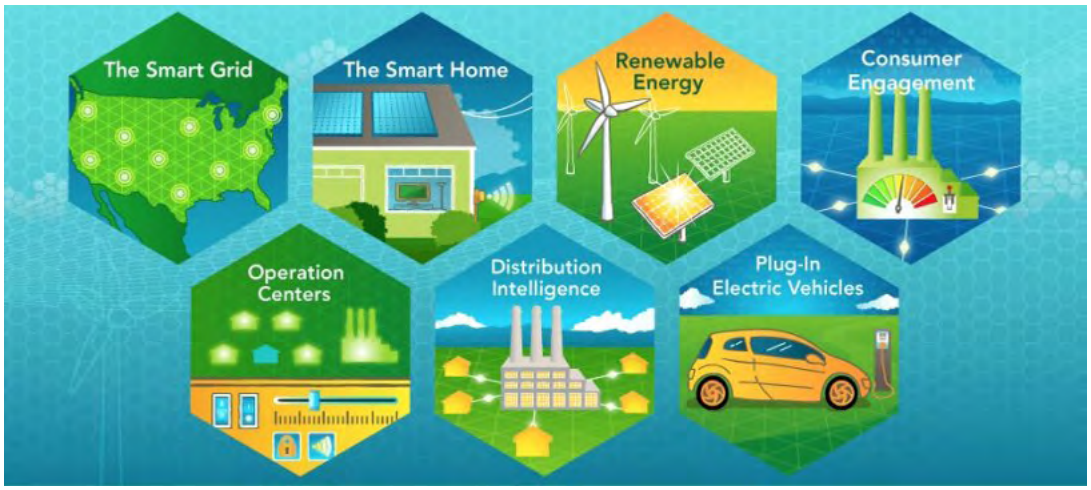

Figure 3.3. The "smart grid" and all its components monitor and respond to changes in energy production and demand in real time (Smartgrid.gov)

through an online app, smart streetlights can communicate with neighboring fixtures to increase light levels when movement is detected. The basic versions use energy-saving LED lights and are equipped with sensors and cameras that detect pedestrians and vehicles, enabling dynamic brightening and dimming in response to movement.

Additional features can include sensors that detect environmental conditions and noise levels, wifi antennas, and solar panels, among others. Further, the data from smart streetlight sensors can be used to detect unhealthy air quality (see the sidebar on p. 84) and warn residents via smartphone to stay in their homes. Based on the number of people detected on the street and related noise levels, they can identify safety levels that can be shared on a smartphone app as well (at night, certain individuals prefer walking on streets where they are not by themselves). Streetlight data is specifically valuable for transportation planning when it comes to bike route optimization, improvements to curb management, and other tasks related to traffic control.

In San Diego, replacement of conventional street lighting with LEDs led the way to the development of a citywide smart city sensor platform (San Diego 2021). The Smart Streetlights project created a connected digital infrastructure comprising sensors that collect data on parking; count vehicle, bicycle, and pedestrian traffic; and measure temperature, humidity, and pressure. Data is uploaded to the city's cloud database and is available for download by application developers and the public. In a similar vein, the City of Los Angeles has installed "smart nodes" that add wifi, USB chargers, speakers, environment sensors, and other features to LED streetlights (Los Angeles 2021). The sidebar on p. 67 describes Los Angeles' smart streetlights in more detail.

Along with this growing list of applications for smart streetlights comes a growing list of benefits. These include reduced energy usage and costs, reduced carbon emissions, reduced light pollution, and solutions for safety and environmental issues, among others.

Water

Sustainable management of water resources is essential for healthy, functioning cities. Urban water systems include water supply, wastewater, and stormwater. While these systems have traditionally been managed separately, planners and water professionals are developing a new approach called **One Water**. One Water is based on the idea that all water within a watershed is hydrologically interconnected and is most effectively and sustainably managed using an integrated approach (Cesanek, Elmer, and Graeff 2017).

Smart technology and IoT sensors are increasingly being used by water utilities in **smart water supply management** (GSMA 2017). Key applications include smart metering, leakage detection, and water distribution management and planning. Smart water meters use wireless technology to continuously monitor water consumption by households and businesses. They allow water utilities to more efficiently collect information compared to conventional meters, build better relationships with customers, and more accurately bill for water consumed. Both utilities and customers benefit from the ability to manage consumption more effectively.

Undetected leakage is a major water supply concern and can be costly for both utility companies and customers. Smart water meters enable utilities to identify potential leaks and communicate with customers. Problems in the water distribution network can be identified by comparing water provided to and consumed by customers, with specific leakage locations determined through use of IoT technologies in the water mains themselves. IoT sensors can also be used to monitor water quality and enable utilities to take remedial action.

Similar to energy supply, water is subject to peak demand periods that can be monitored and managed using smart city applications. More accurate consumption data can inform planning for future water supply needs. Smart city technology can also help water utilities plan for and adapt to extreme weather (floods and drought) associated with climate change (GSMA 2017).

Smart wastewater management is the use of technology to optimize wastewater operations and sanitary network performance to provide reliable sanitation for communities and to keep receiving water sources clean from pollution (Nelson 2020). IoT sensors can be used to detect leaks in sanitary sewer pipes, combined sanitary-storm sewer overflows (CSOs), and the presence of chemicals, which helps optimize wastewater treatment processes. Digital models can be constructed to monitor system performance and anticipate future impacts such as extreme rainfall events. Wastewater treatment systems digital twins—virtual replicas that use machine learning to simulate performance under a range of conditions, predict outcomes, and provide management recommendations—represent the next evolution of this technology (Nelson 2020).

As noted, the One Water approach calls for water systems such as water supply and wastewater to be managed together rather than separately. Increasingly, wastewater is viewed as a resource that, with proper treatment levels, can be used for nonpotable and even potable uses (although there have been few examples of the latter in the United States to date). IoT

sensors can be used to monitor wastewater flows and categorize them according to suitability for reuse. In addition, water consumption data can be used to estimate nonpotable water volumes generated to allow for more efficient water demand planning across the water supply network (GSMA 2017).

Smart stormwater management uses technology to optimize the performance of the stormwater network by reducing flooding and water quality impacts. An IoT network can be used to analyze weather patterns and adjust stormwater infrastructure components (for example, water levels in ponds or reservoirs) to rainfall events. From a water quality standpoint, IoT sensors installed in storm sewers and waterways can be used to collect information about pollutants from runoff, especially after a storm. Other smart stormwater applications include providing early warnings of flood events and gathering data about infrastructure condition and performance, which can be used to reduce maintenance costs and avoid system failures (Morrison 2021).

Louisville, Kentucky's Metropolitan Sewer District (MSD) was an early adopter of real time control (RTC) technology, which uses smart data to manage and adapt water infrastructure in real time in response to weather conditions. MSD's RTC system consists of remote field stations equipped with sensors that monitor water flows and levels and a programmable logic controller that modulates water infrastructure components, such as gates and pumps. Data collected by the field stations is communicated to a central facility that uses decision support system (DSS) control algorithms to optimize flow conveyance, storage, release, and transfer throughout the stormwater management system based on available capacity. MSD's RTC system is attributed with capturing more than one billion gallons of CSO annually that would otherwise overflow into streams and the Ohio River (U.S. EPA OWM 2021).

Smart technology can also be used to monitor the performance of green stormwater infrastructure, as an 18-month pilot project launched in Chicago in 2016 demonstrates (City Tech Collaborative 2018). IoT sensors were installed at four green stormwater infrastructure installations to collect microweather and soil moisture data, which were sent live to the Microsoft cloud. The pilot demonstrated that green infrastructure reduces surges of water into the city's storm sewer system during rainfall events, and that smart technology could reliably and effectively collect and analyze data on relative performance at different sites.

As illustrated by the examples above, smart applications in the water sector to date have focused on individual water systems such as water supply and stormwater management. **Smart One Water** is an emerging concept that refers to the integrated management of natural, drinking water, wastewater, stormwater, and agricultural water systems using digital technologies to operationalize sustainability and resilience at the river-basin scale (Sinha 2021). While there are as yet no good examples of this concept in practice, its proponents believe that Smart One Water represents the next generation of water resource management.

Public Health

Leading areas of digital investment by cities related to health include **remote medicine and telehealth services** (typically in partnership with hospitals), **online government benefits portals**, and **real-time air quality information and apps** (ESI ThoughtLab 2021). For example, the AirNow app, developed by the U.S. Environmental Protection Agency in partnership with federal, tribal, state, and local agencies, provides information obtained from sensors on five major airborne pollutants at the zip-code level (Figure 3.4, p. 41). It is one of several apps used by West Coast residents during recent wildfire seasons to track hazardous air quality caused by particulate matter from smoke and ash (Ehrenkranz 2020).

According to the Centers for Disease Control and Prevention, chronic health conditions such as diabetes, obesity, and cardiovascular disease are leading causes of morbidity and mortality in the United States. **Mobile health apps** installed on smartphones or other digital devices are increasingly being used to promote healthier behavior among individuals with chronic conditions. Various studies have found a positive correlation between use of mobile health apps and behavioral changes such as increased physical activity, fruit and vegetable consumption, and weight loss, although the long-term effectiveness of these changes is not well established (Mahmood et al. 2019). In addition, disparities in access to and adoption of digital technology by the elderly and other demographic groups are barriers to more widespread use.

A literature review of research on smart cities and public health revealed applications addressing promotion of healthy lifestyles and a range of public health surveillance topics (Rocha et al. 2019). Surveillance topics included traffic accidents, environmental conditions, health conditions of older adults, emotions, epidemics, fitness activities, and food activity. The authors conclude that these applications are still in the early stages of development.

Similar to its effects on technological drivers of change such as e-commerce and remote work, the COVID-19 pandemic has accelerated the adoption of smart city applications related to public health. Several tools have been developed that use predictive analytics and artificial intelligence to

identify populations particularly vulnerable to coronavirus and forecast future surges. For example, the COVID-19 Index developed by the National Minority Quality Forum integrates historical data with datasets from public and private sources to enable communities and healthcare organizations to anticipate and focus resources on areas likely to experience future surges (Kent 2021).

Safety and Security

Improving public safety and security is a major smart city performance domain. Leading areas of investment by cities include facial recognition and biometrics, in-car and body cameras for police, and drones and aerial surveillance (ESI ThoughtLab 2021). Other examples include smart street lighting, aerial firefighting systems, and use of predictive analytics to identify locations in which crime is most likely to occur.

Safetipin is a social organization that works with governments and other urban stakeholders to make public spaces safer for women. Safetipin has developed three mobile phone applications that collect data on the safety of public spaces at night based on nine parameters: lighting, walkpath, openness, visibility, public transport, security, people, gender usage, and feeling (Figure 3.5, p. 42). Safety scores are available through the Mysafetipin app to enable users to make safe and informed decisions about their mobility.

The use of surveillance techniques such as cameras, aerial drones, and facial recognition software often raises privacy concerns among residents. For example, San Diego's Smart Streetlight program (mentioned above) included cameras whose raw footage was used by police to help solve serious crimes. In response to mounting criticism after this use was revealed to the public, the San Diego City Council directed that the cameras and other streetlight sensors be deactivated pending development of an ordinance regulating the use of surveillance technology (Wray 2020). An additional concern is that the use of smart city technology for policing can disproportionately impact minority neighborhoods, persons experiencing homelessness, and other disadvantaged populations—an example of social inequity and injustice being transferred from the analog to digital world.

COMMUNITY IN THE SMART CITY

Smart cities and the digital transformation of communities impact community members, bring up the issue of potentially competing values, and can help meet and also generate needs. But all can help create the smart city, if equitable access and digital inclusion are provided.

Shifting Community Values

The digitalization of today's world has affected every aspect of how people live, work, play, study, and move around town. Trends such as remote work/telecommuting, e-commerce,

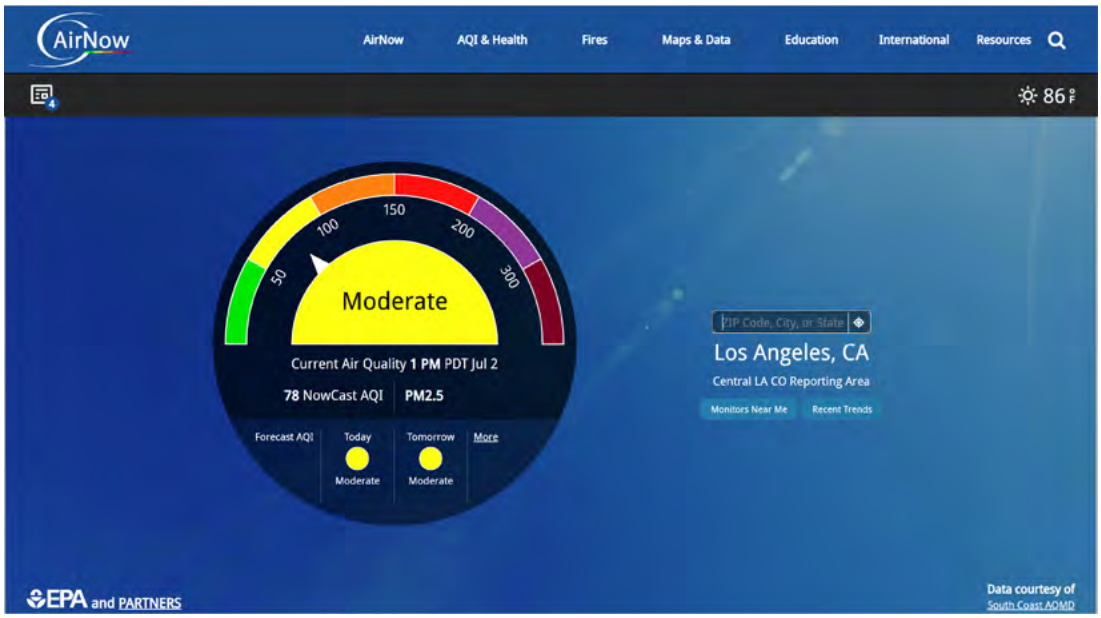

Figure 3.4. The U.S. EPA's AirNow app provides real-time information on air quality (airnow.gov)

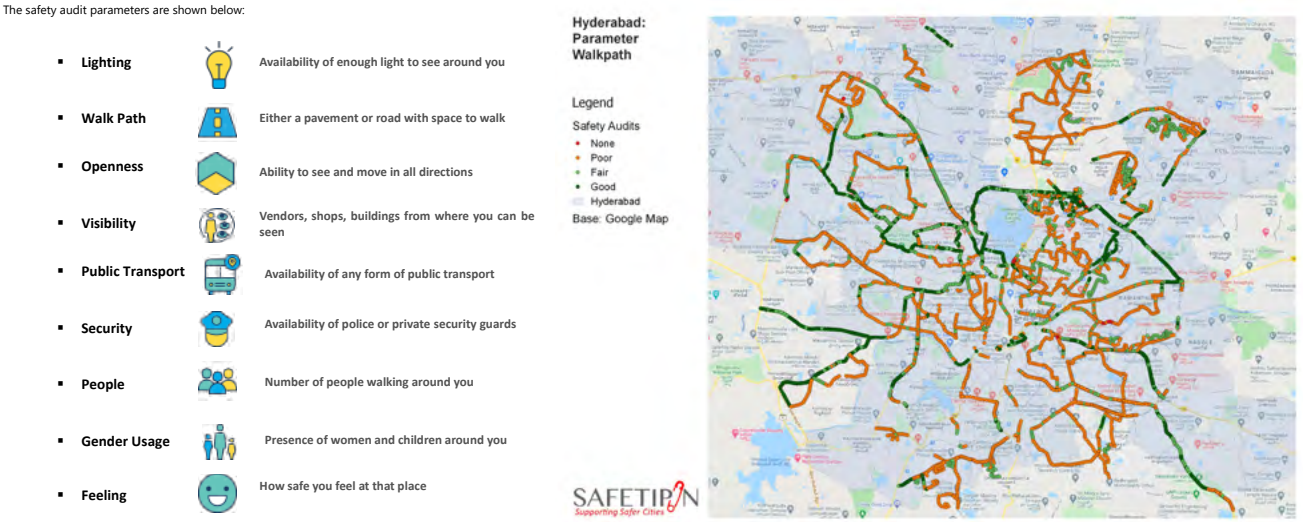

Figure 3.5. The Safetipin app collects safety data based on nine parameters and provides safety scores for public spaces throughout a city (Safetipin)

online social networks, and online education have been growing and were accelerated by the COVID-19 pandemic.

Like most innovations related to digitalization, the digital transformation of cities and communities and related smart city applications aim at enhancing quality of life, efficiencies, and sustainability. Life in the city becomes more efficient if one is connected. And as described above, urban tech smart city applications can improve operations in a wide range of different performance domains.

The "intersection of urban space and cyber space" has not just resulted in a shift from analog to digital, but it has changed community values and created a shift from individualism to a shared society (McLaren and Agyeman 2015). Cities have always been places of sharing among community members, whether through public spaces, public libraries, or many other areas. Today, digitalization and the internet allow everyone in the community who is connected to share apartments (e.g., Airbnb), cars (e.g., Uber and Lyft), bikes, scooters, and many other products. This has enabled the sharing economy and allowed community members to redesign and reorganize how cities function, based on changing values and individual needs.

The next phase in this development is the automation of society (Helbing 2015), something we can already see to some extent. Today, algorithms recommend how and where one should live, where to travel and how to get there, what to buy, and even with whom to become friends or go on a date. Jim Spohrer, IBM's Director of Cognitive OpenTech, predicts that "machines will progress from tool to assistant to collaborator to coach" (LinkedIn 2021). Meanwhile, every flow and activity can be tracked, and individuals serve as data points that feed data into smart city applications to help improve or manipulate the built environment, based on what the algorithms are programmed for.

That being said, planning should be a people-centric process. While technologies and societal values are constantly changing, planners need to keep the human factor at the center of their work. Technologies offer attractive solutions to many community challenges and they allow for many different ways to collect information about the community and the needs of its members. However, as emphasized throughout this report, technology needs to have a purpose. It needs to be implemented in equitable and sustainable ways, and the privacy, needs, and values of the individuals of a community need to be understood and respected to avoid negative or harmful impacts.

With an increasing diversity of identities of individuals in a community and myriad options of technological deployment, it will become an ever more important responsibility of planners to lay the ground for a smart society that participates, innovates, and ensures technology is used for the common good and not to harm others. Planners, with their direct connection to the members of their communities, play an essential role when a community is building the foundational elements of a smart city described above. They can make sure community members have equitable access to the smart city and its applications, including bridging potential gaps be-

tween the community and other smart city stakeholders. As discussed further in Chapter 6, digital inclusion is key so all can participate and benefit from the smart city.

Innovation and Participatory Co-Creation

Civic engagement—the act of meeting with stakeholders to discuss community needs and the impact that government actions or private-sector developments might have on that community—is mandatory for many planning processes.

Often, the government controls the type and amount of information shared with the community as well as the number of options considered to facilitate meaningful discussion and solicit feedback. The challenge is that the amount of information can be highly filtered and narrow, either for political or contractual expediency or because the team involved lacked sufficient knowledge. Civic engagement is decidedly a top-down approach.

Public participation, on the other hand, is a bottom-up approach, in which initiative and communication are initiated by community members or other stakeholders. A good example is when a neighborhood that is concerned about cars speeding through their streets organizes to take the issue to the city council. Community activism has been happening for a long time; what has changed is that today all community members now have much more data and information at their fingertips.

State and local open government or open data initiatives provide free access to spatial and tabular data to the public. This has given rise to a new phenomenon: the "citizen planner." With the advent of personal use GIS software, it is now possible for an individual to come to a planning commission hearing for a new parking lot or development armed with maps detailing constraints on floodplain impacts, vehicle pedestrian collisions, and right-of-way conflicts that may be far more detailed and holistic than those of the petitioner. Such information can provide additional detail to help planning commissioners make more informed decisions.

Recent developments in the smart city arena go even further and take public engagement and participation to the next level—to the top of Arnstein's ladder of citizen participation (Figure 3.6) (Arnstein 1969): citizen control and empowerment.

Open government and civic tech empower the individuals of a community to create changes in their own communities based on their personal experience and available data. Instead of just commenting on proposed developments, community members can now propose their own developments, become citizen planners of their communities, and even implement these grassroots efforts themselves.

Planners need to understand the shift toward participatory co-creation and find new ways to accommodate this new role of community members as they become active participants. Planners will have to create these participatory opportunities, provide transparency to increase trust, reduce biases, support innovation, create inclusive processes, allow for feedback loops, and help the community enhance digital literacy in equitable ways so everyone can participate and co-create their smart city. As an example, the City of Vienna prioritizes social innovation and co-creation in its *Smart City Framework Strategy* and provides multiple opportunities for community members to learn, innovate, and participate in the creation of a smart city (see the sidebar on pp. 16–17). Another example of a city that has embraced civic inclusion and urban co-creation in its smart city strategy is Medellín, Columbia, as described in the sidebar on pp. 48–49.

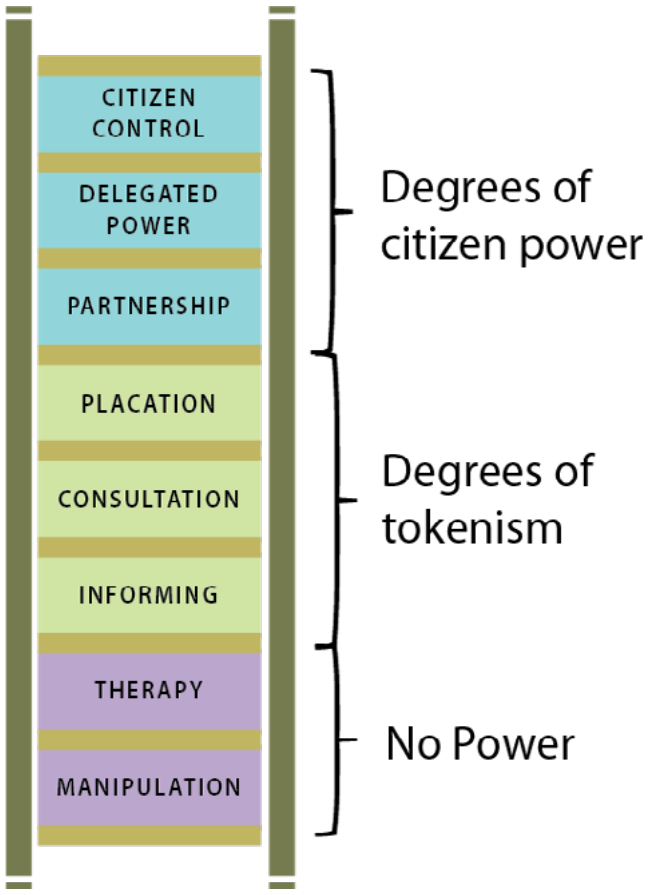

Figure 3.6. Arnstein's ladder of citizen participation

NATURE IN THE SMART CITY

Smart cities use technology to make the functioning of our communities more efficient and sustainable. However, technology alone cannot provide for all the needs of a city's residents. Nature—land, water, air, flora, and fauna—is our essential life support system and will be increasingly important in the era of smart cities.

