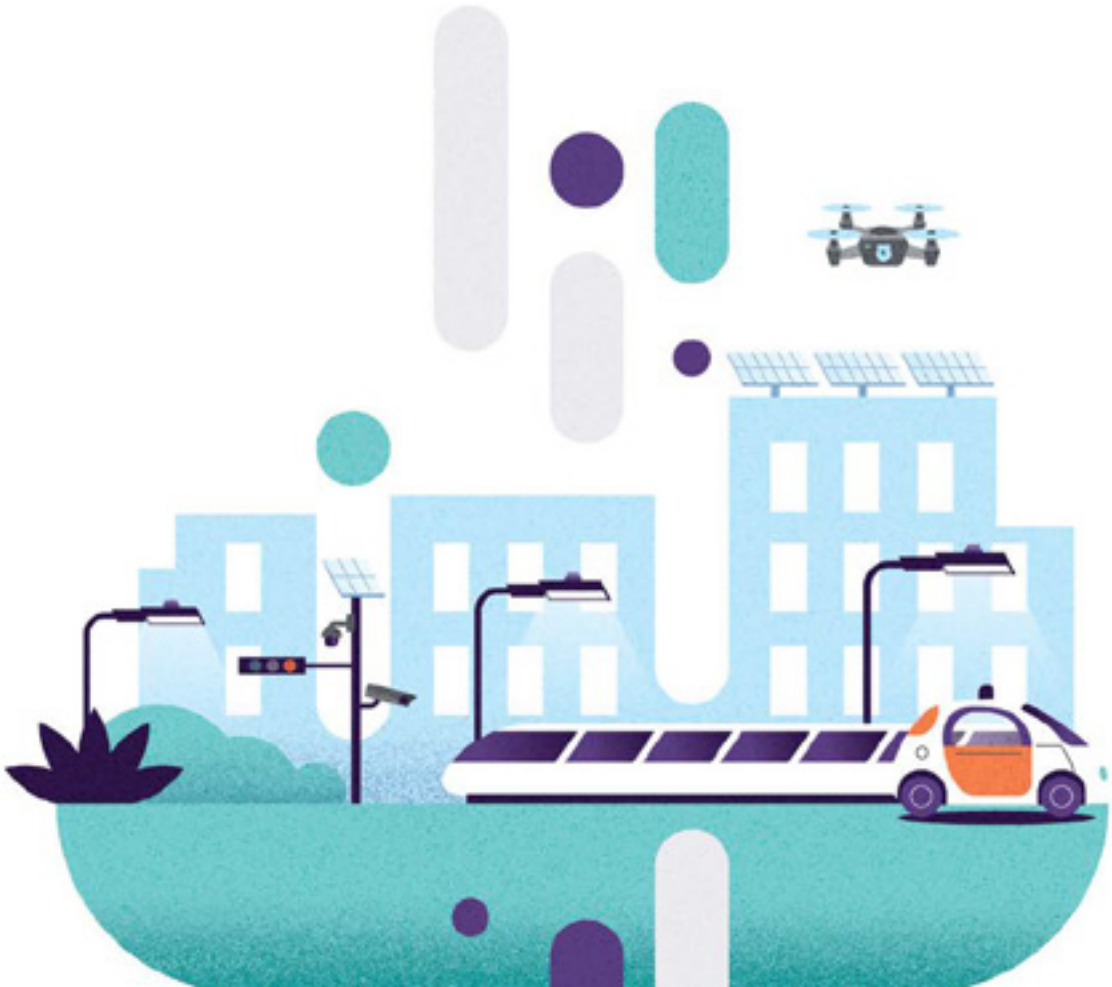
Smart Cities Playbook:

Building Your Connected Community



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Why CTIA created this Playbook

CTIA represents the U.S. wireless communications industry and companies throughout the mobile ecosystem. Our members provide the wireless networks, devices, equipment and solutions that make smart cities possible. This includes the high-speed mobile broadband and services behind video, streaming and cloud computing; the wireless networks and technologies for connected and autonomous vehicles; and the communications technology and infrastructure of smart grids, which enable efficient, dependable control of energy consumption. CTIA members are also the drivers of 5G, the next generation of wireless. As advanced networks roll out across the nation, 5G will allow up to one hundred times more simultaneous connections, up to one hundred times faster connectivity, and lower latency, which is key for innovations like autonomous vehicles. As we look ahead to the exciting possibilities of smart cities technologies, CTIA is committed to helping communities of all sizes become the cities of the future.

Goals of This Playbook

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We see becoming a smart city as an achievable, accessible, desirable goal for communities of all sizes and states of readiness. We hope you find this Playbook a helpful resource for:

+ **Getting started**
+ **Identifying solutions that are a good fit for community challenges**
+ **Prioritizing projects based on the needs of businesses and residents**
+ **Familiarizing yourself with technical terms and concepts, particularly in the area of wireless technology and infrastructure**
+ **Bringing smart cities projects to life—smoothly, affordably and successfully**