Over the last several decades, our society has increasingly distanced itself from its inherent connection to the natural world. Trends such as urbanization and climate change have reinforced this disconnection and made it harder for people to realize the many benefits provided by nature. Additionally, unsustainable resource extraction and inequitable access to green space for disadvantaged communities have complicated people's relationships to natural spaces. The increasing human footprint on natural ecosystems highlights the importance of environmental protection, resource conservation, and the equitable integration of nature into cities.

The term biophilia (*bio* = life, living things; *philia* = love for) captures the innate human desire to connect with nature. Numerous research studies have demonstrated the importance of contact with nature for human health and wellbeing (Wolf 2018). A biophilic city is one in which people can have daily contact with nature, with the city's design and fabric actively and equitably encouraging all residents to connect with the outdoors (Hurtado 2020).

A smart city integrates technology, community, and nature. In doing so, it incorporates natural systems into the built environment to provide mutual benefits for people and ecosystems, while using data and digital technologies as tools to optimize the performance of these systems in delivering these benefits.

Planners can use the concept of **green infrastructure** as an organizing construct to integrate natural systems and processes into the built environment of smart cities. Two definitions of green infrastructure are in common usage: (1) a large-scale, strategically planned network of natural lands and resources (Benedict and McMahon 2006), and (2) stormwater management practices that use or mimic natural processes to capture runoff near where it is generated (U.S. EPA n.d.). The smart city requires a new definition and vision of green infrastructure—one in which nature is not separate from the built environment, but forms a three-dimensional "envelope" that surrounds, connects, and infuses buildings, streets, utilities, and the like (Rouse and Bunster-Ossa 2013).

This vision begins with the urban forest, the largest structural component of green infrastructure in cities. The vision includes parks, green spaces, riparian corridors, and other components of a landscape-scale green infrastructure network. It also includes green streets, green roofs, rain gardens, bioswales, stormwater planters, and other forms of green stormwater infrastructure at the district and site scales. The vision extends to ecological landscape design of public and private properties to replace lawns and ornamental shrubs with healthy, functioning plant communities. Finally, it includes working in concert with nature to manage novel plant communities—the mix of species, mostly nonnative, that occur spontaneously in neglected urban spaces—to enhance ecosystem services (the benefits provided by ecosystems that make human life possible and worth living) and eliminate invasive species.

The foundation of the vision of a green, smart city is the idea that green infrastructure provides multiple co-benefits for people and ecosystems. For example, co-benefits provided by the urban forest include ameliorating the urban heat island effect, absorbing stormwater, reducing energy costs, sequestering carbon, providing wildlife habitat, bringing people in contact with nature, and more. Table 3.2 (p. 45) lists environmental, economic, and social co-benefits that green infrastructure can provide. Smart city technology can be used as an ecosystem management tool that optimizes the co-benefits provided.

Smart Solutions and Applications

Many of the co-benefits of green infrastructure shown in Table 3.2 overlap with smart city performance domains such as energy, public health, and water. Despite this synergy, however, green infrastructure and urban greenspace management have received little attention to date in smart city policy initiatives and funding mechanisms (Nitoslawski et al. 2019).

While green infrastructure is not generally recognized as a separate smart city performance domain, smart city technology is increasingly applied to the field in practice. Examples include the use of remote sensing technology to monitor urban tree canopy cover, digital tools to assess benefits provided, and online engagement of citizens. For example, planners can use the USDA Forest Service's i-Tree software suite to measure environmental benefits such as stormwater management, pollution removal, human health impacts, and carbon storage and sequestration provided by the urban forest.

To support its *Green City, Clean Waters* plan, which sets a goal of reducing stormwater pollution by 85 percent by 2036 using green stormwater infrastructure, the Philadelphia Water Department has developed a green infrastructure tracking tool to monitor and communicate the locations, types,

TABLE 3.2. GREEN INFRASTRUCTURE CO-BENEFITS

Environmental Co-Benefits
Absorb stormwater, reducing runoff and associated impacts such as flooding and erosion
Improve environmental quality by removing harmful pollutants from the air and water
Moderate the local climate and lessens the urban heat island effect
Preserve and restore natural ecosystems and provide habitats for native fauna and flora
Mitigate climate change by reducing fossil fuel emissions from vehicles, lessening energy consumption by buildings, and sequestering and storing carbon
Economic Co-Benefits
Create job and business opportunities in fields such as landscape management, recreation, and tourism
Stimulate retail sales and other economic activity in local business districts
Increase property values
Attract visitors, residents, and businesses to a community
Reduce energy, healthcare, and gray infrastructure costs
Provide management metrics
Social Co-Benefits
Promote healthy lifestyles by providing outdoor recreation opportunities and enabling people to walk, bike, or use other means of active transportation as part of their daily routines
Improve environmental conditions (e.g., air and water quality) and their effects on public health
Promote environmental justice, equity, and access to the benefits of nature for all
Provide places for people to gather, socialize, and build community spirit
Improve the aesthetic quality of development
Offer opportunities for public art and expression of cultural values
Improve human health and well-being by connecting people to nature
Yield locally produced resources (food, fiber, and water)

Source: Rouse and Bunster-Ossa 2013, 12–13

and status of public and private green infrastructure installations throughout the city (PWD n.d.) (Figure 3.7, p. 46).

Opportunities to expand smart city applications to leverage the co-benefits provided by green infrastructure fall into two primary categories: (1) the use of digital technology and data to improve management of and optimize the environmental, economic, and social co-benefits provided by green infrastructure; and (2) the use of digital technology and data to engage citizens and stakeholders in green infrastructure planning, implementation, and management.

Smart urban forest management is an emerging approach to integrating nature into smart cities. This approach involves the design, establishment, monitoring, and management of urban trees and vegetation through digital technologies for the joint purpose of improving the urban environment and engaging all relevant stakeholders in its governance (Nitoslawski et al. 2019). It complements a new paradigm for the integration of nature and technology in cities that has been termed the **internet of nature**. In this paradigm, urban ecosystem components and interrelationship dynamics are described and represented through digital technologies and applications, and information and data obtained from the digital representation of these urban ecosystems can be used to inform management and planning decisions (Gallè, Nitoslawski, and Pilla 2019).

Digital and IoT technologies that have been applied to more established smart city performance domains can be used to advance this approach and paradigm. Possible applications include:

- Sensor networks to monitor environmental factors such as effectiveness of stormwater management strategies, urban heat islands, and air quality (e.g., Chicago's green stormwater infrastructure pilot project, described above)
- Wearable technology to measure health effects of contact with nature
- Digital platforms and mobile applications for crowd science and community engagement in green infrastructure planning and management
- Augmented reality and virtual reality to engage officials and community members in design of urban greenspaces and green infrastructure networks
- Data sensors, artificial intelligence, and machine learning to measure performance, costs, and benefits of green, gray, and hybrid (green/gray) infrastructure solutions

Nature in the smart city can be addressed by all three of the smart city ecosystems described earlier in this chapter.

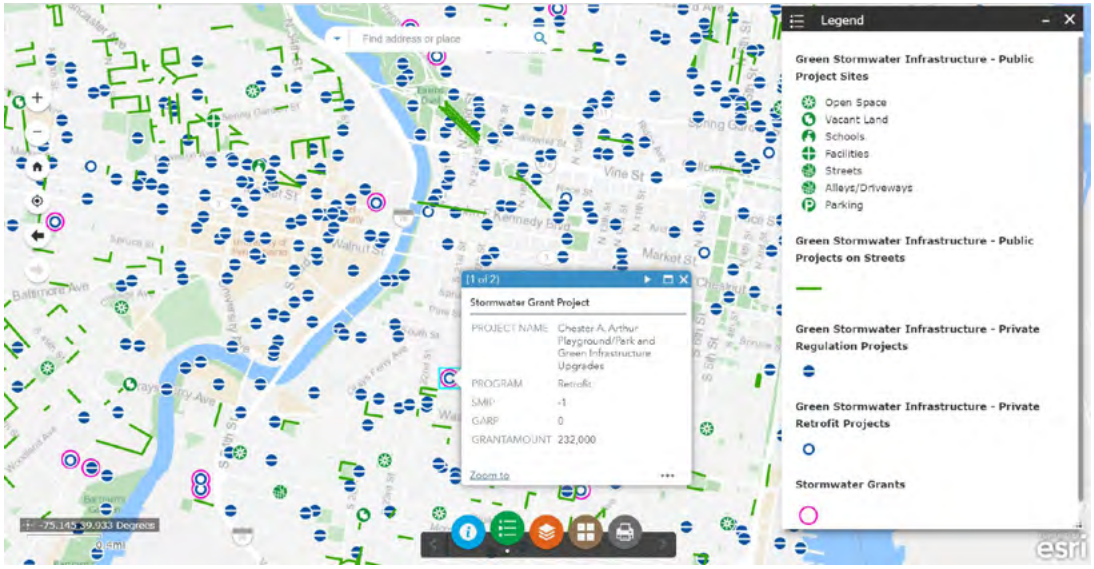

Figure 3.7. The City of Philadelphia's green infrastructure tracking tool (City of Philadelphia)

Within the gov-tech ecosystem, smart apps can be used to improve public-sector management of green infrastructure resources such as the urban forest. Within the civic-tech ecosystem, smart apps can be used to engage the community in urban ecosystem planning and management. And within the urban-tech sector, smart apps can be used to identify, monitor, and optimize the co-benefits provided by nature and green infrastructure.

When focusing on the "latest and greatest" technologies, there is sometimes a tendency to forget the fundamental role of nature as humans' essential life support system. In reality, people and cities are part of nature, and technology is an expression of natural processes. Beyond the basic needs for food, air, and water that nature fulfills, biophilia conveys the importance of contact with nature for physical, mental, and spiritual health and well-being. To be truly livable, sustainable, and resilient, smart cities must integrate nature for the benefit of all. Planners have a unique opportunity to help communities harness technology to achieve this paradigm shift.

DIGITAL INTEGRATION OF THE SMART CITY

The key to a truly smart city, as defined in Chapter 1, is the integration of all its components—in the real world, but also in the digital world. A truly smart city combines the foundational elements described above (policies and plans, network infrastructure, cybersecurity, and digital processes), the three ecosystems (gov tech, civic tech, and urban tech), technology applications in different performance domains, community (digital inclusion, participation, co-creation, and innovation), the individuals of the community and their active roles, and nature (biophilia, green infrastructure, and internet of nature). All these components need to operate, co-create, and evolve together. Additionally, they generate data points that can be mirrored into a digital version of the city, which ultimately can evolve into a smart city digital twin (SCDT).

A SCDT provides a holistic digital replica of the city powered by real world, real-time data, encompassing movements, flows, and processes as well as resource consumption (Mohammadi and Taylor 2017; Arup 2019). It is important to note that a SCDT is more than the 3D model of the built environment provided by a basic city digital twin. For a city digital twin to become smart, it must combine the 3D model with real-time digital tracking of the city's flows of goods, services, and information. This captures interdependencies and allows users to simulate past, present, and potential future conditions. This virtual version of the city requires a digital platform that can support emerging applications within the gov-tech, civic-tech, and urban-tech ecosystems. The concept of digital twins has been maturing rapidly due to advances in data transfer protocols, IoT, ICT, GIS, cloud computing, and artificial intelligence.

SCDTs can be used to simulate, predict, optimize, and test policy options, visualize plans for better civic engagement, and improve decision-making processes (Hurtado and

Gomez 2020). Eventually, they will become a state-of-the-art planning tool for the planner's toolkit. Planners must learn about their benefits as well as certain caveats related to potential data gaps and algorithmic bias (Hurtado and Gomez 2020). Chapter 4 discusses in more detail how planners can use city digital twins and SCDTs in their work.

CONCLUSION

Technology alone will not make a city smart. Smart cities use technology for more sustainable and equitable outcomes, allowing for an integration of technology with community needs and goals as well as the protection and conservation of the natural environment. For technology to work successfully, cities need to provide the needed foundation, including the policies and plans to support this integration, and infrastructure systems and workflows for an efficient operation.

In addition, the three smart city ecosystems—gov tech, civic tech, and urban tech—need to be interconnected, allowing for a symbiosis between the open government and civic innovation while providing high-quality services. Within this symbiosis, the three smart city elements—technology, community, and nature—are overlapping, interconnected, and mutually supportive.

The citizen planner (as mentioned above) innovates and collaborates in the implementation of technologies that help resolve community challenges, improve the quality of life, and preserve the natural environment. Nature provides multiple benefits to the individuals in the community, if distributed equitably and managed sustainably. Processes to do so can be supported by technology. Technology can be the connector among all systems, create more efficiencies, and enable planners and community members to monitor, analyze, and evaluate progress to make decisions, create plans, and prepare for what is on the horizon.

To be successful in this smart city environment, planners will have to understand these elements, how they are connected, and how they can leverage them for better community outcomes. In addition, planners will have to adjust processes, learn new skills, and acquire suitable tools. The next chapter will shed some light on the most pressing competencies for a smart new world.

SINGAPORE'S SMART NATION INITIATIVE

An island nation and city state with limited land area and a relatively small population, Singapore has experienced rapid urbanization and increasing urban density over the last several decades. This growth has raised increasingly complex and interconnected policy issues, such as congestion and overcrowding, strains on infrastructure, and high housing costs, among others (Jie 2018). In addition to addressing these issues, Singapore's continued development depends upon on increasing productivity through technological investment, nurturing homegrown talent, and attracting talented foreign workers (Khern 2019).

Singapore first initiated efforts to digitalize public service delivery in the 1980s, when it recognized that e-government was an important tool to enhance economic competitiveness. Various e-government initiatives, such as an IT 2000 Strategic Plan, e-Government Action Plans, and iGov 2010, were instituted in subsequent years. The Smart Nation Initiative was announced in 2014 in a speech by Prime Minister Lee Hsien Long that emphasized the use of smart city technology to improve citizens' lives and increase economic productivity.

Smart Nation is structured around three key pillars—Digital Economy, Digital Government, and Digital Society—and focuses on six key domains: transportation, urban living, startups and businesses, health, digital government services, and Strategic National Projects. Examples of applications in these domains include autonomous shuttle bus routes; HealthHub, a one-stop online health information and services portal; and the Singapore Housing & Development Board (HDB) Smart Town Framework.

The HDB Smart Town Framework is an approach to transform developments into "smart towns" for an improved and more sustainable standard of living (Smart Nation Singapore 2021). It encompasses five elements:

1. Smart Planning: Use of computer simulation and data analytics to inform urban design
2. Smart Environment: Networks of sensors to capture information on real-time temperature and humidity
3. Smart Estate: Technologies to optimize regular maintenance and preempt problems
4. Smart Living: Digital infrastructure to create intelligent homes
5. Smart Community: Data analytics to better understand and engage residents

An HDB Smart Hub collects and integrates data from sensors to improve building system performance, inform urban design, and better serve residents through "a digital ecosystem of applications and services" (Singapore HDB 2021).

A new agency, the Smart Nation and Digital Government Group, was established in 2017 as an umbrella institution for the various governmental units involved in the initiative. The Government Technology Agency, responsible for delivery of digital services to the public, was tasked with implementation.

Singapore's Smart Nation initiative is a prime example of the gov tech ecosystem, as well as the Smart City 2.0 stage of evolution (see Chapter 2). While it aims to increase digital communication with citizens, this communication is led by government rather than being driven by community members. By centralizing e-government efforts, the initiative has also posed challenges for private-sector participation (Jie 2018).

MEDELLÍN: CIVIC INCLUSION AND URBAN CO-CREATION

Medellín, Colombia, was known as the murder capital of the world in the 1990s. In 2013, it was recognized as the world's most innovative city by the Urban Land Institute, and today, its homicide rate is down to one-twentieth of what it was in 1993 (Freedman 2019). Much of this radical transformation had to do with Medellín's people-centric approach to urban renewal and community building, addressing its challenges by fostering active citizen participation, prioritizing civic inclusion in the process, and spurring citizen co-creation.

This approach has also been key to Medellín's smart city strategy. Instead of focusing on flashy technologies, Medellín puts people first. It emphasizes the use of data to make informed decisions, supports inclusive initiatives, and is driven by community members and their entrepreneurial spirit (Freedman 2019).

Citizen participation, open government, social innovation, and sustainability are the four main pillars of the city's smart city strategy (Amar Flórez 2016). While most smart city initiatives are targeted towards tech-savvy individuals or businesses, Medellín has been focusing on those community members who have the least.

The origins of Medellín's civic inclusion approach go back to the early 2000s, when Sergio Fajardo was elected mayor. His goal was to rebuild civic pride and to use the entrepreneurial spirit of Medellín's communities when rebuilding the city (McGuirk 2014). He believed that social challenges such as inequality, violence, crime, and corruption should be overcome by addressing their root causes: lack of education, hopelessness, and physical and systemic exclusion.

Urban interventions were defined by a social process and active citizen participation. This generated "integral urban projects" (PUIs) that integrated multiple programs. For example, the city created library parks that served both as public spaces to connect and build a sense of community and as places for education. The most famous one is Parque Biblioteca España (Figure 3.8), which resulted in a revitalization of the entire Santo Domingo neighborhood.

In addition to addressing social goals, these projects—and the partici-

Figure 3.8. Parque Biblioteca España in Medellín's Santo Domingo neighborhood (Albeiror24/Wikimedia Commons)

patory processes of their creation—conveyed a message to the community of how much its members were valued and the importance of their role in the transformation of their city. They provided opportunities and hope for a better future.

Mayor Alonso Salazar continued this approach while recognizing the need to build a digital economy to move away from the predominant manufacturing industries toward digital innovation (Freedman 2019). The year 2009 saw the founding of Ruta N, a public nonprofit and joint venture between the mayor's office, the public utilities company EPM, and the telecommunications company UNE. Ruta N is the heart of Medellín's innovation system, with the mission to spearhead inclusive and sustainable innovation and co-creation to improve quality of life in Medellín. It supports innovation, provides office space and funding, connects start-ups to bigger tech companies, and facilitates the participation of smaller companies in city contracts.

To give everyone a chance to participate in Medellín's initiatives, connectivity is key. The City provides 150 free public WiFi zones across the city and more than 500 locations with computers for public use and additional access to the internet. In addition, it set up 48 internet education centers to improve digital literacy among the community members (Freedman 2019). For people with disabilities, the City provides toolkits on how to access and connect to the network, depending on the type of disability (Arboleda Guzmán and Amaya Gallo 2018). Additionally, the City established an online co-creation portal through which the public can share ideas and become part of the urban transformation process (UNDP 2017). Medellín provides open data and other services to facilitate and support citizen participation, social innovation, and co-creation (Amar Flórez 2016).

In the last years of Medellín's long history of civic inclusion, smart tech has played an integral role in enabling the connection of individuals to their communities, supporting civic innovation, and taking co-creation to the next level. Today, Medellín is one of the South American cities with the lowest poverty and crime rates and the highest education and health care rates, and the people who live in Medellín see themselves as the essential actors who generated these improvements.

CHAPTER 4

PLANNING IN THE ERA OF SMART CITIES

Technology is everywhere around us, and innovation has touched every profession. Urban planning is no exception. Planners today have at their disposal a rapidly expanding portfolio of tools, skills, and methodologies to harness for more effective planning. This chapter provides an overview of these items to help planners update their toolbox.

Before the details, however, come two important points. First, as change agents in their communities, planners should see innovative technologies as opportunities to improve the quality of life for all, while being entrepreneurial and providing leadership for communities seeking to embrace smart cities approaches. If planners do not step into this leadership role, others will (as was the case with Alphabet's Sidewalk Labs' Toronto Quayside, mentioned in Chapter 2)—and those actors may not have the holistic and equitable perspectives planners bring to the table.

Second, regardless of the ever-changing technologies of the current moment, planners must not get distracted from their core functions and skills, which are as relevant as ever in this dynamic environment. Technology should enhance urban planning efforts, not dominate them.

The interdisciplinary nature of planning and the variety of skills planners can bring to a team makes planners perfectly suited to spearhead the development of smart cities and the integration of smart tech into all systems of a city. Planners have the skills to facilitate multidisciplinary teams for projects ranging from comprehensive plans, with their variety of community stakeholders, to strategic assignments involving numerous technical experts. Planners connect with their communities in the roles of communicators, facilitators, and consensus builders. Additionally, planners are change agents, preparing communities for the future and helping them navigate change. Planners manage these efforts to produce something that is greater than the sum of its parts for the community.

However, the integration of a smart city strategy into a holistic plan for the city entails adjusting and adapting certain planning processes and skills, a requirement for any profession that wants to continue to evolve, stay relevant, and be future-ready in a constantly changing world. In this digital era, workers and employers must embrace continuous learning and training or risk becoming obsolete. One example of this is the GIS technician, who in the past was primarily a map maker. Today, that same GIS analyst is likely versed in application development, interactive app and dashboard development, Python scripting, urban analytics, and 3D data visualization.

To use the power of new technologies, planners will need to add additional skills, processes, and tools to their repertoires. These can be grouped in two categories:

- **Planning *with* smart cities.** Smart city applications can improve the quality of life, sustainability, and resilience of a city. In addition, these applications can mine extensive amounts of data that planners can use in their work. For planners it will be important to understand how these applications can be used to make data collection and data analytics easier and more efficient. At the same time, planners need to understand how data is collected through these applications, where the data comes from, what is included and what is missing in that data, how to ensure data privacy, and how to address data gaps to ensure everyone is included and no one is left behind.
- **Planning *for* smart cities.** Planners will need to use existing and new skills and processes to integrate smart city strategies into holistic plans and use smart city applications to achieve community goals. These include soft skills related to community facilitation and engagement, as well as technological knowledge and know-how on how smart city applications can be implemented equitably and sustainably.

This chapter describes key competencies and tools that planners can use to plan both with and for smart cities, helping them to ensure that smart technologies are imple-

mented in ways to maximally benefit sustainability, livability, and equity for all.

KEY COMPETENCIES TO PLAN WITH SMART CITIES

Every planning process starts with data collection and insights into the community's needs, challenges, and goals. Methodologies for data collection and analysis have evolved over decades.

Smart cities take data collection and data analytics to the next level. Chapter 3 outlined how the connected devices of a smart city create data points and how the vast amount of data coming from those devices can be used for planning and policy decisions. A smart city digital twin (SCDT) represents the ultimate virtual platform to integrate and use all the data mined from the smart city.

Smart cities provide real-time big data, and planners need to learn how to handle it. With the evolution of data analytics, planners must upskill and acquire state-of-the-art data collection and analytics skills, including the knowledge of how to use new tools, processes, and methodologies. As a result, smart cities provide many capabilities to planners. Digital versions of cities offer safe and secure laboratories for planners to experiment with, test, and prototype ideas and policies without harming the community.

Data Mining and Urban Analytics

Data collection is an essential part of the planning process. Planners use data and the information that can be derived from it to make decisions about what the future of their communities may look like, how they can respond to certain developments, and what specific needs the members of their communities may have.

Cities have tracked and provided data throughout history in different forms; think the yellow pages, or paper maps. Today, the expansion of the internet and digital services has created a world of connected devices in which each person and their activities constantly generate data points. Smart city applications can help to tap and use that data.

The concept of planning with smart cities takes data collection to the next level. Many smart city applications collect data while fulfilling their purpose for a service or system. For example, while the Uber app serves the user as a convenient tool to hail a ride, it also collects data on the user and their transportation behavior. Cities can use this data to improve processes (including planning processes), systems operations, and services. The sidebar on pp. 59–60 describes the wide range of data generated by transportation systems, offers suggestions on how planners can use this data to plan better communities, and highlights some challenges remaining to be overcome.

In another example, during the COVID-19 stay-at-home order in the spring of 2020, the Chicago Department of Public Health collaborated with the health data company BlueDot to monitor whether the city's residents were abiding by the order. It used anonymized location data from cellphones to track people's movements. The location data was available through apps users had installed on their phones, and users had given permission for use of their data (NBC Chicago 2020).

To make the most use of data from different sources, it needs to be standardized and curated on a single platform. As outlined in Chapter 3, this data platform can ultimately serve as a SCDT. However, geospatial data is only useful if it contributes to solutions and related actions in the community. And planners need to be equipped with the right tools, processes, and skills to be able to take advantage of the data available.

Experimentation in the Virtual World

Most industries use testbeds or laboratories to try out and test a new product before it gets mass-produced and put on the market. This is currently not the case in planning. Planners create plans and implement them without further prototyping or experimenting. However, as planning failures from the past show, the quality of plans and policies could be improved if they could be tested and adjusted before implementation (Hurtado and Gomez 2021).

While planners have used urban labs to pilot smart city solutions, this still poses challenges: urban labs are not real laboratories, but real-world settings that experiment with real people's lives. The city digital twin, as well as the SCDT, provides opportunities to experiment without negatively impacting any community members. Planners can use these tools to generate ideas, gain insights on consequences from certain actions, and create virtual prototypes that can later be tested in the physical world together with the community. The smart cities of the future will make their mistakes in the digital world, learn from them, and create better outcomes together with their community members in the real world.

Smart City Digital Twins

The SCDT provides a controlled environment, mimicking movements and flows from the real world and using artificial intelligence to make data-based predictions for future scenarios (Mohammadi and Taylor 2020).

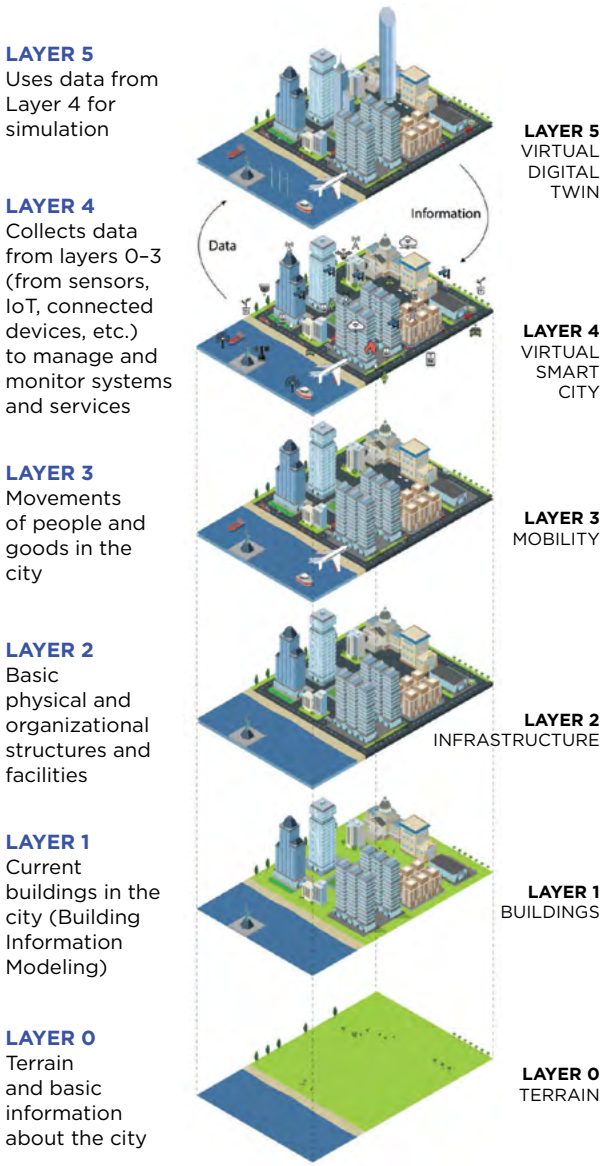

Figure 4.1. The smart city digital twin integrates different layers of data into one platform (©Trinity College Dublin)

The SCDT integrates all layers of data into one platform, including terrain data and basic information about the city, buildings and information on their system flows, infrastructure systems and related parameters, as well as movements of people and goods in the city. Data from smart city devices such as sensors, the internet of things (IoT), and other connected devices can be fed and integrated into this data platform (Figure 4.1).

A SCDT can be used to test and communicate ideas, plans, policies, and potential outcomes, taking public engagement and scenario planning processes to the next level (White et al. 2021). If available data relevant to the city's operations feeds into the SCDT, the result can enhance cross-departmental collaboration, which further improves the efficiency and quality of the outcomes.

Working with real-time data, SCDTs enhance the agility of planning processes and allow for faster adaptation and adjustments. A SCDT can help planners to improve the quality of their plans to enhance the sustainability and resilience of a community. It can save money and time by enabling the testing of ideas in the virtual world instead of building them in the real world at much higher cost, and its visualization and interactive functionalities support better public engagement, which can help increase the acceptance of the plan or project in the community (Hurtado and Gomez 2021).

One of the important reasons why planners need to learn about digital twin technologies (both basic city digital twins, or 3D virtual representations of the built environment, and SCDTs), their inputs, the algorithms they use, and what outputs they create is to ensure that when using these technologies they can produce equitable outcomes. While digital twin products can add great value to the work planners do, planners need to understand where the data that is used for the digital twin comes from, what it covers, and what it does not cover. Data transparency and the knowledge about data gaps is crucial when planning for equitable communities. The data used for a SCDT will come from smart city applications such as sensors and other online devices. Anything or anyone who is not connected or cannot be recognized by these devices will not be included in the datasets used for the SCDT, and therefore will not be included in the plan. Planners can use inclusionary approaches to fill data gaps, such as working directly with community members or community organizations to fill data gaps (Hurtado and Gomez 2021).

While digital twins provide multiple benefits to planning processes, it is the planner's responsibility to make sure everyone is represented in the process and no one is left behind. To be able to do that, planners must learn about these new technologies and include them in their toolbox.

There are not yet many communities working with digital twins, but global tech market advisory firm ABI Research predicts that due to the ever-increasing range of digital twin applications, that number will reach 500 by 2025 (ABI Research 2021; Kosowatz 2021). In the United States, the Boston

Planning and Development Authority has created a virtual 3D map of city buildings to inform development decisions and building design, and cities such as New York, Phoenix, and Las Vegas are launching smart digital twin pilots to help major buildings cut operating costs, manage water use, and reduce carbon emissions (Patrick 2018; Worford 2021; Cities Today 2021). The sidebar on pp. 61–62 describes how planners used digital twin and other technologies to help one North Carolina community plan a better future for its town center.

Game Engines, VR, and AR

Additional tools and technologies that can enhance planning and the visualization of plans and policy adjustments are programs and applications for virtual reality (VR) and augmented reality (AR). Through these visualization tools, planning teams can tie data-rich spatial models to VR and AR to enhance understanding of highly complex and dynamic conditions.

Advances in game engine technology are beginning to inform smart city planning. Esri's 3D-modeling software CityEngine exports to the video gaming engines Unreal and Unity, allowing users to walk around in a virtual master plan (Figure 4.2). This realistic form of visual communication allows stakeholders to better identify, explore, and resolve issues early in the planning process. Graphics and visualization services are particularly valuable for public involvement and information programs, in which the goals are to build consensus and communicate design intent.

AR and VR can help extend imagination from simple visualization to experience. This is especially valuable when planning for diverse communities and the ability to put oneself in another person's shoes. Practicing empathy is important in planning, but is not always easy without experiencing certain constraints firsthand. AR and VR tools can be used to train planners to better understand the diverse ways in which people experience a city, transit system, public space, or other place in the community.

These technologies can be used to improve systems and services for community members and their needs. For example, AR applications can improve wayfinding for people with disabilities, highlighting accessible routes to access public transportation. Additionally, AR phone apps can make signage more readable for people with visual impairments or with different language backgrounds. The City of Philadelphia is currently working on an AR project that aims at making transit more accessible (Stone 2021).

AR and VR can also be used by planners, project stakeholders, or community members to experience new technology innovation and explore how it would play out in the community if it was implemented. Smart city tech is not always well understood or accepted. Trying it out and experiencing it virtually may help to increase acceptance.

Furthermore, AR and VR can make training of staff easier and more accessible. In Austin, Texas, emergency personnel are trained with VR (Stone 2021). Such training can be done anytime, anywhere, using a variety of scenarios, and more training hours can be accomplished, which enhances preparedness and execution during real emergencies.

Figure 4.2. Virtual reality allows users to walk through a virtual master plan (Esri)

KEY COMPETENCIES TO PLAN FOR SMART CITIES

The acceleration of technological innovations as they are deployed in smart cities makes it more difficult to keep up with what is coming and what is already ripe for the market. However, rapid adjustments are almost impossible with current planning procedures.

Many of the ad-hoc planning solutions during the COVID-19 pandemic (e.g., pop-up bike lanes, shared streets, or on-street dining) were made possible by emergency orders—not by the usual planning procedures. Agile processes such as design thinking and a "fail fast, fail small" approach have not been part of the planner's repertoire so far.

Experimentation, prototyping, pilots, and feedback loops are important elements of agile processes and have multiple benefits beyond agility. They enhance community engagement and improve the integration of ideas and feedback of community members in a planning process, they increase the

potential for innovation and outside-the-box thinking, and they can result in monetary savings and risk reduction.

In the era of smart cities, planning needs to be people-centric, agile, and technologically advanced (Hurtado 2021b). Consequently, planners will have to adjust their competencies (skills, processes, and methodologies).

Strategic Foresight and Scenario Planning

Integrating foresight (also called strategic foresight) into long-range planning can help planners create a community vision that prepares for future uncertainties, while giving them the agility to adjust and pivot along the path toward the future (Hurtado 2021a).

Foresight is an approach that aims at making sense of the future, understanding drivers of change that are outside of one's control, and preparing for what may lead to success or failure in the future (Figure 4.3). In today's quickly changing world, it is important for planners to integrate foresight into their work to make their communities more resilient.

Using foresight in planning provides multiple benefits. Foresight helps communities navigate change and uncertainty, makes long-range planning more resilient and nimbler, and fosters community engagement to allow for more inclusive and equitable outcomes.

There are multiple approaches and methodologies to practicing foresight. The components most relevant to planning include the following:

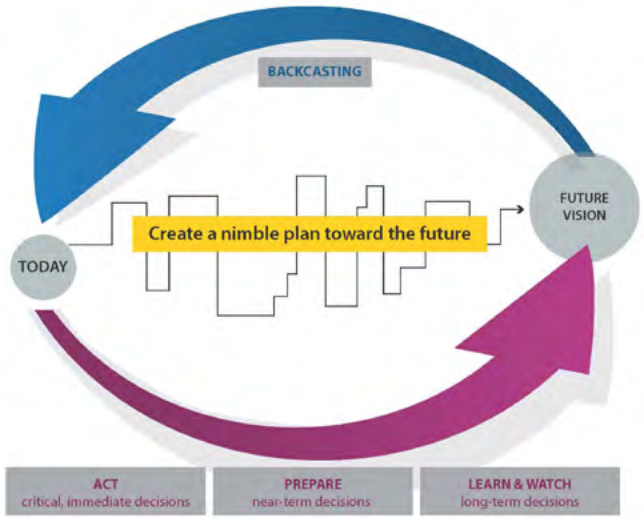

Figure 4.3. The practice of foresight helps planners prepare their communities for the future (APA)

- **Trend scanning:** researching existing, emerging, and potential future trends (including societal, technological, environmental, economic, and political trends, or STEEP) and related drivers of change
- **Signal sensing: i**dentifying developments in the far future and in adjacent fields outside of the conventional planning space that might impact planning
- **Forecasting:** estimating future trends
- **Sense-making:** connecting trends and signals to planning to explore how they will impact cities, communities, and the way planners do their work
- **Scenario planning:** creating multiple plausible futures

Engaging diverse teams with diverse perspectives is critical to avoid missing signals or trends that might not be obvious or might not seem immediately related to planning. For planners, this provides an opportunity to enhance the role of community members in their planning processes. Engaging the community in foresight makes the process more inclusive and will result in more equitable and sustainable solutions.

Foresight does not predict the future; rather, it helps to develop ideas of what the future could potentially look like. Planners can use foresight to consider multiple plausible futures based on different potential drivers of change.

Exploratory scenario planning is a useful tool to create alternative futures. It can help planners prioritize different drivers of change and create scenarios with the ones that seem to have the biggest impact, that communities are least prepared for, and that are most likely or certain to occur. The APA Research KnowledgeBase collection on scenario planning provides more information on this approach.

To create the needed agility and a nimble plan that allows for pivoting and changing directions, foresight needs to be practiced in cycles. Continuous observations, discovery, and sharing of signals and trends, including regular scenario planning to create alternative paths towards the future, are crucial. Adjusting the plan every one or two years in response will enhance community resilience and preparedness for the future.

Foresight can help planners create more resilient communities in a world of accelerated change and navigate the fast-paced innovations in the smart city sector.

Design Thinking

Another methodology to create more agility and to integrate feedback into planning processes is a process called design thinking (Fisher 2021). Originating from the design world, this process has evolved and is now being used to improve development and delivery of services and other systems.

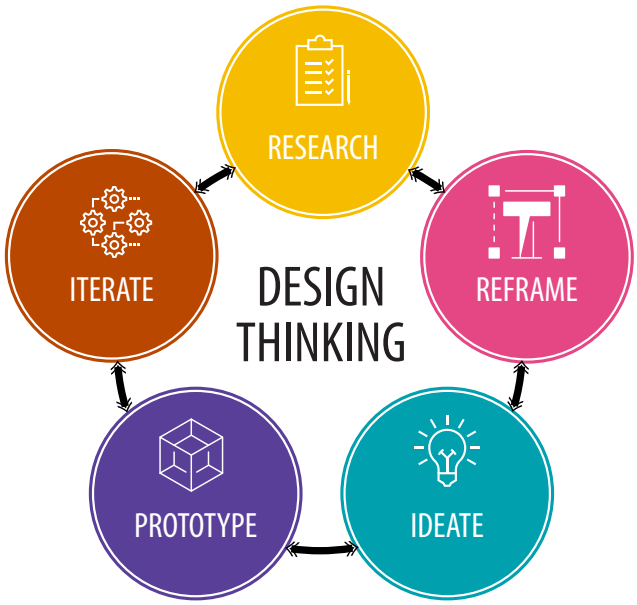

Figure 4.4. Design thinking is an iterative process that allows for creative and agile problem solving (APA)

Design thinking has the greatest value when dealing with unprecedented situations, unexpected disruptions, and uncertain change, in which the future will almost certainly be unlike the past. In such cases, design thinking helps answer the questions of "What is?" "What if?" and "What could be?" based not only on existing data, but also on emergent trends and creative potentials.

The process entails five steps (Fisher 2021) (Figure 4.4):

1. *Researching*: understanding a situation by mapping relationships and connections
2. *Reframing*: repositioning or reimagining the problem to achieve better outcomes
3. *Ideating*: describing and diagramming as many responses or solutions as possible
4. *Prototyping*: testing the most promising ideas as quickly and at as low a cost as possible
5. *Iterating*: assessing the results and repeating the process to find the best solution

Design thinking involves a deep connection to the user, customer, or in the case of planning, the individuals of a community. The research phase is about being curious without judging, applying empathy, and looking for things that prompt behavior (IDEO 2020b). The goal is to uncover opportunities and insights.

As in foresight, stakeholder diversity is key to include diverse perspectives and create a diverse pool of ideas. While design thinking starts with a broad variety of ideas, feedback from the users is used to refine and eventually test and prototype. According to IDEO (a design company that uses design thinking to create products, services, and specific experiences), a playful mindset is key. "Divergent thinking" leads to an abundance of ideas, including outside-the-box ideas. Choosing the one idea that will be transferred into a prototype is done through "convergent thinking," including voting, clustering, discussing, and ultimately, making a decision by using the three lenses of design thinking: feasibility, viability, and desirability (IDEO 2020a).

In the smart city era, design thinking can be combined with the use of online tools to share ideas and receive feedback from community members while ideating or prototyping. Planners can use design thinking to navigate technological innovations, test, and prototype, while engaging a broad diversity of community members.

Translating Technology to Community Needs

Processes such as design thinking are useful to create the connection between the plan and the community members who will ultimately live in the city the plan was made for. Planning needs to be people-centric; smart city applications combined with the right processes can improve participatory processes, augment community engagement, and ensure focus on the individuals of a community and their diverse identities.

Planners are change agents. Additionally, they often serve as facilitators and consensus builders (Hurtado 2021b). For equitable outcomes in a smart city, planners need to be able to facilitate the connections between community members (their needs, goals, and challenges) and the available technological solutions. Hence, planners need to understand the technology deployed in smart cities and be able to explain and translate technical aspects to lay people in their communities.

Planners do not have to become experts in information and communications technology, but they need a basic understanding of emerging technologies to know how they can be used to achieve better outcomes for communities. It is also important for planners to participate in discussions about the development of smart technologies. This is especially important when looking at the pace of technological innovation and the unresolved issues of social inequality, a dangerous combination that bears the risk of repeating past mistakes from the analog world in a digitalized world (Hurtado 2021b).

Along with replicating past mistakes, the digital era and the related digital transformation of cities will most likely create new ones. Inequitable distribution of broadband and connectivity, data gaps, algorithmic bias, and data privacy are not just IT problems, they are the planning challenges of the smart city era. Chapter 6 discusses these challenges—as well as the opportunities brought by smart cities—in more detail.

CONCLUSION

The pace of technological change and the ways it is impacting how we live, work, and play can be overwhelming for planners and government leaders. Planning departments and local resources are typically already stretched. Planners need to understand how the skills, tools, and methods of smart cities can help them make the most of valuable community resources.

Planners need to harness their cities as technological and data platforms, facilitating smart city strategies and comprehensive plans that are grounded in strong spatial analytics. This will make planning more precise, agile, and accessible to community members and community leaders.

But how can planners do this? The next chapter explains the different approaches cities can take to smart city planning and how planners can lead agile planning processes that integrate smart city goals, principles, and actions into a holistic framework for more sustainable and resilient cities.

GEOLOCATION DATA FOR SMART CITIES

Joseph Kane and Adie Tomer, Brookings Institution

In today's digital age, the rapid diffusion of new technologies is changing how transportation systems operate and is causing a surge in new data. Whether we make calls, use social media, or drive to the store, our phones and other devices collect our location information. Storing and analyzing this geolocation data will be a major component of future smart city operations, so planners must understand how this new data can help inform how we plan and build our communities.

The enormous breadth and depth of geospatial information generated each day is the result of many different devices, platforms, and services, typically owned and operated by private companies. Major types of geolocation data that have emerged in recent years include the following:

- **Telematics**—a technology that merges telecommunications and information systems to improve travel performance (Geotab 2021)—is shifting how people, cars, trucks, and even ships navigate regions. This technology often comes in the form of a wireless GPS device that allows for more precise tracking and route information, leading to faster travel, improved safety, and many other benefits.
- Data from **call detail records** (CDRs) is collected by mobile phone operators. It includes the time of calls and messages, as well as the company's specific cell tower used. It allows for the characterization of individual mobility patterns due to highly predictable, spatially recurrent activity.
- Similar data is also available from **surrounding wifi access point records** (SWAPRs). Since individuals tend to rely on the same wifi networks and travel to the same locations each day, it's possible to gauge their travel patterns based on common access points. Unlike cell towers, these access points are more widely distributed and provide a closer look into daily activities. For example, researchers have been able to determine 80 percent of the mobility across a population on a given day based on the location and subsequent use of wifi access points (Sapiezynski et al. 2015).
- Data from **location based social networks** (LBSN), as the name implies, are derived from social media websites, either through web scraping or research agreements. They range from geotagged media-based data (e.g., Flickr, Youtube, and Twitter), to point-location-driven data (e.g., Foursquare, Yelp), to trajectory-centric data (e.g., Garmin Connect, Nike+). Similar to telematics data, LBSN data offer tremendous geographic granularity and have the added benefit of providing more contextual information of individual locations and users.
- Finally, data collected from transit trips and financial transactions can offer a detailed look into travel patterns. For example, **public transit smart card records** not only help agencies understand overall system usage and operations, but also provide insights into how individuals use certain stations, bus lines, and other services. Likewise, credit card companies can trace where individuals are making purchases based on **transaction records**, both by the type of business and where that business is located (Helm 2020; Sulis et al. 2017).

Planners can use geolocation data to plan with smart cities and improve social, economic, and environmental outcomes in several ways.

- Smart card, Twitter, and mobile phone data have been used to measure neighborhood vibrancy, including the importance of urban density and diversity to support thriving, lively places (Brookings Institution 2018; Sulis et al. 2017; De Nadai et al. 2016).
- Linking travel patterns to sociodemographic information can help planners analyze social inclusion, such as how individuals from different ethnic and racial backgrounds interact in physical space and overcome barriers to opportunity (Wang et al. 2018).
- Digital transportation data can reveal how travel patterns relate to economic opportunity. For example, transaction data can show how and where people from various zip codes spend money and demonstrate the need for more basic goods, services, and cultural amenities to be made locally available, especially in lower-income neighborhoods (Louail et al. 2017; Zhou et al. 2017).
- To improve environmental sustainability, digital transportation data can allow planners to optimize transportation operational performance and provide services more efficiently with less waste (Berlingerio et al. 2013; Leng et al. 2016).