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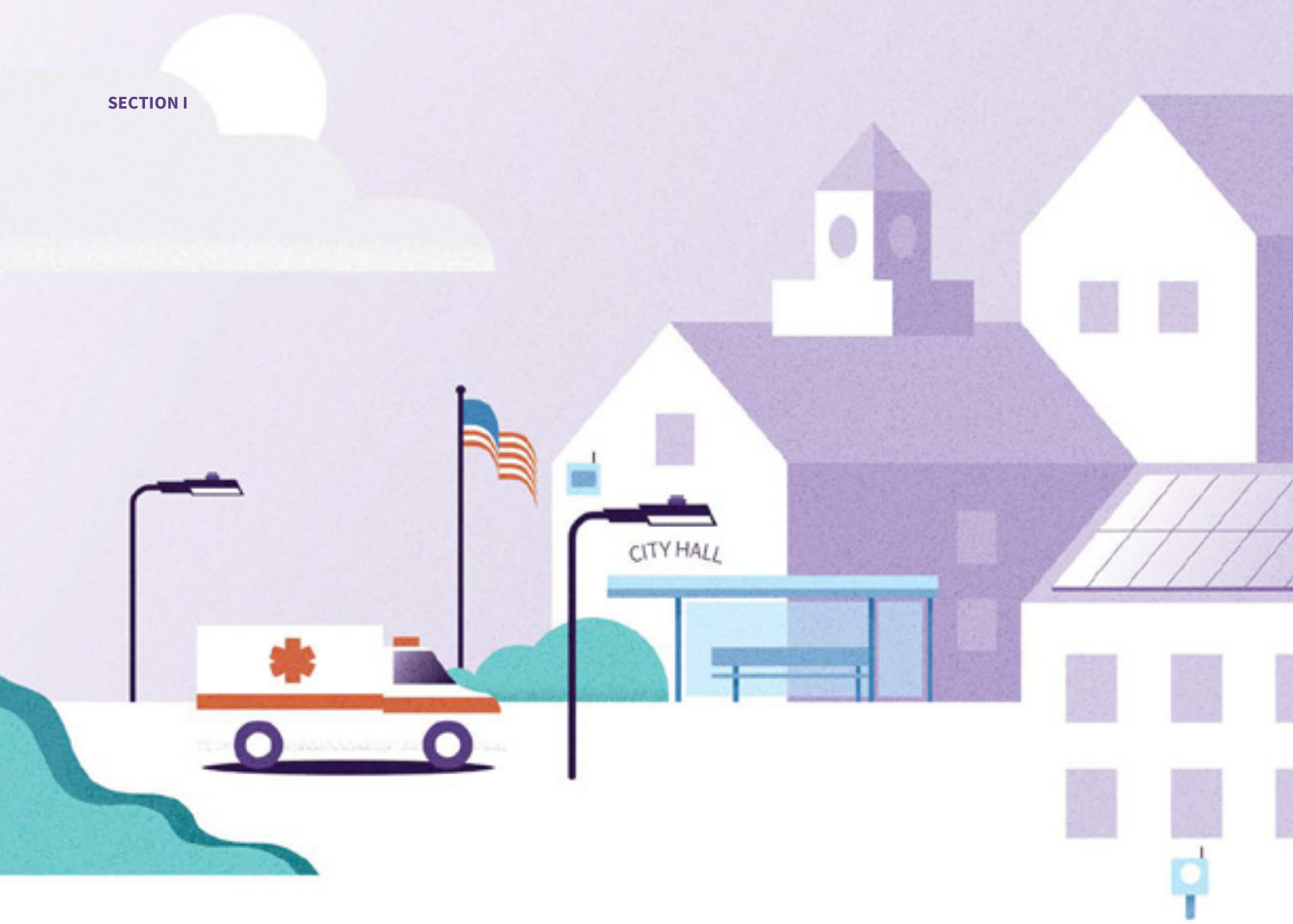

What Could Your City Be?

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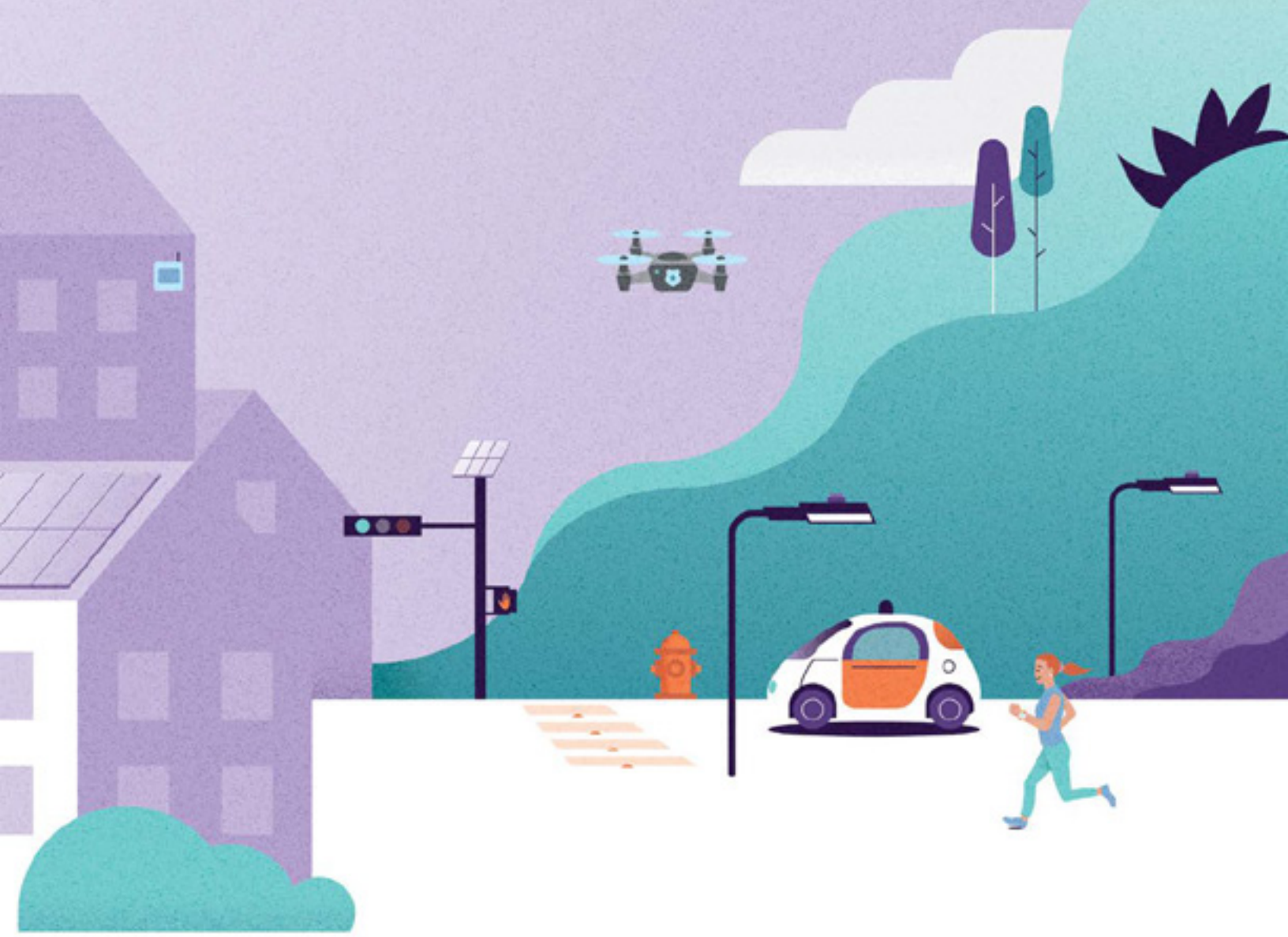

As you approach a traffic light, the signal turns green, adjusting in real time to a lack of cross traffic. You accelerate, saving time on your morning commute. In the lane next to you, passengers on a public bus check their transit connections on a mobile app.

Downtown, the parking lot is crowded, but you remain calm. A series of lights leads you to an available space, signaled because of an in-pavement detector. And you don't have to stop to pay a meter, thanks to a sensor that seamlessly records parking start and stop times.

When you leave work, your walk is illuminated by LED lights that switch on when you approach and off as you continue on to save energy. Although you don't realize it, these same light posts also have acoustic sensors capable of detecting gunshots, connected to systems that immediately notify law enforcement and first responders in the event of an incident.

This is how smart cities operate. Neighborhoods become a network. City services become more efficient. Local communities save money with more informed decision-making, and residents enjoy a more comfortable, convenient, connected quality of life.

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It's not science fiction, or achievable in only the most future-focused and well-funded metropolis. Smart cities are possible everywhere, right now.

Smart cities: Expanding the definition—and the possibilities

Smart cities projects happen anywhere communities put connected devices, wireless networks and data management platforms to work to enhance public services, boost local economies and improve everyday life. You'll find them in Peachtree Corners, Georgia; Carlsbad, California; and beyond.

Smart cities begin with the Internet of Things (IoT): physical devices, vehicles, home appliances and more embedded with electronics, software and sensors that connect across networks and exchange data. But at their heart, smart cities projects are really about communities and connections—people working together on better public services and experiences, then spreading the word to share the benefits.

"But we don't have the right infrastructure for a smart cities project," you may be thinking. "Where do we start?"

Fortunately, smart cities projects are all about resourcefulness, using the infrastructure and technologies you already have and making them stronger. To get started, gather together as a community, identify your greatest challenge and begin exploring your options.

SMART CITIES IN ACTION

San Diego Smart Cities Regional Initiative

San Diego, CA

SCENARIO

Cleantech San Diego launched the San Diego Smart Cities Regional Initiative along with leaders from the cities of Carlsbad, Chula Vista and San Diego, in addition to the Port of San Diego, the San Diego International Airport and SANDAG. The common goals: Integrate local government's numerous services to facilitate connected communities, ensure equity and inclusivity, and provide economic development—ultimately transforming how the San Diego region operates while improving quality of life.

SOLUTION

High-profile projects by cities and public agencies have advanced the San Diego region's reputation as a smart cities leader. But technological improvements have been only one part of the story. Regional collaboration has transformed how the San Diego region's cities and public agencies provide services and has had a major impact on the region's economic, environmental and social development. Furthermore, cross-jurisdictional knowledge has created a truly "smart" region for maximizing public funding, increasing civic participation, creating a consistent platform for innovation and promoting business growth.

RESULTS

Through integrating numerous government services, the San Diego Smart Cities Regional Initiative has established a connected community in support of equity, inclusivity and economic development. Collaboration has strengthened relationships between residents and businesses, harmonized public agency operations and enabled transformational behavior shifts across all stakeholders.