Though geolocation data offers huge potential to reexamine and reimagine how places connect with one another, challenges to using and evaluating this data include the following:

- **Lack of data standardization.** Government agencies and other local public actors typically lack consistent standards for data collection, acquisition, and organization, which can hinder efforts to use this information (Tomer and Shivaram 2017). Geolocation data requires extensive cleaning and validation (Smarzaro, Lima, and Davis 2017)—it can have significant differences in quality between users who enable geotagging and those who do not—and there is generally a low frequency of data sharing.
- **Data privacy concerns.** Data privacy is a major concern among the general public, the media, and many experts across a range of disciplines, including ethicists (Associated Press 2018). Each geolocation source has its own set of personal identifying information, which makes it impossible to design a singular approach.
- **Financial cost.** A lack of programmatic capacity and financial resources rank as common barriers to integrating new data among agencies, in addition to limited staffing and financial resources (Hall 2007). The procurement of data is further complicated by the fact that the largest data collectors—namely private companies—often do not want to share it, or will only do so at a high fee.
- **Integration with current travel models.** Disjointed and jurisdictionally fractured, many agencies lack the technical nimbleness and know-how to experiment with new data and create new performance measures. Sciara (2017) examines how metropolitan planning organizations (MPOs) may struggle to consider new ways of managing and applying data within long-standing planning frameworks.
- **Need for clear performance measures.** When viewed in isolation, raw geolocation datasets can be large and unwieldy to analyze, making it hard for planners to measure and evaluate their region's economic connectivity, social inclusion, and environmental resilience, to name only a few possible objectives. Overcoming potential sample bias—while calibrating and validating results against real-world activity and amongst representative populations—is crucial to inform new ways of measuring transportation and land-use concerns.

Geolocation data has the power to deliver transformative outcomes for people living in regions of all sizes. But to tap into its full capabilities, practitioners must reform business processes where necessary. Local governments must invest in skilled technical staff, new software and hardware, and modernized procurement policies. Staff must be willing to establish new relationships with private data suppliers, aggregators, and developers who have their own expertise. These large real-time data sets will also change how agencies approach data organization, visualization techniques, and data management guidelines (OECD ITF 2015; NACTO and IMLA 2019). Governments must also be ready to formalize their position on privacy concerns.

Geolocation data can feel overwhelming, but the insights it offers into our built environment is too important to overlook. Examining the number and type of trips occurring during particular times of day, over particular distances, and in particular places can shed new light on why transportation and land-use planning matter (Tomer, Kane, and Vey 2020). The ability to directly measure and visualize travel patterns from one place to another, including their relationship to land use and urban design, will help planners better understand economic dynamism and connectivity for different travelers and inform their work to improve these connections.

DIGITAL TWINS AND VR: MORRISVILLE, NORTH CAROLINA

Devin Lavigne, FAICP, Houseal Lavigne Associates

The Town of Morrisville is a fast-growing Raleigh suburb situated amid North Carolina's burgeoning Research Triangle. Despite a strong desire to create a "downtown" and community focal point, local officials have hesitated to approve any development within the designated area for fear of proceeding down the wrong path. Ultimately, they were torn between the vague vision for low-density development established in the 2007 Town Center Plan and input received from residents and the development community for a more compact and dense mixed-use area.

Due to these unresolved questions about appropriate heights and density, Morrisville's Town Center remained largely undeveloped while other areas of the community were thriving. Recognizing the importance of this key area in the community, the Town hired Houseal Lavigne, an urban planning consulting firm, to create a 3D model of the Town Center for $25,000 to help the community reach a consensus and move through the stalemate. This digital twin enabled the community to visualize both scenarios and make an informed decision using qualitative and quantitative information.

With extensive input from the community, land use and development sketch concepts were prepared. This resulted in the development of two development scenarios:

1. Scenario A: a lower-density option, considered by some to be more consistent with a small town, characterized by one- and two-story buildings with surface parking lots.
2. Scenario B: a higher-density option, considered by some to be more desirable and market viable, with four- and five-story buildings serviced by centralized parking garages.

The development of the digital twin for Morrisville's Town Center was a five-step process that took less than a month to complete and comprised the following steps:

1. Constructing the digital twin of the study area and its surroundings
2. Creating a conceptual site plan for the Town Center
3. Identifying key performance indicators and other metrics for each scenario
4. Preparing 3D scenarios and interactive web viewer
5. Using Epic's Unreal Engine to create an immersive experience

To accurately evaluate development options, the project team began by creating a digital twin of the study area to serve as a baseline, allowing comparison of each scenario. This included modelling the existing street network, existing land uses and buildings, and existing natural features.

Next, conceptual sketch plans were prepared for each scenario. Using a new street network as a backbone, building locations and parking lot configurations for each block were established. This step also identified existing buildings to remain. The two sketch plans were then 3D modelled in ArcGIS CityEngine, where key performance indicators and metrics provided quantitative information about each development.

Within CityEngine, as building footprints were extruded and modified, dashboards provided real-time feedback ensuring each scenario followed the Town's recently adopted zoning code. This included live reporting of land uses

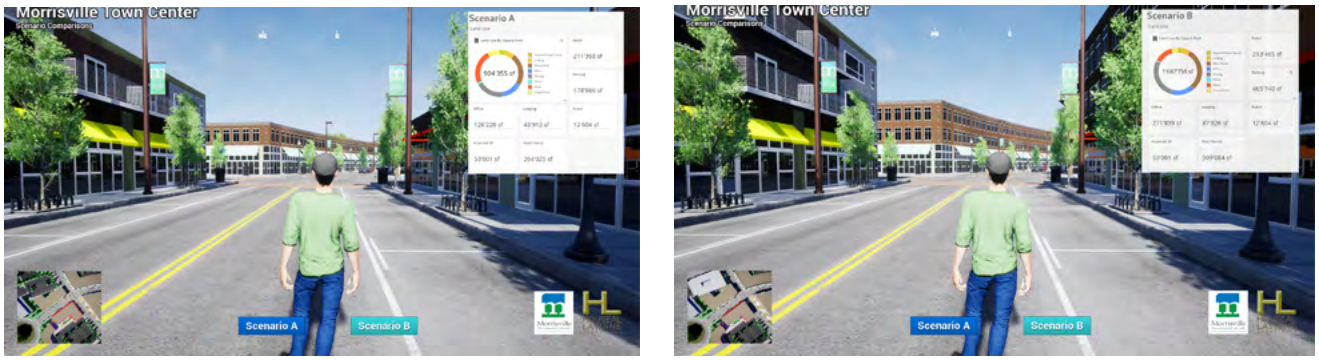

Figure 4.5. Interactive Morrisville Town Center scenarios A (left) and B (right) (Houseal Lavigne)

Figure 4.6. Morrisville Town Center scenario B (Houseal Lavigne)

by square foot, FAR of each site, number of dwelling units, and the amount of parking required for development. Similar dashboards provided information related to parking supply, development cost, and potential population. A CityEngine Webscene was publicly shared, providing Town officials and residents an opportunity to view and compare each scenario. Each building and site in the viewer was enriched with data, allowing a user to compare and contrast the scenarios.

While this provided valuable data, it still did not address concerns that taller buildings would be too dense and "urban." To help better assess the scenarios, CityEngine models were imported into Epic's Unreal Engine, a video game engine that powers Fortnite and other popular video games. Additional detail, including streetscaping, plazas, and open spaces were added to the game engine, along with a "playable" character. Users could control the character as a pedestrian to virtually walk around Morrisville's envisioned Town Center. Buttons on the screen allowed the user to toggle between each of the scenarios and live dashboards provided information about the development (Figure 4.5, p. 61). The immersive application was packaged and deployed at the Town Hall, allowing staff, elected officials, and residents to drop in and explore the potential Town Center.

The process was hailed by the community as a success, and Town officials reached unanimous consensus on Scenario B (Figure 4.6). Houseal Lavigne was then directed to update the community's Town Center plan, policies, and recommendations to help Morrisville achieve its vision of a dense, compact, walkable, and vibrant community focal point.

This project was awarded the APA Technology Division's 2020 Smart Cities Award and Esri's 2020 Special Achievement in GIS Award.

CHAPTER 5

PLANNING APPROACHES FOR SMART CITY IMPLEMENTATION

As the capabilities of smart cities technologies grow in availability and impact, more communities are exploring ways to use them effectively. All cities are unique, and their widely varying demographic, geographical, political, and fiscal contexts mean that each will have different opportunities and constraints when it comes to smart city implementation. However, all cities strive to manage governmental operations, infrastructure, and facilities effectively and efficiently, and all can benefit from the application of gov tech, civic tech, and urban tech to achieve these goals and help create more livable and sustainable places.

Though local governments have begun to implement smart technologies for a wide range of applications and at different scales, the primary approaches they are taking fall into three general categories.

- **Project-driven approach**: By far the most common approach to date, this method consists of a local government or sponsor organization identifying and using a promising smart cities application to help solve a particular community problem or improve a community service.
- **Incremental approach**: Another option is to use an individual smart cities project as a pilot initiative not only to solve an immediate problem, but also to begin developing a larger smart cities capability.
- **Holistic-city approach**: A third approach is for local governments to establish a comprehensive smart cities vision that is consistent with community goals, map out an integrated action plan, and then work to implement it.

Each of these methods has the potential to build on the previous one to move communities along the pathway to a dynamic and impactful smart cities ecosystem. Each approach also provides opportunities for planners to support this work through the use of planning principles and frameworks, such as the American Planning Association's Comprehensive Plan Standards for Sustaining Places and strategic points of planning intervention.

This chapter describes each of the three smart cities approaches in more detail, provides case studies, and shows how they intersect with the Standards and strategic points of planning intervention. It also highlights the importance of collaboration within and across organizations and across sectors. In so doing, the chapter provides a roadmap for more successfully developing and implementing smart cities technologies.

THE PROJECT-DRIVEN APPROACH

The project-driven approach uses smart cities technologies to solve a particular problem. It treats these technologies as another tool in the local government toolbox; each functions as a stand-alone activity that is not linked to a larger smart cities program.

For example, a city might connect its traffic lights to intersection cameras and software that adjusts them in real time based on traffic volume to reduce congestion. Alternatively, an organization or department might work to increase transparency and crowdsource solutions by creating an open data portal to share public information and data sets. One example of the project-driven approach is North Carolina's Orange Water and Sewer Authority (OWASA), which used smart city technology for leak detection to save water and reduce customer costs, as described in the sidebar on p. 65.

The project-driven approach uses new tools and technologies to solve a community problem. At the same time, however, it often occurs in a framework of organizational fragmentation. Data systems may be uncoordinated, locked within individual departments or on individual computers. In addition, a department's "database" may simply consist of a spreadsheet or map or table in a PDF report. This is symptomatic of a larger dynamic in which local government decisions are often compartmentalized by department or func-

AGUA VISTA: INSTALLING A SYSTEM FOR REAL-TIME WIRELESS LEAK DETECTION

The Orange Water and Sewer Authority (OWASA) was looking for a way to read its water meters more efficiently. In so doing, it saw an opportunity to save money, improve service, and save water for its customers in Chapel Hill and Carrboro, North Carolina. To meet this challenge, it turned to smart cities technology.

In 2015, OWASA was using a hybrid system in which it read some meters manually and others using a drive-by meter reading system. By shifting to an advanced metering infrastructure (AMI) system with a fixed radio network, it could check water usage hourly and feed the data into a special software package to provide customers with rapid feedback on water usage. In addition, the new system was more cost effective. Analysis projected that the new system would provide an internal rate of return of 4.8 percent, about twice that of the next best alternative (Don Schlenger and Associates 2016).

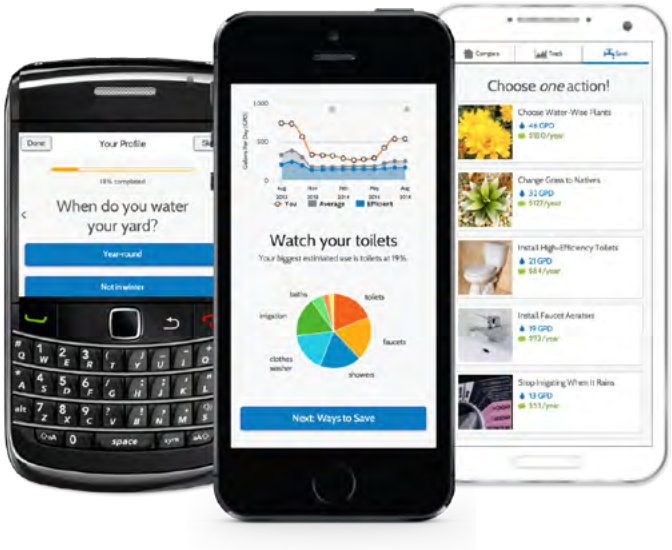

Figure 5.1. User interface for OWASA's smart water meter reading system (Image courtesy of WaterSmart (a brand of VertexOne))

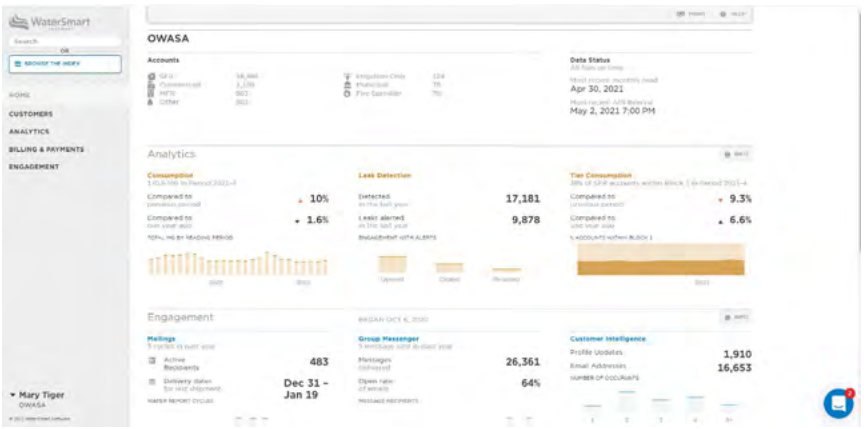

Figure 5.2. Back-end dashboard for OWASA's smart water meter reading system (Image courtesy of WaterSmart (a brand of VertexOne))

Customers register online to access the system. If they do, the system provides them with real-time data on their water usage (Figure 5.1). The system also alerts all customers automatically about unusually high water usage levels. If water usage spikes at a residence and the high level continues for several hours, this might indicate a plumbing leak or an outdoor hose left running in the yard. The resulting alert enables customers to take action to save water—and save money.

"When you use less, you pay less," highlighted Mary Tiger, OWASA's sustainability manager (OWASA 2020). In the past year alone, the Agua Vista Web Portal has alerted customers to nearly 10,000 water leaks (Tiger 2020).

OWASA's smart water meter reading system combines sensors with software to provide an effective smart cities solution (Figure 5.2). This initiative did not grow out of larger organizational smart cities efforts, but its success has caused OWASA to explore smart cities technologies to solve other organizational challenges (Tiger 2020).

tion, so that a community ends up with a separate land-use plan, water resources plan, transportation plan, and hazard mitigation plan, for example, developed by different staff in isolation and sometimes in conflict with one another.

In such cases, a community can miss opportunities to achieve multiple objectives through more coordinated smart cities investment, and they also overlook chances for mutual learning. Without a bigger-picture approach, these one-off initiatives can have limited impact beyond their immediate applications and represent missed opportunities to contribute to the development of a larger, more impactful smart cities ecosystem. As a result, organizations and communities that have experimented with a single smart cities project may want to consider using it as a springboard to pursue an incremental or holistic-city approach (described in more detail below) to begin to develop stronger capabilities and achieve economies of scale across projects in the use of shared infrastructure and human resources.

THE INCREMENTAL APPROACH

In the incremental approach, a local government or other organization conducts one or several pilot smart city initiatives not only to solve individual problems but also to build understanding and develop capabilities that contribute to the growth of a larger smart cities ecosystem.

The demonstration project might feature a particular technology or piece of infrastructure, such as smart streetlights, or it might test a concept in one neighborhood, such as piloting new mobility solutions or creating a smart district. Then, based on the results, the local government can scale up its efforts more effectively. Like a beginning musician who focuses on learning one song to build the skills and motivation to play more complicated music, the incremental approach can help a local government develop the knowledge and organizational infrastructure to construct a more integrated and mutually reinforcing approach to building smart cities applications.

In this framework, planners and other participants can use the principles of design thinking as described in Chapter 4, including ideation and rapid prototyping, to develop and test smart cities projects. Adaptive and opportunistic, this approach places a premium on communication across departments and organizations, community input and feedback, and a commitment to experimentation to continually reassess and adjust the pathway for how to move smart cities applications forward and contribute to the development of a larger smart city ecosystem.

Local governments may discover the incremental approach after trying a stand-alone project, or they may pursue it intentionally from the outset, perhaps with the encouragement of a smart cities technology vendor. Either way, this approach provides an opportunity to test and build a capability over time, spreading out the cost of investment, facilitating identification and engagement with potential partners, and allowing the initiative to track and integrate advances in smart cities technologies and system development techniques.

It can also lead to higher return on investment from each new smart cities project. For example, a community's police department might be testing smart safety cameras, which could also be used to conduct traffic and pedestrian counts more easily (Contreras 2020). A study by ESI ThoughtLab found that cities just starting to pursue smart cities projects were realizing an ROI of 2.6 percent, while smart cities leaders were capturing a 5.6 percent ROI, more than two times as much (ESI ThoughtLab 2019).

The Smart Poles initiative developed by the City of Los Angeles Bureau of Street Lighting, which uses streetlights to host a variety of other useful functions, such as wifi and seismic sensors (as described in the sidebar on p. 67), provides a good example of the incremental approach.

THE HOLISTIC-CITY APPROACH

Instead of simply solving individual problems using smart cities technologies, communities may want to pursue a more integrated, holistic strategy to smart cities development.

One way to do this is to take a planning-driven approach that identifies shared goals and builds an integrated portfolio of smart cities applications to pursue them. Each smart cities initiative occurs within this framework and contributes in a strategic and intentional way to the development of a larger smart cities ecosystem.

The establishment of a smart city vision and goals at the outset allows the local government to harness the power of smart cities technologies in service to community values and a larger community vision, in many cases building on the local government's existing city-wide strategic plan or comprehensive plan. The vision and goals can then be used to create a roadmap for implementation and help prioritize individual projects to pursue, with regular feedback loops to facilitate nimble adjustments over time.

Key considerations in preparing a smart cities strategic plan include the following:

LOS ANGELES: FROM LED TO SMART POLES TO SMART CITY

In 2009, the Los Angeles Bureau of Street Lighting began converting its streetlights to LED to reduce energy use, extend bulb life, and reduce bulb replacement. In the process, it freed up considerable circuit capacity. That set the stage for using light poles to support a host of other public purposes (Figure 5.3).

Today, the LA Lights program includes nearly 20 smart cities functions, including air quality monitoring sensors, broadband connectivity, 5G small cell co-location, EV charging stations, safety cameras, wifi, USB charging, and seismic sensors (Tsurui 2020).

"Streetlights are everywhere. We have the infrastructure, and we have the power," explains Clinton Tsurui, streetlight engineer and lead for the bureau's smart city team. He adds that the smart cities initiative is the product of a culture of innovation within the bureau and the city. The bureau actively reaches out to other departments to explore collaboration and use of the city's streetlight infrastructure, which includes more than 223,000 lights spread over 469 square miles (Los Angeles Bureau of Street Lighting 2020).

The bureau has prepared a plan, *LA Lights: Strategic Plan 2020–2025*, to map out future projects on its journey of digital transformation, including a new software dashboard to enable it to monitor and manage its lights and other smart city solutions from a central location.

Many of these initiatives also support the city's *Sustainability pLAn 2019* to establish a green New Deal for the city by helping to reduce energy usage and improve environmental quality. For example, the city recently installed 13 air quality monitors on light poles in the Watts neighborhood to help measure the air quality benefits of expanded tree planting, cleaner buses, and other sustainability measures in this part of the city. Los Angeles is also developing a city-wide smart cities plan to coordinate its various initiatives across departments (Tsurui 2020). Thanks to its innovations, the Bureau of Street Lighting is helping to illuminate the pathway forward.

Figure 5.3. Los Angeles' smart streetlights (Los Angeles Bureau of Street Lighting)

- Engaging community stakeholders, both at the outset and throughout the process. This work should include soliciting input to find out public needs and concerns about smart cities technologies, as well as providing education to help explain the limitations and the potential of these techniques.
- Establishing an overarching vision and goals, either from the ground up, or building on existing goals included in the local government's strategic plan or comprehensive plan.
- Conducting an opportunity assessment to identify likely areas where smart cities projects can contribute positively to local government functions and the well-being of the community. A more in-depth effort could involve periodic scenario planning to help imagine and evaluate potential future needs and benefits of different smart cities investments.
- Identifying potential smart cities applications and conducting a preliminary screening or a cost-benefit analysis to prioritize them for funding. This could be linked to the annual budget cycle to help these projects compete against other community needs for public investment.
- Identifying funding sources and related partnerships to pilot and implement projects.

Throughout the strategic smart city planning process and beyond, key operational considerations include:

- Promoting a collaborative, cross-disciplinary culture by fundamentally involving representatives from different disciplines and different departments in the program.
- Committing to transparency and trust building, both with staff and with elected officials and the community. This can mean sharing the process for major program decisions and facilitating input and discussion to help stakeholders understand and participate.
- Creating a common data environment to facilitate co-creation, which is discussed in more detail in Chapter 3.
- Taking a multiscale perspective to develop the details needed to make an individual project successful, as well as to understand its relative contributions to other projects and the larger smart cities ecosystem.
- Rapidly identifying synergies and conflicts to seize opportunities, minimize harmful side effects, and resolve potential disputes.
- Seeking partnerships with universities, institutions, private vendors, and other partners to share costs, secure the necessary technical knowledge, and maximize the benefits.
- Tracking progress and making course corrections to help the program keep pace with changes in technology and the evolution of smart cities support systems, such as funding and regulation.

The development of a strategic roadmap to guide integrated investments has the potential to yield economies of scale and synergies over time across applications that deliver more value for each new smart cities project. Given the rapid pace of change, this approach benefits from strong feedback loops and regular communication across departments and organizations.

Planners should note that this approach may be challenging to implement if it calls for large investments early in its development before smart city applications have more fully demonstrated their value. This highlights the importance of engaging community stakeholders to build a shared understanding of the purpose and value of the program, and piloting projects to test strategies before scaling up. If the program supports co-creation by providing open data and other user support, some projects may also emerge organically from the community.

While more challenging and resource intensive to implement, this approach holds the potential to create a more transformative use of smart cities technologies to increase the intelligence and efficiency of services and functions throughout a local government. When led by a carefully crafted vision statement and local goals, a holistic approach to smart city development can contribute to the creation of more equitable, resilient, and prosperous communities. This is illustrated by the experience of West Hollywood, California, and other communities, as described in the sidebar on pp. 69–70.

INTEGRATING THE SMART CITY INTO PLANNING PRACTICE

Smart cities technologies are changing the nature of government services, but planners are often uncertain of their role in this work. Two frameworks provide ways to integrate smart cities techniques into everyday planning practice, and in so doing, give planners ready ways to contribute to realizing the potential of this work. The first is APA's Comprehensive Plan Standards for Sustaining Places (Godschalk and Rouse 2015). The second is the strategic points of planning intervention (Klein 2011).

Sustaining Places Standards for Smart Cities

Smart city applications must be expanded, integrated, and harnessed to serve people and communities. To accomplish this, practitioners and policy makers will need to go beyond

A HOLISTIC APPROACH TO SMART CITIES: THE IMPORTANCE OF COMMUNITY GOAL SETTING

Several years ago, staff in the city of West Hollywood, California, realized the local government was undertaking a number of smart cities projects in isolation. "We saw an opportunity to achieve multiple benefits for the community by coordinating our smart cities efforts," notes Francisco Contreras, AICP, the city's innovation manager (Contreras 2020). As a result, the city decided to develop a smart city strategic plan to involve the public and create a unified framework for advancing its smart cities work.

As consultant Ashley Hand of Cityfi explains, the city also took the inspired step of selecting a planner to lead its efforts. "It's really important to identify the right people within an organization to be the client and empower staff who have a systemic view and strong people skills to develop the cross-departmental partnerships needed to be successful" (Hand 2020).

The city hired a marketing and branding firm—High Pressure Zone out of Los Angeles—to interview residents and ask them about their familiarity with new technologies and what community problems they wanted to see addressed. Next, it hired Cityfi to take this user information and prepare the *Smart City Strategic Plan for West Hollywood,* which it completed in 2018 (Contreras 2020).

Through this process, the city identified five core values: sustainability, mobility, accessibility, resiliency, and transparency, which together formed a SMART framework (West Hollywood 2018). Then it prioritized 14 specific projects organized under three implementation strategies to:

1. Create a culture of data for a smart city hall that is ready for the future.
2. Collaborate and experiment across departments to do more with less.
3. Automate processes for an exceptional customer experience.

This work helped the city take a human-centered approach to "holistically weave technology throughout the urban fabric as a means of improving and enhancing community quality of life," building strong community support in the process. The city now collaborates with vendors to test different smart cities solutions and scale up the ones that work (Contreras 2020).

Along the way, the city did some fun and creative things, such as preparing a short graphic novel to help explain the benefits of smart cities technologies to community residents. Contreras observes that planners are particularly attuned to the impacts of new development and technology on the community, and so are often able to take a more humanistic approach. He adds that seeking user input and developing relatable program messaging has paid off. At the outset of the project, residents expressed concerns about privacy issues and spending public funds on smart cities initiatives. Two years later, they are asking why the city isn't pursuing more smart cities projects (Contreras 2020).

In a similar manner, Chula Vista, California, developed a *Smart City Strategic Action Plan* in 2017 in which it identified four goals to create a city that is connected, responsive, transparent, and innovative (Chula Vista 2017). This has provided an effective framework for organizing a myriad of smart city projects. Signature initiatives include participating as a member of the FAA's Unmanned Aircraft System Integration Pilot Program to test the integration of civil and public drone operations into the national airspace system, as well as serving with the larger San Diego region as one of 10 Autonomous Vehicle Proving Grounds designated by the U.S. Department of Transportation, designed to provide a real-world laboratory to test AV technology (Chula Vista 2021). Together, these efforts have helped Chula Vista establish a compelling brand as an innovative community.

Other local governments have gone through a similar process of goal setting.

- The City of Chicago's *Technology Plan*, released in 2013, establishes five foundational strategies: Next-Generation Infrastructure; Every Community a Smart Community; Efficient, Effective, and Open Government; Civic Innovation; and Technology Sector Growth (Chicago 2013).
- Las Vegas drew from its 2018 *Citywide Comprehensive Strategic Plan* to establish *Smart Vegas* priorities: Create an Iconic Las Vegas, Promote Workforce Development, Become the City of Choice to Develop Smart City Applications, Address At-Risk Populations, Promote Neighborhoods and Preserve Quality of Life, and Enhance Public Safety (Las Vegas 2019).
- Philadelphia used a two-year community engagement process to develop its 2019 *SmartCityPHL Roadmap*, which includes four guiding principles: Locally Inspired, Innovative, Equitable, and Collaborative (Philadelphia 2019).
- Orlando, Florida, used focus groups, surveys, and other public engagement techniques to develop the foundational elements for its 2020 *Future-Ready City Master Plan*: People First, Transparent, Security Focused, Collaborative, Relevant & Timely, Re-

sponsible, Sustainable, Reliable, Resilient, Diversity, and Prosperity for All (Orlando 2020a). Mike Hess, PE, LEED Fellow, director of Future Ready for the City of Orlando, notes, "When a lot of people think smart city, they immediately jump to technology. For us, we had to make sure this was not going to be a technology-led plan. Instead, we worked both internally and externally to define what this meant to Orlando" (Hess 2020).

In each case, the process of goal setting with the public has helped the local government establish a guiding framework and make sure that smart cities investments work in service to community goals.

the current technological focus on improving the sustainability and efficiency of urban systems to address broader issues related to governance, access to and control of data, and equity and inclusion.

Planners have an important role to play in this work. The six principles and two processes defined by APA's Comprehensive Plan Standards for Sustaining Places offer a framework to help guide the evolution of the smart cities of the future.

The principles (Livable Built Environment, Harmony with Nature, Resilient Economy, Interwoven Equity, Healthy Community, and Responsible Regionalism) are normative statements of intent that underlie the goals, policies, strategies, and tactics of a plan. The processes (Authentic Participation and Accountable Implementation) are the planning activities that define the plan's direction based on community values and goals and the actions that will be taken to bring about the community's desired outcomes. The Standards also define planning practices that communities can use to "activate" each principle and process.

While developed for comprehensive plans, the Standards can be adapted for use in a variety of contexts—including the implementation of smart cities. Table 5.1 (p. 71) presents each principle and process with an example of a practice illustrating how smart city technology could be used to address community needs and priorities. The overall goal is to promote a comprehensive and integrated planning approach to creating sustainable, resilient, and equitable smart cities.

Strategic Points of Intervention

Another framework that identifies ways to incorporate smart cities technologies into regular planning practice is the strategic points of planning intervention. Developed by former APA research director William Klein, FAICP, this framework identifies five critical enterprises carried out by planners that hold the most promise for making a change in communities (Klein 2011)—and for advancing smart cities projects.

Visioning and goal-setting. Planners can help engage stakeholders in setting goals and developing a shared vision for smart cities. The commitment of the planning profession to empowering all voices is particularly important in addressing the need for digital equity. In addition to traditional methods like surveys and public meetings, creative public involvement techniques can help involve stakeholders at a time that is convenient to them.

For its *Future-Ready City* master plan, Orlando hosted a virtual workshop online, which stakeholders could visit at their leisure to obtain information, view documents, and provide input (Orlando 2020b). The City of Neptune Beach, Flor-

TABLE 5.1. SUSTAINING PLACES PRINCIPLES, PROCESSES, AND SAMPLE SMART CITY PRACTICES

Principles	Principle/Process	Sample Smart City Practice
1. Livable Built Environment	Ensure that all elements of the built environment—including land use, transportation, housing, energy, and infrastructure—work together to provide sustainable, green places for living, working, and recreating, with a high quality of life.	Incorporate provisions for shared mobility and autonomous vehicles to allow local communities to leverage the benefits of these new technologies while planning for future impacts (McMahon 2018).
2. Harmony with Nature	Ensure that the contributions of natural resources to human well-being are explicitly recognized and valued and that maintaining their health is a primary objective.	Reduce carbon footprints with new technologies such as smart buildings, electric vehicles, smart city lighting, smart grids, and other technologies that conserve energy (McMahon 2018).
3. Resilient Economy	Ensure that the community is prepared to deal with both positive and negative changes in its economic health and to initiate sustainable urban development and redevelopment strategies that foster green business growth and build reliance on local assets.	Provide for "new economy" jobs that utilize non-traditional work arrangements such as telework, innovation districts, flex space, public spaces with access to wi-fi, sharing economy, and co-work spaces (McMahon 2018).
4. Interwoven Equity	Ensure fairness and equity in providing for the housing, services, health, safety, and livelihood needs of all.	Promote equitable, easy access to digital information by positioning internet access across a variety of platforms as public infrastructure (Horwedel et. al. 2015). Work to remove other barriers to digital inclusion, for example by offering digital literacy training.
5. Healthy Community	Ensure that public health needs are recognized and addressed through provisions for healthy foods, physical activity, access to recreation, health care, environmental justice, and safe neighborhoods.	Develop a participatory web-GIS application to facilitate communication between healthcare organizations, patients, and cities on factors that affect community health (Afzalan and Chethan 2017).
6. Responsible Regionalism	Ensure that all local proposals account for, connect with, and support the plans of adjacent jurisdictions and the surrounding region.	Develop a regional smart city strategy addressing access to and use of technology and data through collaboration by local and regional jurisdictions and agencies.
Processes		
1. Authentic Participation	Ensure that the planning process actively involves all segments of the community in analyzing issues, generating visions, developing plans, and monitoring outcomes.	Use a combination of online and traditional engagement methods to bridge the digital divide and involve all segments of the community in determining needs and priorities that smart city technology will address.
2. Accountable Implementation	Ensure that responsibilities for carrying out the plan are clearly stated, along with metrics for evaluating progress in achieving desired outcomes.	Use data and technology, including online participatory platforms that can be easily accessed by the public, to monitor and assess progress in achieving community goals.

Source: Adapted from Godschalk and Rouse 2015

ida, created a virtual engagement hub and hosted a virtual charrette to facilitate remote participation in its *Community Vision Plan* (Neptune Beach 2020).

Plan making. Planners can use their plan-making skills to help develop smart cities strategic plans. This includes organizing the plan-making process and successfully executing it to create a shared vision and a compelling pathway forward. Clear and effective communication on the purpose and approach of the initiative is vital to capturing community input and building support for smart cities investments.

West Hollywood's focus on understanding the user experience and stakeholder needs helped build a strong foundation of support for its *Smart City Strategic Plan*. Las Vegas built on six core priorities identified in its *Citywide Comprehensive Strategic Plan* to craft a "Smart Vegas" approach for using new technologies and data to improve city services (Las Vegas 2019).

Standards, regulations, policies, incentives. Once decision makers have established high-level public policies regarding smart cities, planners can help translate these into requirements for new development projects and more detailed policies, standards, operating procedures, and incentives to help implement the smart cities vision and goals.

For example, Chandler, Arizona, amended its zoning code with revised parking standards to prepare it for increased use of ride-share and autonomous vehicles (Chandler 2018). Las Vegas has structured its Innovation District downtown to support the use of emerging technologies, combining autonomous vehicle licensing with investments in intelligent transportation systems, robust wireless service, and highly accurate road mapping to support use of the area as an AV proving ground (Las Vegas 2021).

Development review. Planners can then apply these new requirements on a parcel-by-parcel basis where they intersect with the plan review process for proposed new developments. For example, a community might establish a "Dig Once" policy, as was the case in Santa Cruz County, California, that requires all construction in its road rights-of-way to include installation of telecommunications conduit, wherever practical and feasible, to support the current or future installation of fiber-optic cable (Santa Cruz County 2015; Kruse 2018). In turn, Loma Linda, California, requires new construction to connect to the city's existing fiber network, with residential and commercial builders obliged to include broadband-capable wiring and fiber-optic interfaces in new buildings (Loma Linda 2021).

Public investment. Planners can help identify, prioritize, and, in some cases, implement public infrastructure projects to advance smart cities goals, such as smart traffic signal systems or public wifi supported by smart poles in high-use areas such as downtowns.

Smart cities projects can be expensive and often must compete against other proposed capital investments, so piloting new technologies can help confirm whether a full-scale deployment is worthwhile. For its *Future Ready City* plan, Orlando developed a strategy prioritization tool that ranked prospective smart cities projects across four areas (readiness, implementation, multiple pillars, foundational elements) for consideration as part of its capital improvements program (Figure 5.4, p. 73) (Orlando 2020a). As described in the sidebar on pp. 76–77, Philadelphia uses a "Pitch + Pilot" approach, inviting vendors to compete at pitch events for the opportunity to pilot their products, with successful pilots then having a chance to scale up for broader deployment.

Partnerships with other institutions and private vendors can help reduce the cost of smart city implementation. Columbus, Ohio, has been successful in collaborating with more than 100 smart cities partners on different projects. For example, the City has worked with Columbus State Community College, the Central Ohio Transit Authority, the Columbus Metropolitan Library, and St. Stephen's Community House, among others, to create smart mobility hubs, as described in the sidebar on pp. 76–77 (Columbus 2021a). Planners should understand and be able to speak to the return on investment (ROI) that smart initiatives can bring to local governments; see the sidebar in Chapter 6, p. 94, for further information on ROI for smart cities.

Programs. As a sixth area of intervention, planners can also help implement new programs such as online public meetings and initiatives. Austin, Texas, provides one example of an open data portal that includes an extensive portfolio of publicly accessible data sets (Austin 2021). In addition, Austin's *Digital Inclusion Strategic Plan* includes actions such as digital literacy training in different languages to help overcome barriers to internet use (Austin 2016). See the sidebar in Chapter 6, p. 89, for more information on Austin's efforts.

Processes. A final area of intervention for planners is to advance the use of different ways to explore and visualize the future. In a rapidly changing world, scenario planning can help communities better understand potential futures to help build greater community resilience and shorten response times to address emerging challenges and opportunities. This work can be supported by 3D visualization, digital twins, and geodesign to create easily explorable digital replicas of human and natural systems. If used thoughtfully, these tools can facilitate rapid and meaningful public conversa-

tions about planning for the future across broad stakeholder groups to help build agreement on a shared pathway forward for the community. Other processes, such as the foresight and design thinking approaches described in Chapter 4, can help planners imagine and prepare for the future and more creatively and nimbly plan for and implement smart city applications accordingly.

By using these techniques, planners can integrate smart city considerations into their everyday work and contribute to the development of a smart cities ecosystem with every new project, policy, or plan.

COLLABORATING TO CREATE A SMART CITY

Planners do many things, and they do almost none of them alone. Collaboration is also critical to smart cities development.

The development of smart cities requires the involvement of many different organizations and types of expertise. A core competency of planners is the ability to work with a diversity of stakeholders and subject matter experts from different disciplines. Planners often translate technical information into lay language to help facilitate mutual understanding and decision making, and they transform broad policies into targeted actions to catalyze effective implementation.

The development of smart cities is a complex undertaking, one that requires effective collaboration with a myriad of agencies and organizations to accomplish effectively. Planners have the skills to play key roles in facilitating organizational communication and collaboration in service to advancing smart cities initiatives and optimizing community outcomes.

Cross-Departmental Collaboration

The development of smart cities places special needs and demands on interdepartmental collaboration. Often, these initiatives may be led by an information technology (IT) department or a special innovation department, if the organization has one, or the IT department might serve as an internal consultant to other departments that function as the client on particular smart cities projects. No one department, however, usually has all the expertise and capacity needed to carry out major smart cities projects.

For example, implementing a "Dig Once" policy, such as those in Santa Cruz County or Loma Linda, often requires coordination between several departments, including IT, planning, engineering, and public works. Such coordination on one project can lead to greater collaboration on other issues. During the pandemic, for example, the New York Department of City Planning's Capital Planning Division used its knowledge of community data and capital facilities to assist in the identification of potential locations for surge hospitals, helping build cross-departmental collaboration and trust in a time of community need (Tuttle and Dillemuth 2020).

Figure 5.4. Considerations for future readiness in Orlando, Florida's Future Ready City *plan (City of Orlando)*

Planners' longstanding use of geographic information systems (GIS) and experience acquiring, managing, and analyzing data provide a frequent point of commonality with IT professionals. A local government may have already completed other collaborative IT/planning projects as well, such as installing an online permitting system or developing an open data por-

tal. If so, the working relationships that resulted could help lay a strong foundation for subsequent smart cities collaborations.

In addition, projects may involve many departments throughout the organization, including finance, engineering, building inspections, public works, parks and recreation, police, fire, and transportation/transit, among others. Planners are well positioned to lead or support collaborative initiatives with all of these departments because their regular work often brings them in contact with staff from these different parts of the organization.

To advance this work, it is helpful to build an understanding of each department's capabilities and needs, and to establish a clear project management structure and coordination schedule. Strong collaboration can help support successful project implementation and maximize the public good accomplished by smart cities initiatives.

Public-Private Collaborations

Collaborations across sectors are also essential to developing impactful smart cities projects and building a well-functioning smart cities ecosystem. From telecom infrastructure to sensors to data storage to analytics to funding, many skills and resources are needed to realize the smart city of tomorrow. In addition, it will take time to carry out projects and build the ecosystem. This places a premium on developing lasting working relationships with various smart cities collaborators. The sidebar on pp. 76–77 offers some examples of how local governments have successfully partnered with the private sector to advance smart city implementation in their communities.

Some key questions planners should ask as they do this work include the following:

- What components do we have in place, and what components do we need to advance smart cities development?
- What role can planners play in facilitating smart cities development?
- What are the potential contributions and needs of partners?
- Where do they fit into the smart cities ecosystem?
- What motivates them to participate in smart cities development?
- How can we engage with them effectively?
- What mutual learning would help our departments or organizations work together well?
- How can we support our partners to help them play their role more effectively?
- What do we need from them?
- What needs to happen next to advance this work?

By asking and answering these and related questions, local governments can improve their ability to form mutually beneficial and lasting relationships with other partners.

After a series of smart city pilot projects that failed to move the ball forward, the City of Boston issued the *Boston Smart City Playbook* to help private smart cities vendors engage more productively with the city (Boston 2021). This included providing real-world examples of how vendors' smart cities tools have worked in solving community problems, learning how city decisions are made to better customize smart cities tools to support these processes, and identifying how smart cities products have been future-proofed and designed to be interoperable to continue to function as standards and technologies evolve. This kind of effort to facilitate constructive dialogue can help very different organizations and agencies work together on smart cities initiatives.

Lack of coordination between the public and private sectors on smart cities projects can hamper their effectiveness and lead to significant wasted effort. One example of this is the e-scooter "war" on cities, in which the idea of a small innovation disrupting city halls overnight became a reality (Dickey 2018). E-scooters, electric vehicles, and the possibility of autonomous vehicles started an important conversation among city planners, policy makers, and businesses: How can cities and innovative companies better collaborate with one another? As Aaron Peskin, the co-writer of San Francisco's e-scooter permit bill, noted, "It would be very nice if the tech bros could come in and ask in a collaborative fashion for permission rather than after-the-fact forgiveness" (Marshall 2018).

The concept of asking for forgiveness rather than permission might work in the testing stages of innovation, but when seeking community-wide deployment, an applicant usually needs a permit to help ensure that they have addressed public goals and project impacts before the local government authorizes the new activity. At times, however, getting a permit from a city can be a frustrating and lengthy process—and for new technologies there may not yet be a permitting process in place. Cities need to provide a fast, clear, and easy way to obtain permits, not just for innovative technology but for other activities as well. In some cases, the pandemic combined with new software tools to spark rapid innovation in this regard. The City of San Francisco, for example, developed and launched a new online permit system to authorize outdoor dining in just a few weeks (Geanuracos 2021).

How then can cities become enablers of innovation more broadly? Successful collaboration—whether between two teams in the same organization or a municipality and a young start-up—requires following a few basic rules.

1. **Building trust.** Respecting the process and the laws and regulations in place to protect the welfare and safety of residents should be among the top priorities for tech companies looking for long-term working relationships with local government. Local governments in turn need to demonstrate an openness to supporting innovative business activities and work collaboratively to create a reasonable framework in which new companies can operate. A community-based, public-private partnership can provide one potential mechanism for collaboration. Another effective approach can be to engage with a consultant or nonprofit such as US Ignite, Transportation for America, FUSE Corps, or the Institute of Electrical and Electronics Engineers that can act as a neutral mediator, facilitating collaboration between cities and tech companies and helping to map out some rules of engagement.
2. **Building tech and policy.** Once a foundation of mutual respect has been established between public and private parties, the real work begins. The potential for building technologies that can solve urban problems will not be fully realized if government policies and regulations unnecessarily impede their development. Public and private stakeholders need to come together and have an open conversation around change and possibilities. Policy makers must be willing to rethink city policies. California governor Gavin Newsome had to issue an executive order to allow telework for public meetings during COVID-19 lockdowns in 2020 (Maclean and Perez-McEvoy 2020). The technology for virtual meetings had been around for years, but there was no will to change policies until it was absolutely necessary.
3. **Building with the community.** Once public-private trust is established and there is agreement on the scope of work and change, cities and tech vendors need to involve the community that will be the users and reviewers of new ideas. This is important not only to build solutions that are closer to users and their problems, but also for decision makers to advocate for change directly to the public. Any partnerships that result can provide a means of sharing talent and resources to deliver new products and services. And as noted above, the public needs to be part of the conversation to set the community vision and goals that guides a local government's efforts in implementing smart city technology.

With their diverse skill sets, communication and facilitation skills, and responsibility to pursue the public good, planners need to be involved on both the public- and private-sector sides of the discussion.

CONCLUSION

As interest grows in smart cities technologies as tools to help improve service delivery and solve important community problems, understanding how to operationalize the development of smart cities projects and the construction of a supportive smart cities ecosystem will be essential to realizing this potential. And as smart cities technologies grow in availability, how do governments sort through the dazzling array of shiny objects to find the jewels that will deliver real value to their communities? From goal setting to public engagement to partnerships to implementation, planners have a key role to play in advancing this work.

Three approaches—problem-driven, incremental, and holistic-city—describe an overarching framework that a local government might use to develop its smart cities capabilities, with the potential to move along this continuum toward a more integrated and impactful approach over time. Planners can use APA's Comprehensive Plan Standards for Sustaining Places and consider the strategic points of planning intervention described in this chapter to integrate smart cities considerations into their regular work. In so doing, planners can help to harness the power of smart cities technologies in service to the values and needs of their communities, one policy, project, or parcel at a time.

To better inform this work, the next chapter highlights the opportunities presented by smart city applications, as well as the challenges communities may face in implementation.

PILOTING AND PARTNERSHIPS

Local governments are spending the public's money, so they are often cautious about trying new things. Yet, the challenges of a rapidly changing world—and the problem-solving potential of smart cities technologies—demand innovation. One way to address this conundrum is by collaborating with other organizations and with vendors to conduct pilot projects to test smart cities applications.

Philadelphia has established a smart city "Pitch & Pilot" framework that establishes two separate tracks. Institutions and vendors that are interested in partnering with the city on smart cities research and development submit a formal request to partner on a specific project. Then a city working group reviews the requests and selects promising ones for design and implementation (Philadelphia 2019). This approach has helped the city solidify relationships with anchor institutions and academia, such as the Penn State AI Alliance (Yates 2020).