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An investment in community pride—and the future

Through monitoring water and energy use, making services more efficient and proactively identifying maintenance needs, smart cities projects save communities money.

Communities use smart cities projects to reduce emissions. Examples include smart buildings with automated HVAC controls, programs that help residents monitor energy usage and smart grids that accommodate solar power. Communities are also using data-powered transportation to reduce fuel usage and expedite the transport of people and goods.

Smart cities are safer cities. Integrated video sensors can help identify missing persons and solve crimes. Gunshot sensors can summon police to a scene, and weather sensor technologies can alert residents to the nature and location of weather emergencies and recommend a path to safety.

Smart technologies also give communities the tools needed to track resources and optimize systems, so they can operate in a more sustainable fashion.

Finally, smart cities foster economic growth. People like to live and do business in safe places with reliable electricity, water, gas and internet and convenient public services. Smart cities are places built to thrive, now and into the future.

> Wireless-enabled reductions in energy use, fuel costs and traffic congestion are estimated to generate **$160 billion** in savings and benefits.

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Smart Cities in Action: CTIA Smart Cities Working Groups

Throughout this Playbook, you'll see photos of collaboration in action to advance smart cities initiatives. CTIA Smart Cities Working Group members meet regularly to share best practices, engage city officials and explore projects that are being deployed in communities nationwide. The goal: educate municipalities—and each other—about the benefits of smart cities technology, and how smart cities solutions can make communities safer, smarter and more secure.

Dennis Gakunga, Chief Sustainability Officer, City of Chula Vista

As part of the Federal Aviation Administration's UAS Integration Pilot Program, the Chula Vista Police Department uses drones to respond to emergency calls within a two-mile radius of the station. The department has flown over 1,080 missions in support of patrol operations since October 2018.

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Qualcomm President Cristiano Amon: “5G will be a fundamental enabler for smart cities, supporting a massive scale of connections between everything from streetlights to water meters to security cameras.”

At Qualcomm headquarters, Qualcomm President Cristiano Amon and Mark Stainbrook, Port of San Diego Harbor Police Department Chief, highlighted the lifesaving potential that smart cities applications have and the important role 5G networks will play in keeping communities safe.

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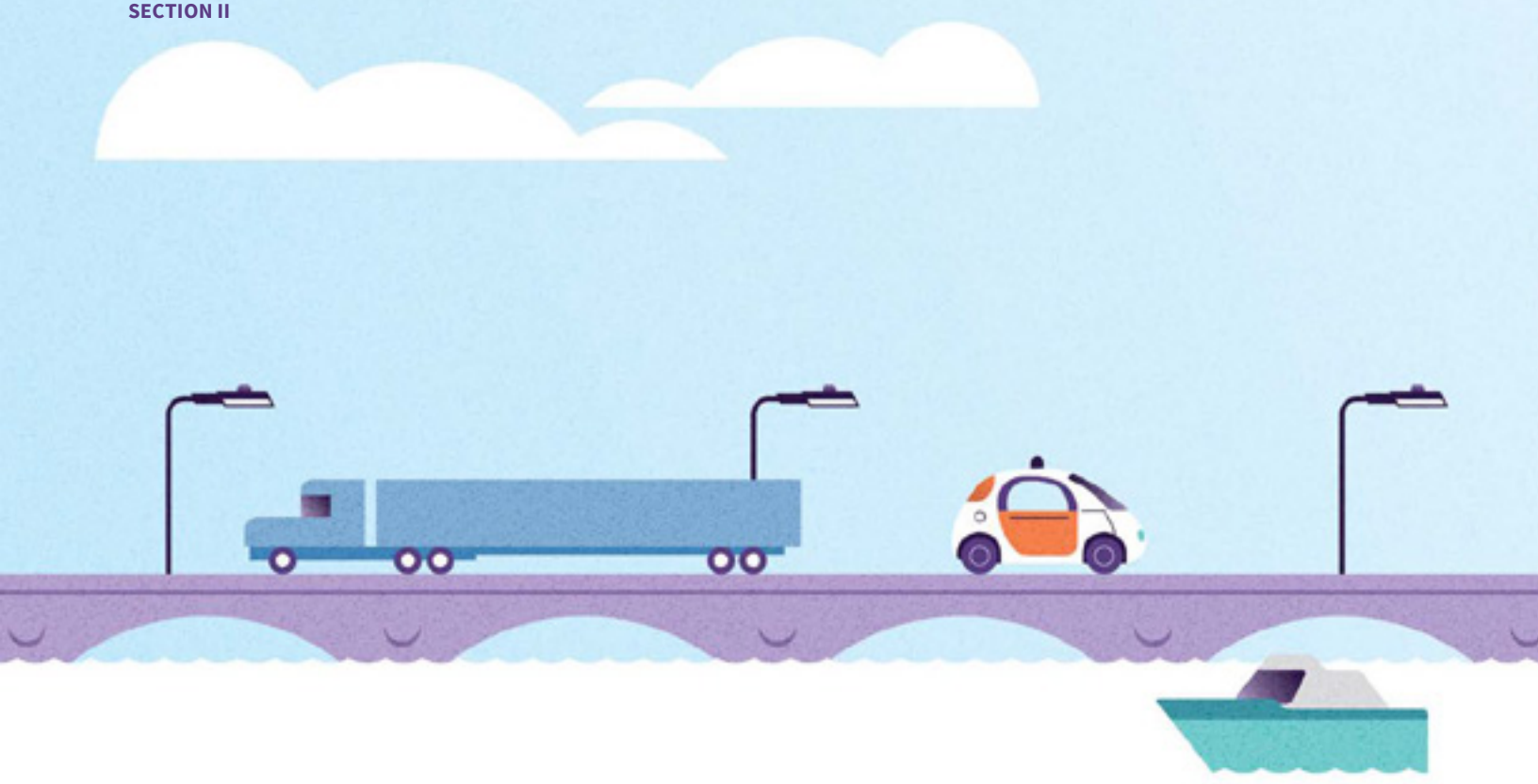

Welcome to Smart City, USA

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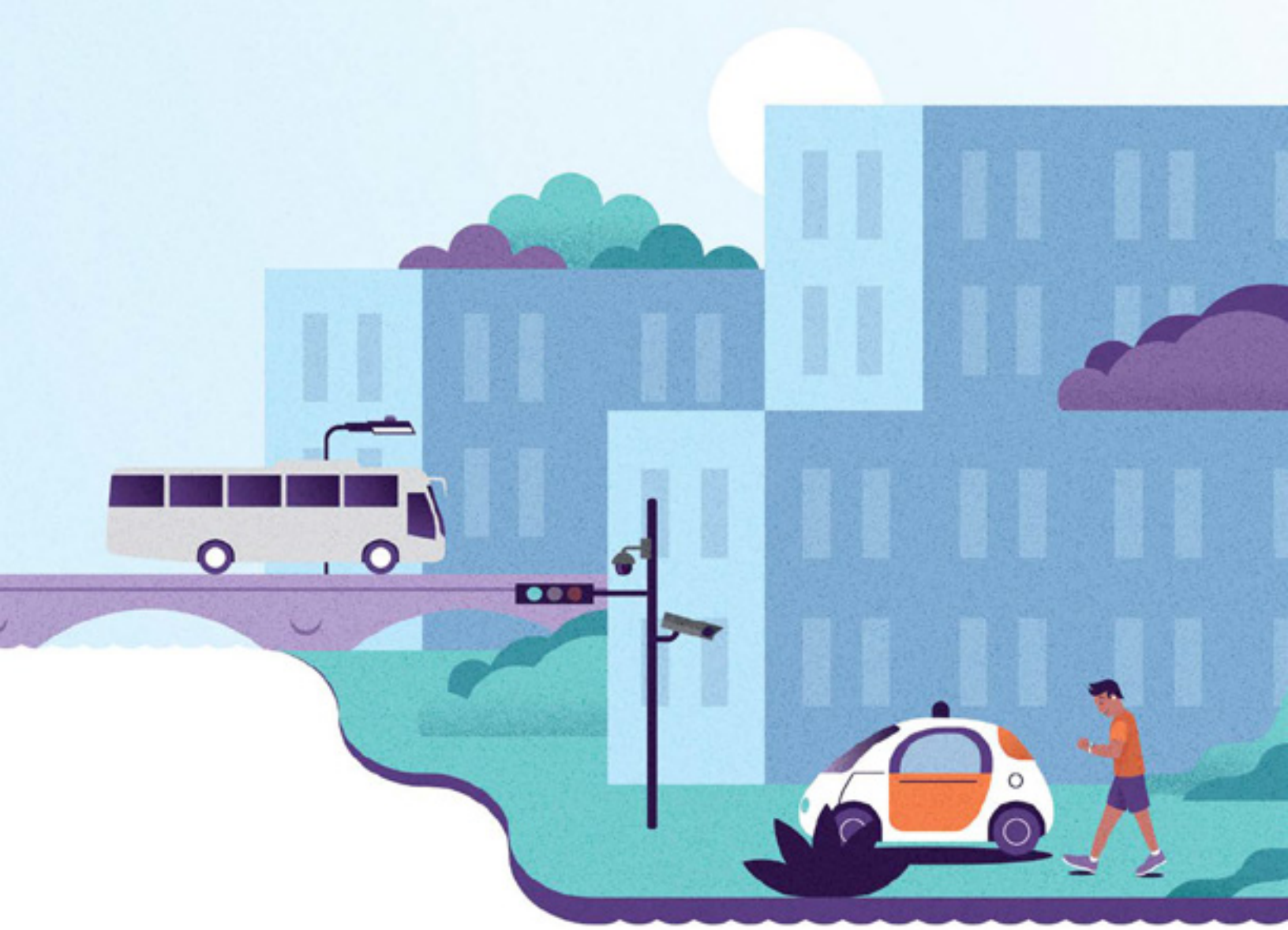

What does a smart cities project look like? How do I get started? The answers to these questions vary from community to community, and from project to project. There is no “one size fits all” in uniting data, connectivity and technology for the public good, and the possibilities can seem overwhelming.

When considering when, where and how to launch your project, it helps to narrow your community’s focus, with a focus on achievable wins. In our experience, three areas with particularly strong odds for buy-in, implementation and results are public services, transportation and utilities.

These can be defined by looking at the benefits. Smart public services contribute to public safety, cost savings and the public buildings and spaces that enhance residents’ quality of life. Smart transportation projects make fleets, intersections, highways, transit hubs and beyond safer and more efficient. And smart utilities initiatives help communities reduce energy and fuel costs, achieve environmental goals and meet the needs of growing populations.