The city also issues open calls for solutions to municipal challenges and holds pitch events for solution providers to share ideas. A panel then selects projects for piloting. Successful pilots can lead to a competitive bid process to scale up a solution. One example is a partnership with the company Retrievr to provide on-demand recycling for clothing and electronics, high-value items that often end up in the landfill (Yates 2020). The city is also exploring the possibility of using "gamification" like SimCity software and other techniques to help engage community members in important public decisions. The City of Charlotte, North Carolina, for example, has developed a partnership with Pixels & Potions, a nonprofit organization that utilizes games to create social impact (Yates 2020).

With the explosion in new smart cities applications, some local governments get frequent marketing calls. As a result, vendor management has become an important task. Francisco Contreras, AICP, West Hollywood's innovation manager, says the city's *Smart City Strategic Plan* has really helped with this. When he gets calls from vendors, he refers them to the plan and asks if their technology addresses any of the city's priorities. If the answer is yes, the ensuing discussion could lead to a pilot project. Contreras says that staff is often able to persuade vendors to test their products at little or no cost to the city. This enables decision makers to see how well the merchandise works, and it provides the vendor with a technology showcase (Contreras 2020).

One successful pilot that West Hollywood conducted was for smart bus shelters (Figure 5.6). The City partnered with Outfront Decaux Street Furniture, LLC, to test two bus shelter prototypes on Santa Monica Boulevard with real-time visual and audio bus arrival information, USB charging ports, wifi, and LED lighting. The test was a success and now the resulting public-private partnership is conducting a city-wide rollout of the shelters. In addition to installing new infrastructure at no cost to the public, the city is receiving a share of the revenue from advertising on the shelters, while Outfront Decaux receives a new source of revenue (West Hollywood 2019). Now that's a win-win.

Orlando has taken partnerships to the regional level, working with Orange County, Florida, on a materials resource system study to identify innovative ways to improve regional solid waste management, and with a technology company,

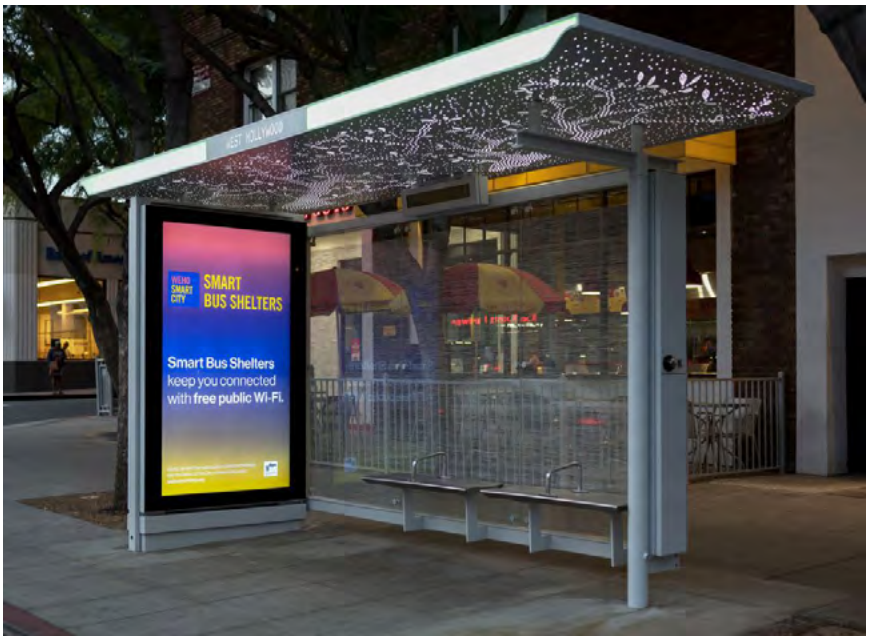

Figure 5.6. West Hollywood's smart bus shelter (Jon Viscott/City of West Hollywood)

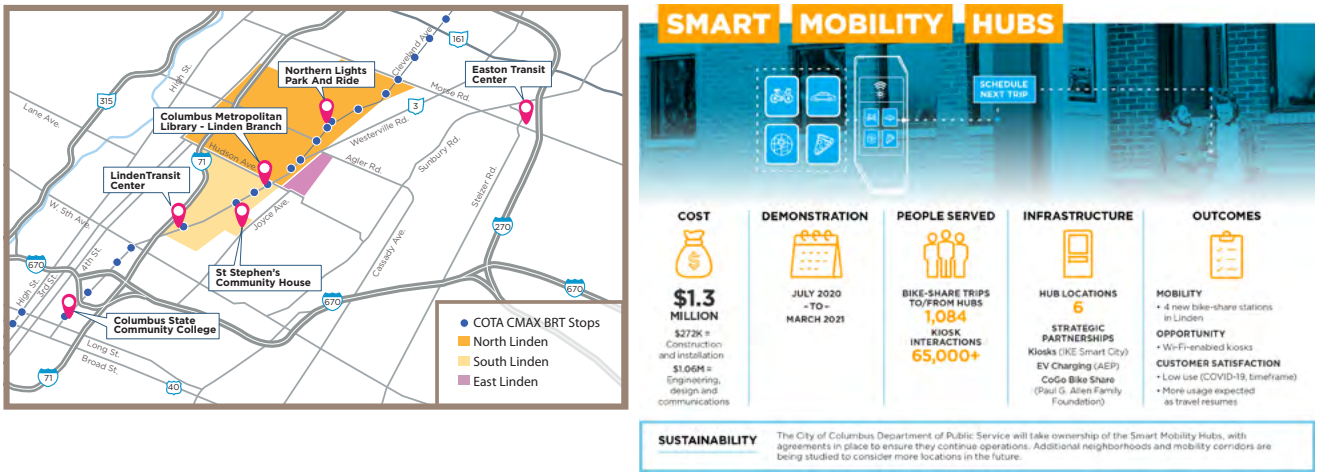

Figure 5.7. Smart mobility hubs in Columbus' Linden neighborhood (Smart Columbus)

as well as Metro Plan (the metropolitan planning organization) and LYNX (the regional transit provider) on a regional rewards program for using alternative transportation, including walking, biking, bus, train, and carpooling (Hess 2020).

The City of Columbus and the Columbus Partnership have built a smart city collaboration that extends across a seven-county area in central Ohio (Columbus 2021b). Funded in part by a $40 million grant from the U.S. Department of Transportation and a $10 million grant from the Paul G. Allen Family Foundation, the Smart Columbus initiative tested numerous projects with a focus on transportation, including self-driving shuttles, mobility assistance for persons with cognitive disabilities, smart mobility hubs, and the development of a multimodal trip planning app.

In the latter two projects, six interactive kiosks were sited in and around the Linden neighborhood, along with consolidated travel options including bike share, scooter-share, ride-share pick-up/drop-off, car sharing, transit, and electric vehicle charging (Figure 5.7). Travelers could also access the new trip planning app to help plan their personal route and transfer efficiently from one mode of travel to another. Partners on this one project alone included Columbus State Community College, the Central Ohio Transit Authority, St. Stephen's Community House, and the Columbus Metropolitan Library, among others (Columbus 2021c).

Five years later, outcomes of this initiative are mixed (Marshall 2021). The effort started with 15 projects and ended with eight (Columbus 2021a). Though some of the proposed projects were cancelled or little used—in part due to the COVID pandemic—city officials consider the initiative a success and gleaned important lessons from the undertaking. Chief among these is the importance of focusing on community needs rather than flashy technology and the need to test applications to determine what works—and what doesn't. And that, in the end, is the purpose of conducting pilots.

As public sector organizations pursue smart cities technologies, they and the communities they serve will need to support thoughtful experimentation and develop an understanding that selected project failures are a necessary stop on the road to overall program success. Developing partnerships can help governments access the resources and expertise they need, and also share the risk.

USING SMART CITIES TECHNOLOGIES IN SMALL COMMUNITIES

Smart technologies are not just for big cities. Smaller communities can use them as well to provide greater transparency, improve internal systems, and deliver services more efficiently to customers. While smaller communities may have fewer resources for such initiatives, they may also have less red tape and be able to act on innovative ideas more quickly (Collier 2018).

Smaller communities around the world are taking a wide range of smart cities approaches to advance this work, including the following:

- **Saratoga Springs, New York** (population 28,212), created a Smart City Commission to work with nonprofit technology advisor NYSTEC to develop a Smart City framework and lay out a *Smart Cities Road Map 1.0* (2016) (Saratoga Springs 2016). The framework includes five domains that are aligned with the city's 2015 comprehensive plan: Better Public Services, Connected Community, Education & Training, Environmental Innovation, and Intelligent Infrastructure (Figure 5.5). The city has been working on 17 initiatives that support the five domains, including expanding residential broadband, improving public wifi, promoting smarter energy, and providing smarter parking and traffic management.
- **Danville, Virginia** (population 40,044), has developed and updated an *IT Strategic Plan* (Danville 2020) to guide its technology investments, which are focused on improving governance, client services, application solutions, infrastructure reliability and security, and innovation development. The city has been recognized by the Center for Digital Government for its IT work and resiliency planning (Grenslitt 2020).
- **Coral Gables, Florida** (population 49,700), set up a Smart City Hub (Coral Gables 2021) on its website that provides links to support local government transparency, increase public engagement, provide access to eGov services such as online bill pay, connect users with open data sets, enable users to see data from electronic sensors that monitor pedestrian and vehicular traffic, and provide maps showing where public wifi is available, among other initiatives.
- **Palo Alto, California** (population 65,364), has an *IT Strategy* (Palo Alto 2020) and has conducted more than 25 smart city projects to improve government transparency and community service, including an open data portal, smart lighting, smart parking and traffic detection, and air quality sensors (Shueh 2017). In 2014, it ran a Palo Alto Apps Challenge to encourage the local development of smart city solutions. In 2016, the city signed an agreement with 20 other U.S. cities "to ensure the responsible and equitable deployment of smart city technologies" (Smith 2018).
- **San Leandro, California** (population 88,815), developed a public-private partnership with OSIsoft in 2012 called Lit San Leandro to improve San Leandro's communications infrastructure and build a fiber optic loop. This work has helped attract new businesses and address the digital divide in the community. In 2017, the City hired a consultant to prepare its *Fiber Optic Master Plan* and smart city strategies to help it provide broadband service at a reasonable cost, and help achieve its *2035 General Plan* vision as a community focused on "technology, research and innovation." The plan calls for managing the public right-of-way, using advanced networks to deliver government services, leveraging public works projects to support the cost-effective installation of telecommunications infrastructure, partnering with local and regional utilities and transportation agencies for joint trench and other cost sharing opportunities, and facilitating competition to encourage universal access and address the digital divide (Magellan Advisors 2017).
- **Saint-Grégoire, France** (population 10,475), developed a "small smart city" program to simplify municipal services, promote a circular economy, and improve communication between community stakeholders and city government (Saint-Grégoire 2020). Specific initiatives include offering more city services online, monitoring building systems to reduce energy usage, facilitating smart parking to reduce congestion and carbon emissions in the city center, providing public wifi, and creating more opportunities for online public engagement.
- **Riihimäki, Finland** (population 28,757), has worked to become a smart city by establishing itself as a capital for robotics in order to promote job growth and improve the community. It is the only city in Finland in which all children receive robotics education from pre-school to high school (Riihimäki 2021). These educational programs are combined with contests and quick trials in the community, such as testing robotics applications in local nursing homes (Ruohomaa, Salminen, and Kunttu

2019). A European Regional Development Fund is supporting this work and a *Riihimaki Robotics Roadmap* shows the town's strategy for smart city development (EFVET 2021).

From online services to broadband to infrastructure management to technology development, smaller communities are demonstrating their ability to use smart technologies to improve their operations and help create smart city ecosystems.

CHAPTER 6

SMART CITY OPPORTUNITIES AND CHALLENGES

Smart cities can provide many opportunities for improvements in cities and communities, such as enhancing resource efficiency, providing opportunities to correct or balance deficiencies from the analog world in digital ways, and offering enormous potential to collect real-time data for movements, flows, and processes that are happening in the community.

However, smart cities can only be successful if they are implemented equitably, allowing access for all, and without compromising the safety and privacy of all community members. Challenges such as data protection, digital inclusion, and an ethical deployment with equitable funding mechanisms need to be resolved for smart cities to be truly smart.

This chapter explains some of the opportunities smart cities provide and how they can contribute to sustainable, equitable, and resilient cities and communities. It also takes a closer look at the challenges and risks related to smart cities and offers solutions on how these challenges can be overcome and risks prevented.

SMART CITY OPPORTUNITIES

Smart city applications provide multiple opportunities to create equitable, sustainable, resilient, and livable cities and communities. Examples of successful implementation already exist across the globe.

Smart city applications can result in the conservation and more efficient use of resources and more successful mitigation of climate change, making cities more sustainable. Smart city operational efficiencies, improvements of related processes, and financial opportunities can enhance quality of life. And digital inclusion can correct or balance inequalities from the real world in the digitally transformed city. Planners and decision makers can use data from the smart city to detect deficiencies and adjust policies to make improvements.

Enhancing Efficiencies

Throughout centuries, technological progress has helped to improve processes, provide more efficient outcomes, and enhance the quality of life for people across the globe. Technology has increased productivity, while making many industries more resource efficient and less polluting. It has enabled us to travel farther away in less time, and it helps us use less to have more.

However, unsustainable implementation and use, unequal distribution, and inequitable access to technology may result in some people being left behind and negative impacts outweighing the benefits. Technology implementation must put people at the center, use natural resources sustainably, and benefit all communities and individuals equally.

An equitable implementation of smart city applications can improve efficiencies in cities in multiple ways. It can improve operational efficiencies of a city by connecting the city directly to the individuals who live, work, and play in it, connecting people to people, and interconnecting infrastructure systems, responding in real time to different needs or issues. It can reduce natural resource consumption and environmental pollution, providing a better quality of life and healthier communities, while mitigating climate change. And it can create financial efficiencies through collaboration with the private sector, experimenting, and prototyping.

Resource Efficiencies and Climate Mitigation

Achieving sustainability goals and resource efficiency in growing cities requires technological innovation. However, technology alone will not result in sustainable solutions without changing consumer behavior (Skinner 1971).

Digitalization and the use of information and communications technology (ICT) in this context can help increase efficiencies while creating awareness among users about their behaviors through monitoring and reporting, and it can bridge gaps where hardware alone is not sufficient through

machine-to-machine (M2M) communication and the internet of things (IoT). Many smart city applications provide green, sustainable, or low-carbon solutions.

For instance, a resource-efficient building that saves energy through insulation, energy-efficient appliances, LED lighting, and on-site energy generation through solar panels can become even more energy efficient with the use of smart technologies. Smart technologies can make energy flows visible in real time and can therefore regulate sustainable consumption by automatically reacting to surges of energy consumption when they occur. Additionally, smart meters can notify a user about an increase in energy consumption and the related increase in one's energy bill in the moment, thereby creating the awareness needed for behavior change.

Feedback and consequences need to happen in immediate succession to be effective (Skinner 1987). Providing immediate information on potential consequences of an action can "nudge" people towards improved decision making or (in this case) more sustainable behavior. Receiving the information about one's increased energy bill a month later is not as effective.

To make a 100 percent renewable energy vision possible, smart grids and energy storage solutions are needed to balance energy peak and off-peak times with the times energy can be generated. Other smart city technology examples that result in less resource consumption range from innovations in vehicle technology (e.g., electric mobility, connected vehicles) to traffic and parking management, to tracking of air pollution through sensors and related environmental actions. There are many more smart city applications that help to improve resource efficiency, mitigate climate change, and protect the environment. Some examples are outlined in more detail in Chapter 3. Using smart tech that results in resource conservation alongside smart tech that nudges people towards resource-conserving behavior is most effective.

Operational Efficiencies and Quality of Life Improvements

Convenience and time savings are just two aspects of quality of life. Smart technology can improve both tremendously.

Being able to look at a transit app to see when the next train will arrive while finishing breakfast at home makes the use of public transit more attractive. Using a scooter that is parked right in front of the house and can be activated by a smartphone app to get from home to the train station may be one way to overcome the well-known "first mile–last mile" issue of transit. This is just one example of how smart tech can make sustainable lifestyles more convenient and less time consuming.

However, many of these applications exclude certain population groups from these benefits—in this case, people who do not own a smartphone, do not have a bank account or credit card, or cannot ride a scooter. Creating inclusive and equitable solutions is imperative and something planners have the means to do. For example, in addition to its online service, the scooter provider could establish a phone service where people without internet connection or smartphone could call to order a scooter. Community services can offer pre-paid credit cards for unbanked community members. And scooter companies could add a diversity of e-vehicles that allow people with disabilities to participate (Zhou 2021).

Additionally, smart city tech can help to create a better connection between government and the people who live, work, and play in the city by enhancing two-way communication. As described in Chapter 3, gov tech can enhance the service quality of governmental services, and civic tech can enable community members to directly engage, more easily participate, and even co-create their city. That way, all can play an active role when planning the smart city, and more diverse needs can be addressed and resolved through grassroots initiatives instead of top-down ideas. People will be able to see themselves as an important part of the development process of their smart city, while learning about the technologies and processes used.

Enhancing the digital literacy of the community is key to ensure no one is left behind and everyone can participate in the city's co-creation. As described in this report, cities such as Vienna (see the sidebar on pp. 16–17) and Medellín (see the sidebar on pp. 49–50) have developed equitable training and education formats. Co-creation and the related feeling of community and belonging will result in a better understanding and acceptance of the decisions made, the technology deployed, and the smart city as a whole.

Financial Efficiencies Through Private-Sector Collaboration

Chapter 5 of this report discusses the need for planners and local governments to collaborate with technology companies. While the challenges lie mainly in the lack of city-wide visioning and the need to plan for the common good, opportunities can be seen in the more efficient and agile ways in which the technology sector works, and in the financial efficiencies that collaboration can create. Cities can benefit from public-private partnerships (PPPs) in which the private-sector company finances a smart city project and the municipality can leverage tax revenue or federal or state funding.

Employing agile methods in planning and implementing smart city tech can also lead to better use of financial

resources. Using experimentation and pilot projects to prototype and try out ideas before full implementation can save governments considerable time and money. Using creative methodologies such as design thinking for traditionally linear processes is becoming increasingly important. The fast pace of change requires processes that allow for faster, more agile adjustments (Fisher 2020).

A "fail fast, fail small" attitude is not yet common in the public sector. However, if projects fail big after years or millions of dollars in implementation, the damage is much greater than if they fail small as a pilot or prototype. Investing in new technology or infrastructure systems always bears a risk, especially if implementation is long term amid short-term change. Minimizing that risk through experimentation and prototyping—and sharing that risk with the private sector through PPPs—may help governments to deploy innovation more quickly and more safely.

Additionally, using smart city technology to improve two-way communication between government and the public can help decision makers better understand the users and their needs, further decreasing the risk of failure and improving decision making on how money is spent. Operational efficiencies, as mentioned above, result in financial efficiencies. For instance, a thoughtful and effective implementation of gov tech can make processes more efficient and therefore reduce required staff time, conserve resources, and save money.

Closing Gaps in Existing Systems Through Digitalization

To achieve their full potential, smart cities must improve quality of life for all. Cities have historically excluded certain population groups from different services, urban amenities, and a variety of activities.

This has happened through the intentional use of discriminatory policies, such as segregation and redlining, but through unintentional circumstances as well. For example, elderly people and people with certain disabilities may not be able to take advantage of the micromobility services provided by scooters or e-bikes. People who live in neighborhoods that are not connected to a transit network may miss out on jobs, healthcare, and other services elsewhere due to the lack of mobility options. The digitalization and implementation of smart cities provide opportunities to correct some of these inequities and close some of these gaps in urban systems.

To create equity where the analog world left people behind will require an equitable deployment of smart city technologies and equitable access to the internet. The challenges related to the "digital divide" and the inequitable distribution of broadband are real and must be overcome, as discussed further below. But once broadband for all is a reality, smart cities can provide innumerable opportunities to ensure all residents have access to a better quality of life.

Smart city technologies offer the opportunity to fill certain gaps in existing systems or services in a city. One example where deficiencies from the analog world may be resolved in the digital world is the opportunity to offer public meetings and community engagement online. Digital solutions can extend the reach of public engagement and increase the number of people participating by offering more flexibility in terms of meeting times and locations. Virtual public meetings allow residents to dial in from wherever they might be (at home, at work, on transit), alongside whatever else they may be doing (eating lunch, preparing dinner, watching the kids).

The COVID-19 pandemic has accelerated the adoption of virtual meetings and online public engagement. This shift has allowed for more inclusivity, but it has created some challenges as well. What about people who do not have internet access or devices to participate? Solutions from local governments have included providing call-in numbers and broadcasting public meetings on local TV stations. It is important that planners carefully plan and design virtual community engagement and public meeting events in ways that identify and meet access needs for specific communities, including elderly people, people with visual or hearing impairments, immigrants and refugees, youth, and people with lower incomes who might not have access to broadband (Ntagora et al. 2020).

Ultimately, a hybrid approach that combines in-person and online access may be the most inclusive solution. When creating such approaches, planners should focus on the most advantageous aspects of each element and how each aligns with their goals for public engagement. For example, online approaches allow people who can't attend an in-person event at a certain location or who have other ongoing responsibilities or tasks to still participate, receive information, and voice opinions or concerns. The benefits of in-person participation include the ability to connect in person to community members and the option to physically experience a project site. Planners should consider what combination of virtual and in-person approaches will result in the best outcomes for a particular project or process.

Equitably deployed smart city applications can make cities more just and inclusive. However, that doesn't mean that the analog world should simply be digitalized. Merely creating an online version of an analog process will most likely not result in any improvements. If a process did not work well in the analog world, it does not make sense to reproduce it in

DIGITAL SOLUTIONS FOR HEALTHIER COMMUNITIES

Smart cities offer a myriad of digital solutions to include people who were left behind in the analog world. These may be implemented in a wide range of areas, including the healthcare sector and the environmental justice field.

Smart air quality sensors measure and monitor air pollution, including parameters such as temperature, humidity, levels of carbon monoxide, carbon dioxide, particulate matter (PM2.5 and PM10), and VOCs (volatile organic compounds). The U.S. Environmental Protection Agency's Air Quality Index (AQI) uses such data to provide information on air pollutant levels, their impacts on health, and how to avoid exposure. AQIs are being reported daily by metro areas with populations of over 350,000. Checking the AQI to plan one's grocery run has become the norm in U.S. West Coast cities that have experienced devastating wildfires in recent years.

Richmond, California, is using air quality sensors to address local air quality and related health challenges. A predominantly Black community just north of San Francisco, Richmond is surrounded by industrial activity, ports, and two interstate highways, a legacy of its World War II-era economic boom. With a $500,000 microsensor project, the city is looking at whether and to what degree these sources may be affecting the local air quality (Ramboll Group 2019). The results of the project will help the community develop actionable plans for improvements. Similar data-driven research is also being conducted in Germany and India to detect and track the origins of air pollutants.

the digital world. Creative and sometimes hybrid solutions that combine analog concepts with digital solutions—as described above for public meetings—can help address the variety of needs of a diverse community.