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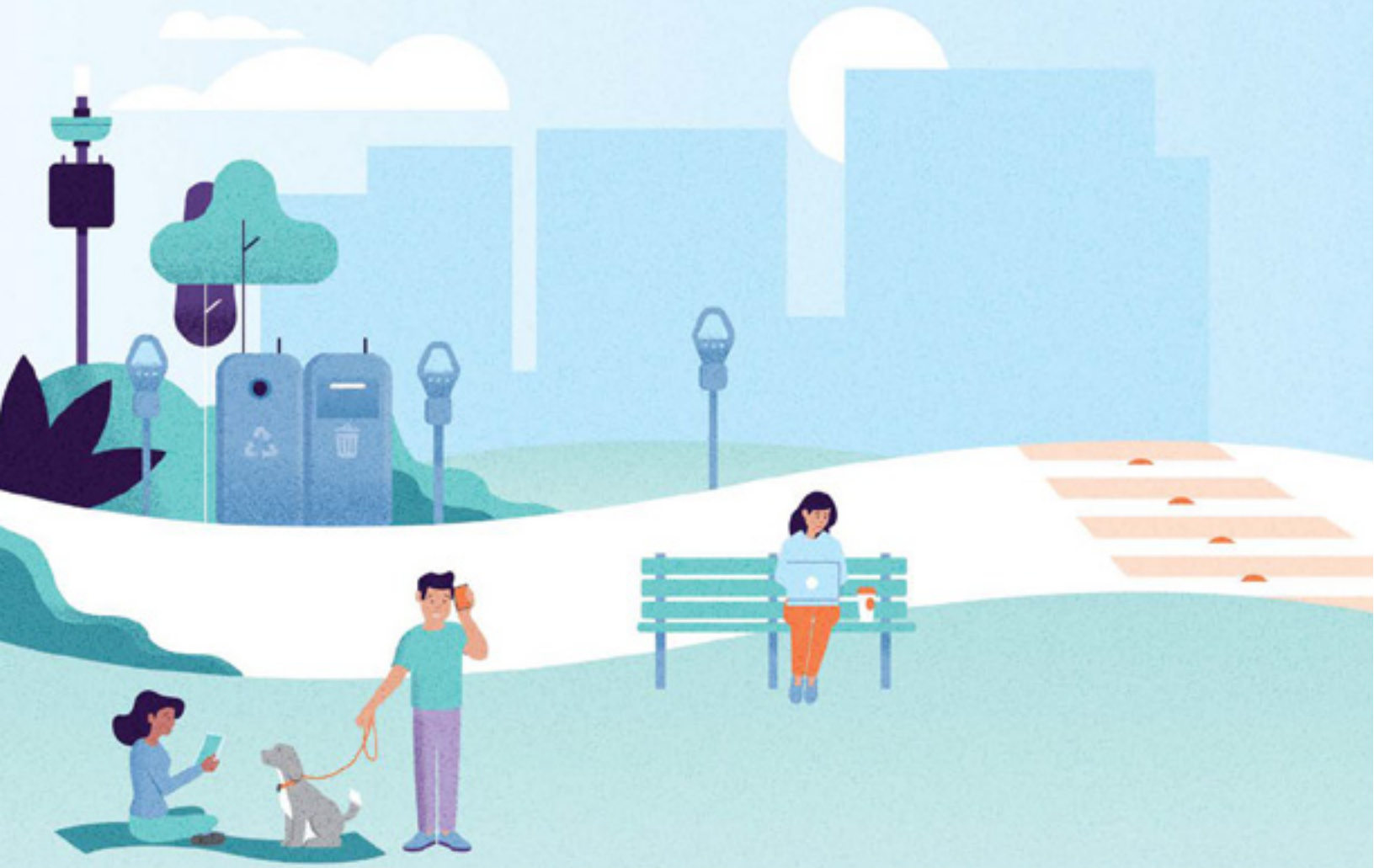

Smart Public Services

For taking public services to the next level, one of the most exciting advancements in recent years has been the Internet of Things (IoT): all of the items in our world that connect to the internet and share and receive data. IoT devices currently number in the billions, permeate every aspect of daily life and open up exciting possibilities for new and improved public services—particularly as supporting technologies evolve.

> Smart lighting solutions have the potential to save more than **$1 billion** per year across the United States.

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With advanced analytics, organizations can harness data for informed action. And with 5G wireless connectivity, IoT networks will be able to support hundreds more devices, with low latency and lightning-fast speeds.

Read about specific solutions, technologies and applications and see how communities are harnessing today's "internet of everything" to save money, serve residents and make their public safety, public infrastructure and public transit ready for the future.

Smart public safety

IoT devices connected by wireless networks offer innovative new ways of spotting danger, managing risk and keeping people safe.

Video sensors can help identify missing persons and solve crimes. Gunshot sensors can summon police to a scene. Weather sensor technologies can alert residents to the nature and location of a tornado, hurricane or other emergency and recommend a path to safety.

Smart public safety projects empower communities to be more proactive to their residents' safety needs. Communities are mounting sensors on drones, deploying them through neighborhoods and beyond to gain more complete, timely views of potential incidents and accelerate their response. Find ideas for your community in the examples below.

SMART PUBLIC SAFETY IN ACTION

Drones as First Responders

Chula Vista, CA

SCENARIO
The Chula Vista Police Department (CVPD) needed to maximize its resources—including its limited number of officers—to keep the growing population of Chula Vista safe.

SOLUTION
CVPD launched a "Drone as a First Responder" (DFR) program. When someone calls with an emergency, the department sends a drone to the site to feed live video to ground units and collect critical intelligence. The program is the first of its kind to deploy drones as a first responder. CVPD also uses its drones to document crime and accident scenes, search for missing or wanted persons, respond to fires and evaluate damage after a major incident or natural disaster.

RESULTS
CVPD has flown over 1,080 missions in support of patrol operations since October 2018 and is now flying from two launch locations. The program became the first urban police response program in the nation to obtain FAA approval to fly beyond visual sight lines.

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Public Safety

Atlanta, GA

SCENARIO
Atlanta needed to expand its citywide surveillance efforts—cost-effectively—to better protect its nearly half-million residents.

SOLUTION
To increase visibility of situations across the city, the Atlanta Police Foundation launched Operation Shield. This integrated system would pull video resources from private and public entities into a single command center. The challenge: Create a robust platform that could support over 10,000 cameras across brands, networks and video management systems.

The foundation deployed over 400 of its own cameras, with thousands more supplied by other city organizations like MARTA (Atlanta's rapid transit authority), the Atlanta public school system and the departments of public works, watershed management and aviation. Videos stream across a network of wireless mesh, fiber and 4G connections to secure cloud storage. Police officers can access these videos as needed via a security information management system.

RESULTS
Atlanta's police department is now able to leverage security footage from across the city without the cost of owning and maintaining thousands of cameras. Private businesses, shopping malls and housing complexes are sharing their live video with the police department and benefiting from faster, more prepared service from emergency responders.

Wireless sensors can reduce gun crimes by up to **50%**.

Smart public infrastructure

Because community buildings, parks, structures and equipment play such a significant role in economic growth and community quality of life, smart public infrastructure projects can yield big benefits. Take smart lighting, for example. In targeted areas, this can contribute to a greater sense of safety and equity, as well as greater satisfaction with community services when burned-out lightbulbs are quickly replaced.

Smart infrastructure technologies help communities make the most of their existing resources. Examples include LED retrofits that reduce energy consumption,

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smart light poles that work double duty in the deployment of 5G networks, and building management and automation systems that centralize control of heating, ventilation, air conditioning, lighting and more.

In parks and community spaces, smart irrigation controllers, rainwater harvesting and energy-generating exercise equipment maximize resource use. Restroom occupancy sensors both save energy and contribute to a feeling of safety, and free internet access in public spaces increases community engagement.

Intrigued? Read on for stories of smart public infrastructure in action.

SMART PUBLIC INFRASTRUCTURE IN ACTION

Smart Lighting

Baltimore, MD

SCENARIO
Baltimore aimed to improve nighttime safety around entertainment districts, improve response time to streetlight outages and track the savings of money and energy.

SOLUTION
The city joined forces with Baltimore Gas and Electric and Philips Lighting for Baltimore Bright, a connected lighting system. This pilot program focused first on 20 city-owned streetlights in a downtown entertainment district. The team installed Philips CityTouch "nodes" which can dim or brighten, monitor energy consumption, self-report outages and other issues, and provide data about the streetlight infrastructure via a wireless network. The next step: convert all current streetlight fixtures to LED, which last 15 years longer. This switch will reduce maintenance costs by 60 percent and add thousands more lights to dark areas.

RESULTS
Through the Baltimore Bright pilot, the city was able to cross-reference 311 data points regarding light outages, crime and traffic incidents with information about streetlight infrastructure, helping to confirm priority areas for lighting upgrades.

Baltimore Bright is generating energy cost savings upwards of **50%** and reducing response time to streetlight outages and issues down to **24 hours**.

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Radar Technology for Smart Waste Management

New Orleans, LA

SCENARIO

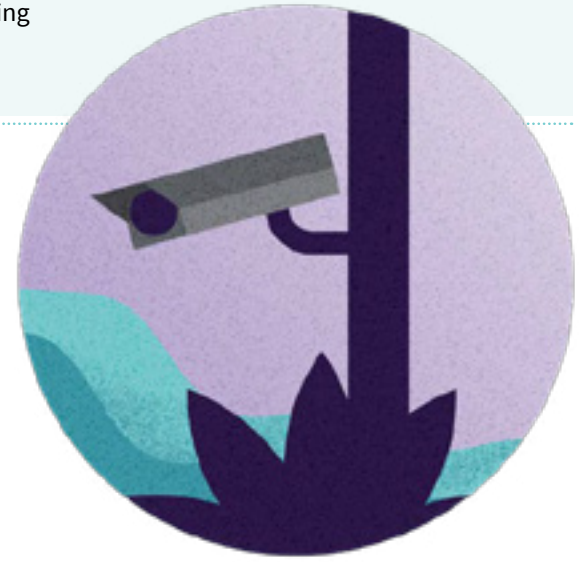
The New Orleans sanitation department was doing admirable work collecting refuse for residents, businesses and hundreds of thousands of tourists. Yet trash remained an issue for the city—particularly illegal dumping.