Data as the New Oil

As described in Chapters 3 and 4, smart city applications enable city governments and planners to collect vast amounts of data they can use in their work to inform planning and policy decisions. Additionally, cities can leverage their data, using it as a currency to negotiate with third-party vendors and partners in exchange for services and insights.

Private-sector firms can use publicly collected infrastructure information to develop and shape new products and services. Local governments can ask companies seeking municipal data to provide community benefits or services in exchange for collecting city-owned data or using public infrastructure. For example, if a city is approached by an autonomous vehicle company to run a pilot program, it could negotiate an exchange of insights and require service in unconnected neighborhoods as part of the permitting process. This would give the city new information on the future of transportation and help improve mobility services in underserved neighborhoods.

The North Texas Innovation Alliance is an alliance among municipalities, agencies, companies, and academic institutions to create a smart region in Northern Texas (including the cities Dallas, Arlington, Irving, Plano, Frisco, and Garland). It has been evaluating concepts to monetize data on land, buildings, lighting, and roads. While open data platforms can support innovation and co-creation in a city, the increased complexity of the available data and the related increasing cost of processing the data may justify a monetization of the data, at least for companies that will create revenue with that data (Wray 2021).

In many respects, data is the new oil (Mavuduru 2020). Its value has been recognized, made visible, and monetized by companies such as Google. Planners rely heavily on data and knowledge about their communities in their work. Data can give insights for innovation, co-creation, and problem solving.

Data is the foundation of the work planners do. Planners collect, analyze, and use data to make decisions regarding the future of their communities. Therefore, planners should participate in the discussion around data and how it is used and shared. Local governments need to develop equitable solutions that allow community members to access data to be able to co-create while charging those who benefit financially from that data.

SMART CITY CHALLENGES

While smart cities offer many opportunities to make cities better and improve residents' quality of life, there are just as many challenges related to smart cities and their implementation.

A key challenge, as outlined in Chapter 1 and reiterated throughout this PAS Report, is the question of the role of the planner in the process of developing smart cities. The need for the involvement of planners to create sustainable and equitable smart cities should be clear by now and will be summarized in Chapter 7.

In addition, planners will face a range of challenges when engaging with or spearheading smart city processes. Inequitable distribution of internet connectivity, complex processes, and skills gaps were mentioned in previous chapters. Additionally, challenges related to data privacy, data gaps and biases, and the lack of funding for smart city projects can slow down progress and may result in outcomes that do not meet a community's goals.

Data Protection and Data Privacy

Smart cities need smart policies. Data has significant meaning, impacts, and applications. It is extremely valuable when used correctly, but if used incorrectly it can have devastating effects on societies and individuals' lives.

Today's world of connected devices is generating a massive set of data points being captured and processed actively in real time, with a reach and scope that is yet to be fully realized. IoT devices, cashless cards, vehicle software, energy grids, and sensors—anything and everything connected to the internet—are sending an array of information to a wide range of data management and operation systems. There is currently no unifying set of regulations, however, addressing where this data will be stored and how it will be sorted, managed—and shared. Each local, state, and national government, and every technology vendor, has its own set of data policies.

Big data poses another challenge: data ownership. As noted above, municipalities can monetize their data and communities can benefit from the monetary value of data. This concept relates to data that is owned by the local government. However, many data points are generated and held by private entities, such as behavior data from navigation applications such as Google Maps and Waze (transportation behavior) and e-store accounts such as Amazon (shopping behavior). Determining appropriate regulations for privately held big data collected from individuals is one of the biggest challenges facing modern policy makers.

While governments around the world are beginning to adopt regulations about data management and ownership, we are still a long way from truly understanding what will be needed to regulate all these different data streams and data sets in a way that protects the individual while making the handling of data still manageable.

Regulations regarding data have been struggling to keep up with the digital revolution. The time when people were able to determine when, how, and to what extent information about them was communicated to others is long over. Obtaining consent from individuals for the collection of their data through IoT devices such as sensors or cameras, which are ubiquitous in public space across today's cities, is impossible. Concerns are particularly raised if it is private companies who collect that data without sharing their approach to data privacy or the handling of that data in general (O'Laughlin 2019). Alphabet's Sidewalk Labs' Toronto Quayside project was originally designed with a multitude of sensors and other IoT devices to track any movement or behavior across the neighborhood. The project was cancelled in 2020, but similar privacy concerns remain in other places across the globe where private companies collect data without developing and sharing a data privacy strategy (Johnston 2020).

The sidebar on p. 86 discusses the current state of data protection and privacy laws in Europe and the United States. Though an in-depth analysis of such laws is beyond the scope of this PAS Report, it is important for planners to be aware of these regulations and their continuing development. When working with data, storing, or sharing data, it will be ever more important to ensure data privacy and manage the data in line with legal requirements. Planners should consult local legal counsel for information on the latest regulations that apply to their jurisdictions.

Cybersecurity

Chapter 3 touched upon cybersecurity as part of the foundation of a smart city. Cybersecurity is a growing challenge for many local governments as the built environment and the individuals in a community become more connected.

As the world becomes more dependent on technology, data breaches and cyberattacks are ever-present risks. Each device that is connected to the internet expands the attack surface, and the number of connected devices is increasing exponentially. In 2003 there was less than one connected device per person across the globe, but by 2010 that number had grown to 1.84, marking the first time that connected devices outnumbered the human population (Evans 2011). By 2019, the number had grown to 7.74 devices per person,

DATA PROTECTION AND PRIVACY LAWS

The European General Data Protection Regulation (GDPR), which went into effect in 2018, is currently the strongest data privacy and security law in the world (Wolford 2021). It requires that data collected, sorted, or processed on EU citizens is subject to EU laws and regulations. This, for example, can limit companies collecting data on street conditions or mapping street views. Google and Facebook have been fined on many occasions (West and Allen 2020).

The GDPR includes restrictions on the use of artificial intelligence and machine learning, such as regulations that "prohibit any automated decision that 'significantly affects' EU citizens [including] techniques that evaluate a person's 'performance at work, economic situation, health, personal preferences, interests, reliability, behavior, location, or movements'" (West and Allen 2020). Under this law, EU citizens are given the right to review algorithms that may affect them, which may impact innovation and technological applications as they can be found in smart cities.

However, a lack of enforcement and many loopholes have made many question the effectiveness of the GDPR, especially when it comes to smart city infrastructure and the IoT. As noted elsewhere, it will be impossible to obtain consent from everyone moving through a city to collect their data (O'Laughlin 2019).

Currently, the United States does not have a national data protection law. With the California Consumer Privacy Act (CCPA), which took effect in January of 2020, California has put in place what is currently the most significant privacy legislation in the country (Marini et al. 2019). The CCPA applies only to California residents and aims to increase users' awareness of how their personal information is used by businesses (O'Laughlin 2019). California's Security of Connected Devices Act (SB 327), which also took effect in 2020, addresses user privacy in IoT applications specifically (George 2020).

While the GDPR and CCPA have many similarities, they also have some significant differences. Most notable in the smart city arena is that while the GDPR applies to "controllers," which can be natural or legal persons or nonprofit, for-profit, private-sector, or public-sector entities, the CCPA applies only to for-profit "businesses" of a certain size that do business in California, collect personal information, and make a specific amount of revenue with selling that data (Marini et al. 2019).

Neither the CCPA nor SB 327 are specific enough about users' rights in relation to IoT. They are a start, however, that encourages the public to begin understanding the implications of their rights regarding IoT data collection in public spaces (Laughlin 2019).

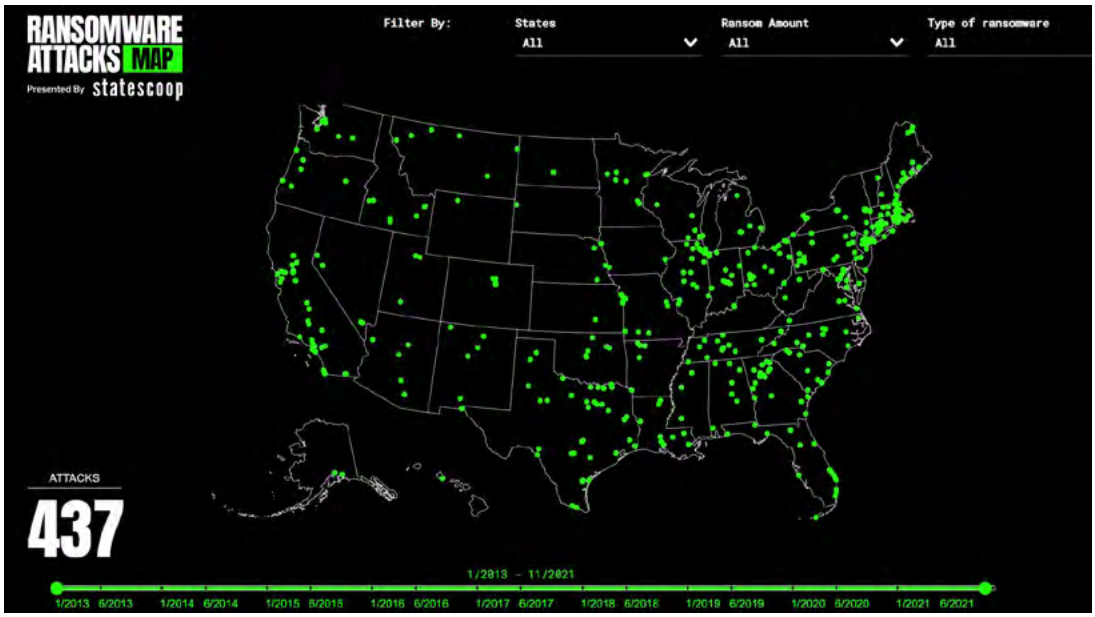

Figure 6.1. Real-time cyberattack interactive map showing attacks on local and state government as of November 2021 (Ransomware Attacks Map/StateScoop, https://statescoop.com/ransomware-map)

and it is expected to more than triple to 25.4 devices per person by 2030 (Holst 2021).

Each smartphone, sensor, camera, or other device connected to the network represents an entry point for bad actors to hack into data and networks, threatening privacy and security. Cities must understand the risks that come with smart city technologies.

Cyberattacks do not have physical boundaries. In a ransomware attack, bad actors gain access to an organization's data and threaten to publish the data online or block access unless a ransom is paid. Local government and cities have been targets of ransomware attacks for years, and these attacks happen daily across the United States (Figure 6.1). In 2019, New Orleans declared a state of emergency after a ransomware attack that coincided with similar incidents in two Florida cities as well as one in California (Patterson 2019). Other major cities such as Baltimore and Atlanta have faced similar cybercrimes in a disturbing trend of increasing cyberattacks on local government and school systems (Cranley 2020). Since 2017, attacks on local and state government have risen an average of 50 percent (Kanowitz 2020). This trend is expected to get worse with the increase in digital services following the COVID-19 pandemic.

In 2021, the SCADA (supervisory control and data acquisition) system of a water plant in Oldsmar, Florida, was hacked. While this attack was resolved without any community member being harmed, this example demonstrates that when it comes to infrastructure systems that distribute vital resources such as water, cybersecurity should be a top priority (Goldstein 2021).

Cyberthreats can compromise not only virtual and physical infrastructure but also the civic process. In early 2020, many U.S. cities moved to virtual public meeting formats in response to coronavirus lockdowns, and many became victims of cyberattacks. Public meetings in Des Moines, Iowa, Kansas City, Missouri, and other cities were cancelled or had to be moved to different platforms due to disruptive or offensive "zoom bombing" activity (Des Moines 2020; Kite 2020; Devereaux 2020). A lack of cybersecurity understanding plus the overnight digital transformation of the civic process opened the door to these cyberattacks. Cities must now play catch-up to get ahead in securing their governments, staff, and communities.

Cities should integrate principles of cybersecurity as a part of staff training and procurement requirements. On an organizational level, local governments need to have a plan for potential attacks. Creating a cyberincident response team similar to one that addresses disasters is a must for all governments. Cities may also consider hiring cybersecurity personnel, which is an area of expertise often lacking in the public sector. While some steps can be taken on an individual level, planners can help make a case for investment from the state and federal levels to help all cities and their IT departments invest in and manage digital infrastructure. The fed-

eral Cybersecurity and Infrastructure Security Agency offers resources to help local governments and other stakeholders better protect against and respond to cyberattacks.

The acceleration of new technology has pushed the digital transformation agenda, but it has also showed gaps and challenges in local government. Digital literacy among planners about basic concepts of cybersecurity is necessary. Home internet connections used by government staff working remotely and the use of legacy devices and infrastructure increase the threat risk.

Planners don't need to be experts in cybersecurity. However, planners should know about the risks of smart city applications and consult cybersecurity specialists and their IT staff when planning to implement these technologies to ensure safe smart cities.

Ditigal Inclusion and Universal Access

For smart cities to be successful, equitable access for all is imperative. Digitalization has been a trend for the last two decades, but the COVID-19 pandemic forced the transition to an online environment practically overnight. Many companies shifted to remote work, schools turned to online schooling, and almost every aspect of life—shopping, entertainment, healthcare, socializing—became virtual.

Tens of thousands of Americans, however, do not have access to broadband internet or are not able to afford high-quality internet (Brookings 2020). In February 2020, almost half of U.S. households with incomes under $30,000 did not have broadband (Hollister 2020), and research indicates that heading into 2021, up to 12 million K–12 students remained underconnected due to limitations of poor broadband mapping data, current infrastructure and supply chains, insufficient marketing and adoption support, and inadequate funding (Ali et al. 2021).

While internet was a luxury in the 20th century, today's digital age makes it an essential utility, necessary to be able to access jobs and education, socialize, visit a doctor, or do one's errands. Not having access to the internet can have severe negative impacts on people's lives. And the more services and systems go online, the more people without access to the internet will be excluded. Now is the time to make digitalization equitable and inclusive, or these inequalities created in the analog world will snowball to irreversible challenges.

Cities across the country and the world acknowledge the importance of digital equity and digital inclusion. In 2019, the City of Detroit hired its first digital inclusion officer, tasked with the goal to include everyone in Detroit's online experience (Quaintance 2019). Many more cities have followed. The National Digital Inclusion Alliance tracks which U.S. cities employ full-time staff for digital inclusion and which ones have digital inclusion plans, funding, and other aspects needed for implementation. One example of a city that is leading the way in this area is Austin, Texas, as described in the sidebar.

The challenges related to digital inclusion—the "digital divide"—are threefold, and not always within the planner's realm of authority. The first challenge is digital literacy. People need to be trained and educated on how to use the internet and how to use the devices that allow them to access the internet. Elderly people and people with certain disabilities struggle with digital devices and therefore risk being excluded from today's digital society. The City of Vienna's *Smart City Wien Framework Strategy* (see the sidebar on pp. 16–17) proposes several solutions to foster digital education, such as city-wide *Bildungsgrätzl* (learning communities) and collaborations with private and academic entities in Vienna's ICT sector to provide trainings.

The second challenge is access to devices. Many people cannot afford the computer, tablet, or smartphone required for internet access. Libraries are one of many community places in a city that can provide the devices needed to access the internet. Transit agencies can provide smart spots at public transit stops so people who do not have smartphones can access the transit app.

The third challenge, and the one most connected to planners' work, is the issue of broadband infrastructure. Just as planners have not thus far been as involved in the development of smart cities as they should be, they have not been involved in the distribution of the infrastructure needed to make smart cities work equitably: the installation of broadband internet. In 2012, PAS Report No. 569, *Planning and Broadband: Infrastructure, Policy, and Sustainability*, outlined this issue: "No area seems to have been left to others by public planners more than that of the communication technology systems connecting us to the Internet and its worldwide resources" (McMahon, Thomas, and Kaylor 2012). Sadly, this has not changed. The installation of broadband internet has mainly been driven by provider companies and their need for return on investment (ROI) instead of planners and the need for equitable distribution.

During the COVID-19 pandemic, creative solutions were deployed to provide internet access for communities that were not connected to broadband. One such program was conducted by the California State Transportation Agency in collaboration with the City of Sacramento and the Sacramento Regional Transit District, along with technology partners. Ten wifi buses offered free high-speed internet for three-and-

a-half hours per day in 140 locations for 60 days (Figure 6.2) (Sacramento Regional Transit 2020). Other cities have piloted public wifi projects in libraries and parks. The investment in bridging the digital divide through public wifi also forms a foundation for future smart city projects (Demers 2020).

While these are ad-hoc (and in some cases interim) solutions that temporarily resolved the acute issue caused by the pandemic, a sustainable solution—that is, universal broadband—is needed to allow all to be successful in this digital era. According to the UN's 2019 *Digital Economy Report*, the communities that are benefiting the most from the digital economy are the ones that are connected (United Nations 2019). Growth in connected communities is on the rise, while the efforts to provide connectivity to all is moving much slower. The report suggests that the deployment of 5G in coming years may further deepen the gap between urban and rural areas. It is a call to action for political leaders to not only invest in connectivity to bridge the gap but to see this as an investment to build a better economy for their communities and future generations.

In some cases, as noted above, digital services need to include analog solutions for people who cannot participate otherwise. One such example is the use of transportation network companies (TNCs) such as Lyft or Uber, or the use of shared bike or scooter systems, all of which require a smartphone and a credit card to access. This poses equity challenges that need solutions. How can people with low or no incomes, people without credit cards or bank accounts, or people without smartphones access these services?

To resolve the challenge of financial inclusion in the transportation sector, Minneapolis bike share provider Nice Ride offers a program, Nice Ride for All, that provides special rates for those enrolled in food assistance programs, and it is partnering with a local nonprofit to provide access to bikes to those who do not have a credit card or bank account (Raza 2019). Similar models can be implemented for any type of shared mobility, mobility as a service (MaaS), and even applications outside of the transportation sector.

Biases and Data Gaps

According to the AI Now Institute at New York University (n.d.), "Data reflects the social, historical and political conditions in which it was created. Artificial intelligence systems 'learn' based on the data they are given. This, along with many other factors, can lead to biased, inaccurate, and unfair outcomes."

Smart cities offer opportunities to collect real-time data for agile decision making. The concept of planning with smart cities uses the smart city as a new planning tool that

AUSTIN'S STRATEGIC PLAN ON DIGITAL INCLUSION

A growing number of cities are identifying digital inclusion as a key goal of their smart cities strategies. Austin, Texas, has taken this work to the next level by convening a digital inclusion steering committee, preparing a digital inclusion strategy, drafting a digital inclusion roadmap report and business plan to implement it, and tracking progress (Austin 2021).

As part of the strategic planning effort, the City of Austin worked with the University of Texas at Austin to conduct a survey in 2014, and found the following (Austin 2016, 2):

- 8 percent of adults do not use the Internet on any device
- 40 percent of nonusers are not interested in using the Internet
- 42 percent of users would need someone to help them to get online
- Nearly all adults own cell phones, and 83 percent own smartphones
- 1 in 4 nonusers feel they do not speak English well enough to use the Internet
- Internet nonusers primarily live in Southeast Austin

The strategic plan identifies 25 actions organized into five categories: Connect, Engage, Include, Integrate, and Coordinate. The specific actions range from conducting a marketing campaign on digital inclusion programs to providing diverse language offerings for digital literacy training, with the current status of each action updated on the city's website (Austin 2021).

allows for ever larger datasets (big data) and real-time data. Artificial intelligence (AI) enables us to process and make sense of the data.

However, planners need to be aware that though datasets might be getting bigger and bigger, they most likely still exclude data about certain population groups whose needs should be heard as well. This data bias accumulates in a snowball effect when data is collected, analyzed, evaluated, and used for decision making, as the population groups left out (the data gaps) will not be represented in that decision. The outcomes could be even more inequitable when AI makes decisions with algorithms that use the available data and is trained by that data through the process of machine learning.

Incomplete Datasets

Datasets are often incomplete. This has resulted in planning decisions that were biased by the data that was available, typically based on a default population group (usually white males). Inclusive planning processes, gender mainstreaming, and approaches to planning with diverse communities try to resolve inequalities coming out of planning. However, issues related to data gaps have not yet been resolved.

As an example, transportation planning focuses on commuter patterns and related data. Efforts to build transit capacity revolve around rush hour times for a nine-to-five society. The results, however, exclude population groups that are not living and working on a nine-to-five schedule: caretakers, the very young, the very old, and others. Additionally, people who need to make multiple stops ("trip chaining") end up paying a much higher price for their transportation needs. Parents—in most cases, women—who need to drop off their children at school or daycare on their way to work pay extra every time they get back on the train or bus. This is the result of planning with average numbers or generalized data instead of looking into the specifics (Criado Perez 2019).

Different population groups have different needs. These needs must be addressed equitably, or there will always be population groups that are left out. This is especially important in the current era of big data and AI. Knowing about the inaccuracy and incompleteness of datasets is crucial. It is imperative to know where the data comes from, how it was collected, and what the data gaps are that need to be filled so no one will be disadvantaged. For instance, data collected through crowdsourcing of cellphone data excludes people who do not have smartphones and will therefore not represent a complete picture of the community.

One of the world's biggest crowdsourcing platforms, Open Street Map (OSM), collects data about roads, trails, cafes, services, railway stations, and many other amenities in places across the world. More than one million users are adding data to the platform. Planners and decision makers can use the data from this open-source platform for their work.

Figure 6.2. The Sacramento Regional Transit District's WiFi Bus (SacRT)

Most contributors, however, are male, and the mapped content might not always reflect women's perceptions, which can be different—especially when it comes to topics such as safety issues or general needs in daily life (Kalms, Johnson, and Matthewson 2020). For example, women are more likely to add amenities such as public toilets or domestic violence shelters, which may be less important for the male community. A group called GeoChicas has been working on changing this since 2016, introducing women to this platform and collaborating with OSM on the integration of amenities that are useful to women. Adding more diversity to the group of data contributors is crucial to achieve equitable outcomes when using OSM for planning (Moloney 2020).

Data Gaps Can Be Deadly

Increasingly, applications use AI, in which algorithms make decisions or problem-solve through automated processes (Lenzen 2018). AI can work with huge amounts of data that could not be processed otherwise. But questions arise about the use of AI and its abilities to be "neutral" towards all population groups.

One could assume that an algorithm based on rationality would include everyone equally and be bias-free. However, there are three risks attached to that idea. First, an algorithm is only as fair as the person who wrote it; it will reflect the biases of its creator. Second, if the data the algorithm uses does not represent the entire population, the algorithm will exclude everyone whose data was not included. And third, to correct and balance out today's inequalities, solutions need to be equitable and allow for equal outcomes for all. Algorithms need to be programmed to make fair decisions that reflect all of society and not just one part of it.

Data gaps have been detected in AI and machine-learning applications used for autonomous vehicles. Researchers at the Georgia Institute of Technology showed that self-driving cars were more likely to kill people of color than white people. The reason for that was twofold: The database of photos that was used for machine learning to train the algorithm mostly contained pictures of white people, and the algorithm was not programmed to detect people of color in the same way it would detect white people. A more diverse dataset and a fair algorithm could have resulted in better outcomes (Hao 2020). However, this poses another question: What will happen if the car must decide between running over an elderly woman or running over a young man? What will teach the algorithm to make the right ethical decision, and what will the data look like that will be used for that training?

Filling Data Gaps to Avoid Algorithmic Bias

In 2019, New York City created the position of Algorithms Management and Policy Officer, a role reporting directly to the mayor. In addition to helping different departments use big data more effectively, the position will also daylight assumptions behind algorithms to make their use more transparent, fair, and equitable in all the tools and applications the city is using (New York 2019). Mayor Bill de Blasio issued Executive Order 50 in November of 2019 to create the position, noting that "traditional governance frameworks must evolve and adapt to ensure that principles of fairness, transparency, human-centered design, and privacy protection remain central to government practices" (New York Office of the Mayor 2019). The position implements one of the recommendations outlined in a report of the Automated Decision Systems (ADS) Task Force convened to study the topic (New York 2019).

It will be important for planners to become part of the discussion around data gaps, algorithmic biases, and ethical AI to make sure that the planning tools of the future will support ethical and moral outcomes. Three factors are important regarding AI and automated decision making for the common good (Zweig 2019):

- The quality and quantity of the data used
- The nature of the question or problem that needs to be resolved, how it is defined, and transparency around it (i.e., what do we ask the algorithm to solve and do we ask the question in the right way?)
- The definition of "common good" and the identification of the ethically correct or morally acceptable outcome

Big data is often defined through three V's: volume, velocity, and variety. Planning for fair and equitable outcomes requires the addition of value and validity of data to the mix (Zweig 2019).

There are several actions planners can take to avoid bias and data gaps in their work. It is important to know where data is coming from, how it was collected, and which population groups are not represented in that data. If the data collection method did not capture the diversity of the community's needs or population groups, planners need to find ways to collect the data that is missing or use a different methodology. Transparency and traceability while ensuring data privacy are key for identifying the gaps.

Funding

As discussed in multiple chapters of this PAS Report, technology needs a purpose and should not be implemented just for technology's sake. Related discussions revolve around funding opportunities for smart city innovations.

Local governments need to look at the return on investment (ROI) of data analytics (as discussed in Chapter 5), enable their communities to innovate, and support the transition from pilot projects to city-wide implementation and integration. The sidebar on p. 94 explains how ROI is being used to advocate for public-sector smart city investments.

In addition, funding needs to be equitable. Everyone must be able to benefit from the smart city, not just wealthy people and specific neighborhoods. Funding opportunities should be available and accessible for all potential drivers and implementers of smart city projects, and the projects that receive funding should benefit all population groups.

Funding considerations relating to smart city implementation include the following.

- **Funding as a part of long-range planning.** Though few local governments are explicitly investing in smart city solutions, many city departments and transit agencies are actively investing in technology for efficiency and security—which is the foundation of the smart city. As discussed in Chapter 5, cities will need to integrate these fragmented investments into the overall picture of long-range planning, however, for the most effective and efficient community outcomes.
- **Funding for building a digital workforce.** Cities should also consider partnership investments in skills that will have an impact on the overall growth of the digital community. For a smart city to be successful and inclusive, digital literacy of the community is key.
- **Funding for local economies and businesses.** Investment in smart city approaches needs to be part of a city's economic growth vision, from individual upskilling to harnessing the power of technology to help local businesses thrive. For example, a zoning-based application could help a small business owner find an optimal location based on multiple data points from a common data pool shared by agencies in a region.
- **Funding and financing innovation.** Creating a community of software developers, policy experts, and user experience and user interface (UX/UI) designers and analysts can help foster a community of innovators. Code for America, a volunteer-based organization, operates across the country with individual chapters fostering technology-enabled solution building for local governments. Cities can invest in project with grant funding, but also with resources and expertise.
- **Funding to scale pilots citywide.** Once a pilot is successful, then what? Cities need to build partnerships to plan and execute scaling for viable solutions. This can be a shared venture with local partners or a regional effort where shared cost agreements can help multiple municipalities scale up a successful pilot.

The biggest challenge in this area remains finding the funds to support innovation. Many cities struggle to find dollars to support innovation, yet most are spending significant portions of their budgets on management of aging legacy technology. According to the U.S. Government Accountability Office, 80 percent of the federal government's $90 billion IT budget in fiscal year 2019 was slated to be spent on operations and maintenance of existing IT investments, including legacy technology (U.S. GAO 2019). The Department of Health and Human Services, for example, has systems as old as 50 years that are high cybersecurity risks. Legacy systems consume a large piece of an agency's technology budget, so the challenge is managing upgrades while supporting day-to-day operations. IT services management needs to be aligned with investment, which is a bigger undertaking than trying to find money for innovation.

With the strong involvement of the private sector in smart city projects, it makes sense to collaborate with the private sector when it comes to funding them as well. The options range from completely publicly funded projects to hybrid versions to privatization. An analysis by the European Commission found that 41 percent of smart city projects were funded by a hybrid of public-private funding, about 49 percent by public funding alone (federal, state, or local funding), and only 10 percent solely by the private sector (Deloitte 2018). The sidebar on p. 95 offers more information on funding smart city projects.

Some examples of how cities in the United States are funding smart city initiatives include the following:

- **Local bonds.** Atlanta issued $250 million in general obligation bonds, collected as part of property taxes, for improving infrastructure through smart city projects (Hudson 2017).
- **Federal funding.** In 2015, the U.S. Department of Transportation launched its Smart City Challenge, offering $2 billion in funding for the creation of a smart transportation system. 78 cities submitted proposals and seven were chosen as finalists: Austin, Texas; Columbus; Denver; Kansas City, Missouri; Pittsburgh; Portland, Oregon; and San Francisco. The winner was Columbus, with its holistic, integrated plan that focused on community needs and proposed a mix of connected infrastructure systems, autonomous vehicles, electric vehicle charging infrastructure, and an integrated data platform (U.S. DOT 2016).
- **Private-sector funding**. The private sector can fund innovation through competition as well. Private foundations such as the Bloomberg Foundation have been funding urban innovation projects (Bloomberg Philanthropies 2021). Additionally, private companies can act through direct investment in projects, such as Sidewalk Lab's investment in the Toronto Quayside project, which as noted elsewhere in this report was ultimately cancelled.
- **Public-private partnerships.** PPPs are not a new concept for cities. Many have created PPPs for infrastructure de-

velopment and maintenance. The Dallas Innovation Alliance is one example of a smart city PPP. The alliance includes three dozen partners across the public, private, civic, and academic sectors and more than 20 city departments (Newcombe 2019).

Ultimately, the funding and financing challenge for smart city projects boils down to planning and management of infrastructure, support of innovation, risk tolerance for new investments, creating an ROI model, and aligning policies with the changing needs of communities.

CONCLUSION

Smart cities offer many opportunities that can help planners tackle some of today's primary planning issues, such as inequality, climate change, and budgetary constraints. However, to achieve successful smart cities, planners need to overcome challenges and create solutions to ensure smart cities are enhancing the quality of life for all while protecting the environment. This chapter highlighted some of the most promising opportunities provided by smart cities while also acknowledging the real challenges that lie ahead on the path to equitable and sustainable implementation.

Successful smart cities require technological advancements in cities and communities that are people-centric, not technology-centric. Therefore, it is important for planners to spearhead these processes while collaborating with technology companies. The final chapter of this PAS Report will shine some light on the potential of planners to do this work—and what the future of the planning profession may look like in a digital era where smart cities are the new normal.

SMART CITY RETURN ON INVESTMENT

As local governments and other organizations work to evaluate proposed new smart city technologies, products, and services, calculating return on investment (ROI) should be a key component of any such assessment.

In its simplest form, ROI consists of calculating the net profit resulting from the deployment of a new product or service, dividing it by the cost of the investment, and multiplying by 100 (Stobierski 2020). The resulting percentage provides a valuable tool in comparing the financial benefits of different smart city investments.

Say, for example, that a local government invests in software that enables developers to submit development permit applications online. The software has a one-time cost of $20,000; will reduce the staff time needed to process permits by 20 percent, resulting in an estimated annual savings of $5,000; and is projected to have a five-year life before it needs to be updated or replaced.

To calculate ROI, the local government would calculate net profit as the total savings (5 years x $5,000 savings/year) and subtract the cost of investment ($20,000) to arrive at the net profit ($5,000). The ROI would be the net profit ($5,000) divided by the cost of investment ($20,000) x 100—in this case, 25 percent.

In practice, this calculation is usually more complicated. It may be difficult to project what the potential time savings might be. In addition, there may be additional variables that need to be considered. For example, on the cost side, the vendor might also have an annual maintenance fee that would need to be included. In turn, the local government might need to dedicate staff time to facilitate the initial software installation and maintain a help desk to provide ongoing user support. On the benefit side, customers might also experience a savings in staff time needed to apply for permits, and local governments might see a reduction in permit processing inquiries to local staff now that customers can check the status themselves as needed online.

Given these variables and the frequent uncertainty associated with them, more sophisticated analysts may conduct a "sensitivity analysis" to see how the output from their financial model might vary in response to changes in assumptions. Some analyses can get very detailed. Siemens and Arup developed a model to calculate ROI for digital urban infrastructure that includes 350 inputs, considering not only typical cost-benefit factors, but also the value to the city, investors, and others (Findlay 2017). In addition, the anticipated ROI calculated at the start of the project will often differ from the actual ROI after its completion.

ESI ThoughtLab (2019) used ROI analysis to evaluate the impact of various smart city measures used in cities across the globe. The 100 cities that it studied projected they would spend $141 billion on these projects, or $1,220 per resident, on average. The typical ROI ranged from three to four percent per initiative.

While financial metrics provide an important means of evaluating and justifying projects, however, they are not the only consideration. Respondents from about half of the cities that ESI ThoughtLab studied said they would spend money on a project that had no or a negative ROI if it advanced an important community goal (ESI ThoughtLab 2019).

Communities are also finding creative ways to share the costs of new smart cities projects, which can help make the case for these investments. Two approaches local governments are using include partnering and conducting pilot initiatives, sometimes at vendor expense, to see if a product is worth scaling up for widespread deployment (see the sidebar on pp. 76–77 for more information on these approaches). But given the frequent limitations on available resources, communities will often have to build the case for investing in smart cities projects, and ROI can help them do it.

FUNDING FOR SMART CITY PROJECTS

The public sector needs to lead the way in smart city funding, but the scaling can be done in partnership. When making decisions about how much private-sector involvement is desirable, local governments need to be aware of the increased risks—as well as the increased potential for innovative solutions—that come with growing private-sector involvement.

According to the 2018 report *The Challenge of Paying for Smart Cities Projects* from the consulting company Deloitte, different funding mechanisms require different procurement structures. The following exist in the smart city arena (Figure 6.3) (Deloitte 2018, 16–17):

- **Direct delivery**: The public sector provides goods or services directly to the customer using the public sector staff or assets.
- **Conventional procurement**: The public sector defines its requirement for goods or services, procures them via traditional procurement and contracting methods, and pays for them.
- **Operating contracts**: The public sector contracts with a vendor to provide goods and services. These short-term contracts may cover a range of activities, from technical assistance to full responsibility for the operation and management of a public infrastructure asset.
- **Licensing**: Typically used for procuring technologies, these agreements generally come in two varieties: perpetual licenses, which are one-time, up-front capital expenditure purchases, and subscription licenses, supported with regular payments from operating budgets.
- **Long-term lease**: Leasing property or equipment provides flexibility and reduces up-front costs.
- **Joint venture (JV)**: Under this structure, the public sector joins with the private sector to jointly deliver a service or asset to maximize the strengths of each party; sometimes this structure is used by the public sector to involve itself in a project by providing assets rather than funding.
- **Public-private partnership (PPP)**: Under this structure, the government contracts with the private sector for the provision of a service. The delivery of the service may involve the construction of a related and underlying asset; however, payment is made based on performance and availability of the service. This allows the public sector to transfer some risks to the private sector.
- **Franchising**: An agreement to allow others to operate government-owned assets on a commercial basis to generate returns.
- **Privatization**: The private sector is fully responsible for the design, delivery, or operation of projects or assets that provide (or previously provided) a public service. The public sector has no direct control over these entities except for legislation and regulation.

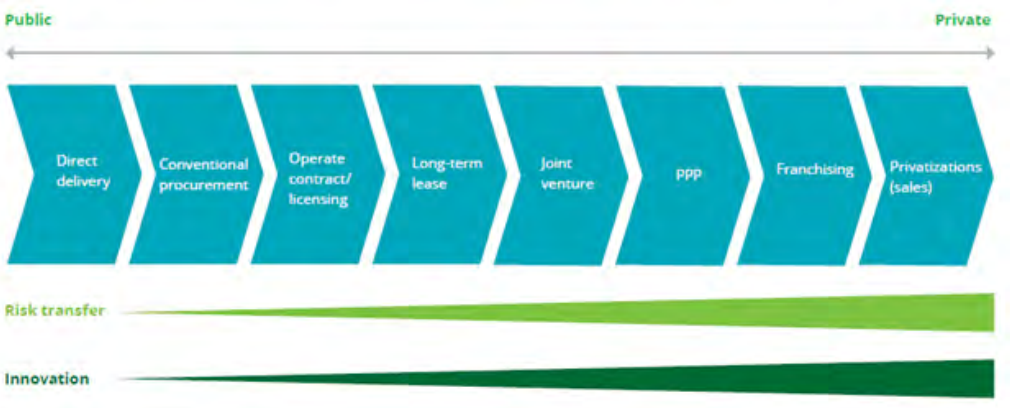

Figure 6.3. Different funding options on the public-private sector spectrum offer differing levels of risk and innovation (Deloitte 2018)

CHAPTER 7

LOOKING AHEAD

The digital era has arrived, and with it the digital transformation of cities and communities. Almost anything in life can take place in a virtual world today, and the COVID-19 pandemic has accelerated this trend, spurring changes and new trends in lifestyles, social behaviors, economic structures and systems, and the built environment.

Planners, and the planning profession as a whole, must be prepared to serve their communities as leaders and guides in a world of rapid technological and social change. Only then can the truly smart city—one that equitably integrates technology, community, and nature to enhance its livability, sustainability, and resilience, while fostering innovation, collaboration, and participatory co-creation—be achieved.

It will require commitment and willingness to continuously evolve and innovate. Being the connectors between the community's needs and technological possibilities, planners need to aim at collaboration and creating trust amongst all stakeholders, building bridges to create mutual understanding. They must make sure everyone has the opportunity to actively participate in the process and that no one is left behind.

Smart cities are a product of the digital era we live in today. The question is not whether planners should plan for smart cities, but rather how they can do so in equitable and sustainable ways. As pointed out in Chapter 1, smart cities should be the state of the art in planning practice. Smart technologies offer myriad opportunities to enhance the quality of life in communities, if planned and implemented in the right ways.

The world around us is changing and the planning profession needs to evolve with these changes. This may mean adding new processes, tools, and planning competencies as laid out in this report; it may also mean a reinvention of what planners do and what their roles are supposed to be. While the goal of planning remains the creation of great communities for all, the path to get there can be improved and made more effective and inclusive by using state-of-the-art technology. Improved communications between stakeholders, enhanced service quality, and empowerment of all community members to experiment and co-create can be powerful outcomes of smart cities that planners should emphasize in their work.

PREPARING FOR A SMARTER FUTURE

Planners play an essential role in shaping the future of communities and in preparing community members for what is on the horizon. It is therefore the planner's responsibility to be prepared and ready to guide communities towards an uncertain future, while providing equitable and sustainable outcomes.

Looking ahead, for planners to be successful in the future and to be able to spearhead smart city developments, they must consider two aspects in their work (Hurtado 2021). Planning needs to be people-centric and technologically advanced, and planning processes need to become more agile while considering multiple plausible futures.

People-Centric and Technologically Advanced

In planning, preparedness is key. Challenges should be proactively addressed before they become problems. While smart cities seem to be all about technology, they underscore the importance of the human factor of planning.

As discussed in Chapter 1 of this PAS Report, technology needs a purpose, and planners are the ones who can determine that purpose based on the community needs and goals. Planners can use technology to prevent problems, to resolve challenges, and to achieve an envisioned future. To do so, planners must keep up with technological innovation and learn about smart city technologies, while emphasizing their roles as community facilitators, consensus builders, and change agents.

Many existing inequalities related to the use of technology could have been avoided if diversity, equity, and inclusion had been part of the implementation process. This is where the role of the planner comes in. If planners do not learn about the technologies that tech companies implement in

their communities, they will not be able to facilitate equitable deployment. Thus, they risk creating additional inequalities in the future or missing out on opportunities that could have improved the community or resolved existing issues.

Additionally, planners can use smart cities to improve their own processes with the data that can be collected from smart city applications. For data analytics, it is crucial that planners use a people-centric approach here as well. Data needs to be used responsibly and in transparent ways. Data gaps need to be resolved for inclusive outcomes.

Planners should see themselves as the connectors between community members and technological possibilities, embracing meaningful innovation. Partnerships and collaboration with the tech sector instead of competition or conflict are imperative to generate innovative solutions that are beneficial and valuable to all individuals within a community.

While smart cities and the digitalization of systems and processes may cause an impression of anonymity and personal disconnect, they can be used to create better community connections and a sense of belonging. As the story of Medellín shows (see the sidebar on pp. 49–50), smart city technology can take civic inclusion, active participation, and co-creation to the next level if implemented in equitable ways. Diverse perspectives are needed to plan for a diverse community. By including the individuals of a community in the planning process or letting them create their own planning processes, planners can address the true root causes of challenges and resolve those instead of just the symptoms. Instead of sending additional police into the streets, Medellín focused on providing education and building hope to combat violence and crime, and it was very successful with this approach.

Agility and Future Literacy

Today, the only constant is accelerating change. This is especially true for the pace of technological innovation and related disruptions in the smart city field.

While communities are trying to accommodate and find the right policies for tech and business innovations, such as transportation network companies and shared scooter programs, more disruption is waiting on the horizon. Self-driving cars will enter the markets soon, and according to NASA, flying taxis could serve as public transit services as soon as 2028 (Hurtado, Sauceda Hannon, and Stephens 2021). Artificial intelligence will likely be the most disruptive force in technology in the coming decade (Rana et al. 2017), and the implications for planners and the planning profession are still unclear.

The COVID-19 pandemic and related extreme disruptions taught planners a lesson that will be useful when looking at technological progress and related smart city developments: conventional planning processes are not nimble enough to pivot and quickly adjust when disruption happens. During the pandemic, emergency orders were necessary to make changes (e.g., pop-up bike lanes or shared streets) when communities needed them, not months or years later.

While planning is a future-focused, long-term task, it needs to allow for adjustments along the way. What might look like a desirable community vision from today's perspective may change into something irrelevant or harmful in the future. The future is uncertain, and therefore plans need to be nimble—or as Hoch (1994) put it: "Planners compose and offer advice on preparing for an uncertain future."

SHAPING THE SMART CITY

Planning is a multifaceted profession. This often makes it difficult to define what planners do; however, it is a real advantage when it comes to planning with and for smart cities. There are multiple opportunities for planners to play an important role in the development of smart cities and to prepare their communities for a smarter future:

- Planners can (and should) spearhead the process of planning for smart cities and integrating smart city applications into community systems. This can be done by including smart city solutions into long-range community visioning and comprehensive plans. An integration of smart city tech into existing plans instead of having a separate smart city strategy can furthermore make the outcomes more sustainable and equitable, as technology will be used to achieve community goals and not for technology's sake. The more foresighted the approach, the more sustainable the outcomes will be (see Chapter 4).
- Planners are facilitators and consensus builders, and in this role, they can serve as the connectors between the community's vision, needs, and challenges and the technical possibilities that can help resolve issues and achieve goals.
- Planners prioritize community outcomes, aiming for equitable solutions. While tech companies often prioritize profits and market growth, it is the responsibility of the planner to put the common good first.
- Planners can be involved in drafting new policies or standards that may be needed for smart city related innovations. Policy usually lags behind innovation. But when planning for the future of a community, planners should proactively initiate discussions around needed policies.

To prepare for shaping the smart cities of the future, the planning profession will have to adjust and redefine planning competencies. Increasingly, planners will need to be equipped with general knowledge on smart tech and how it can be equitably implemented and operated. They will also need the ability to translate that knowledge into lay language and planning contexts. Planners will need new skillsets that allow them to more effectively work in a fast-changing environment, allowing them to pivot and add more agility to planning processes, as discussed in Chapter 4. Planners will also need to learn future-focused approaches and be able to work with multiple future scenarios to create more foresighted and more resilient plans.

The academy has a role to play. Planning schools and educational programs should update their planning curricula to prepare their students for emerging tech applications in the planning field. This could include more focus on education about smart technologies and how they can be used equitably and sustainably in cities and communities.

Planners collaborate with many different disciplines, including civil engineering, architecture, landscape architecture, and sociology. They traditionally have not connected with the information and communication technology (ICT) or the smart tech sectors, but as this report has shown, these sectors are increasingly relevant to all fields, including planning. Besides offering opportunities to learn more about tech systems and how they can best benefit communities, the ICT sector uses workflows that incorporate the more agile methods needed for addressing a quickly changing world. Planners should explore how collaboration with IT and technology sectors can inform planning practices and processes as well.

In today's quickly changing world, practitioners in all professions must continuously upskill in line with changing needs and requirements, and planners are not an exception. The American Planning Association is working to help planners better understand the evolution of planning skills, identify new requirements in the field, and connect to related training opportunities. Planners should also explore offerings provided by other professions and organizations for further training and educational opportunities.

THE FUTURE IS NOW

We are in the midst of a digital revolution. Everyone needs to adjust and pivot as innovation is changing how people live, work, and play. Planners need to become a driving force of this revolution and embrace meaningful innovation. The holistic perspective planners provide in their work and the people-centric approach they take are imperative when shaping the future of smart cities and communities.

The deployment of smart city technologies will happen with or without planners. However, planners are needed to integrate these technologies into a holistic community vision, to ensure equitable and sustainable implementation and operation, and to create solutions that will benefit all community members.

The digital era provides opportunities like never before. Planners should embrace these innovations and the opportunity to create smart cities to benefit community members, improve local government operations, correct planning mistakes from the past, and shape a better future. Only in a climate that fosters innovation, collaboration, and participatory co-creation will smart cities live up to the promises they offer of livability, sustainability, and resilience for all.

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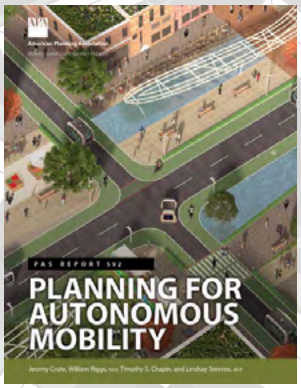

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