SOLUTION

As part of the mayor's CleanUpNOLA initiative, the sanitation department installed HDTV-resolution cameras, integrated with radar detectors, at locations identified to be chronic illegal dumping sites. The system identifies illegal dumping activity and automatically tracks the vehicle or person that has triggered an alert. When they're not detecting sanitation crime, the cameras augment video monitoring managed by the New Orleans Office of Homeland Security and Emergency Preparedness at the city's Real-Time Crime Center.

RESULTS

Video evidence helps the city collect hefty fines from illegal dumping activity, and the system's radar detection technology gives the sanitation department the ability to use cameras more flexibly, doubling the city's return on investment.



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Smart public transit

Smart public transit projects help people get where they're going faster and more efficiently, with a more pleasant experience.

These projects do so through technologies that take transit to the next level of access and convenience. For subway and bus riders, this includes mobile ticketing, digital displays with emergency information and apps that give riders real-time information on departure and arrival times, including any delays. Within neighborhoods, smart parking meters and apps expedite the quest for the perfect parking spot, and sensor-equipped crosswalks are helping pedestrians and vehicles co-exist in greater harmony.

Learn how one community is harnessing apps and wireless beacons to make its downtown more accessible.

SMART PUBLIC TRANSIT IN ACTION

Wayfinding for the Blind

Long Island, NY

SCENARIO

The Nassau Inter-County Express (NICE) carries 20,000 riders each day, including people with visual impairments. Despite growing costs and shrinking government funding, NICE aimed to ease the stress of daily commuting for these customers and help them navigate the Rosa Parks Hempstead Transit Center, a major transfer point to the Long Island Rail Road and 19 NICE routes.

SOLUTION

NICE partnered with Sensible Innovations to install a wayfinding system. Sensible Innovations installed iBeacon low-energy electronic sensors throughout the transit center including all bus bays, ticket counters and entrances. These sensors connect to an audible wayfinding app, AWARE, to connect users and their mobile devices to the transit center in real time.

RESULTS

Commuters who are blind or visually impaired now use AWARE to locate their bus bays and bus routes and navigate within the transit center.

Through bringing IoT technologies, wireless networking and data management platforms together for public safety, infrastructure and transit, communities are saving money and delivering a safer, cleaner, more accessible experience to residents and visitors. Read on for guidance on starting your own smart public services projects.

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Making it work in your community: smart public services

Step 1:
Look at the bigger picture.

What resources will you need to create your new smart public service? Does the infrastructure and connectivity already exist for accessing the service, or will it need to be developed?

Before you start developing a new smart service, review all of your organization's master plans to see how your project fits in. For example, a smart lighting project might fall under a larger energy plan. In this way, you leverage resources, align goals and avoid reinventing the wheel.

Step 2:
Know what you're working with.

Take an inventory of:

- ☐ Infrastructure (e.g., light poles, parking spaces)
- ☐ Improvements to date
- ☐ Costs (e.g., capital expenditures, ongoing operating costs, maintenance)
- ☐ Plans your community already has in related areas
- ☐ The amount of funding you will need to get to your goals

Be sure to evaluate the right-of-way (ROW), the easement granted over public land or property for transportation purposes, electrical transmission lines, oil and gas pipelines, and telecommunications networks.

- ☐ Are multiple stakeholders or property owners involved in ROW?
- ☐ How does your organization currently manage ROW?
- ☐ How strong are ROW relationships? What can be improved?

Step 3:
Prioritize security.

Creating a cybersecurity plan during the design phase of your project is a good way to protect the public services on your community's network. Specific to wireless connectivity, public service IoT devices should be certified to CTIA Cybersecurity Certification Level Two or Level Three. This provides proper management, oversight and integration with your existing cybersecurity systems.

Consider certifying:

- ☐ LED motion detection streetlights
- ☐ Police and traffic cameras
- ☐ Gunshot detection sensors
- ☐ Smart parking meters
- ☐ River overflow monitoring devices
- ☐ Vehicle tracking devices

10 steps for getting started

Apply the framework from the Baltimore Bright pilot to your project.

1. Identify your team across stakeholders, departments and vendors
2. Set your goals
3. Determine your project locations
4. Provide specifications to your vendor(s)
5. Install the equipment
6. Schedule training
7. Schedule ongoing check-in calls and workshops
8. Analyze data
9. Finalize outcomes and results
10. Identify what's next

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Smart Transportation

When communities unite IoT devices with transportation and traffic management systems, the result is smart transportation: connected and autonomous vehicles, next-generation public transportation and industrial transit.

> Smart traffic management systems have the potential to reduce congestion by **40%** and save **$100 million** annually.

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Here vehicles share data with networks, the internet, city infrastructure and each other and leverage automation to varying degrees. Apps deliver real-time information on transit hubs, schedules and parking options. Intelligent transportation systems share live video of roadways to commuters, maintenance crews and transportation planners.

Smart transportation projects empower communities to keep people, goods and businesses moving more safely, efficiently, economically and sustainably. Learn more about the technologies behind these initiatives and how communities of all sizes are putting them to work.

Vehicle-to-everything communications

Your community can turn traffic into a powerful tool for safety, savings and quality of life—preventing accidents, managing congestion, delivering navigational guidance and more.

"Vehicle-to-everything" technologies make it happen.

Vehicle-to-everything ("V2X") projects represent a variety of configurations:

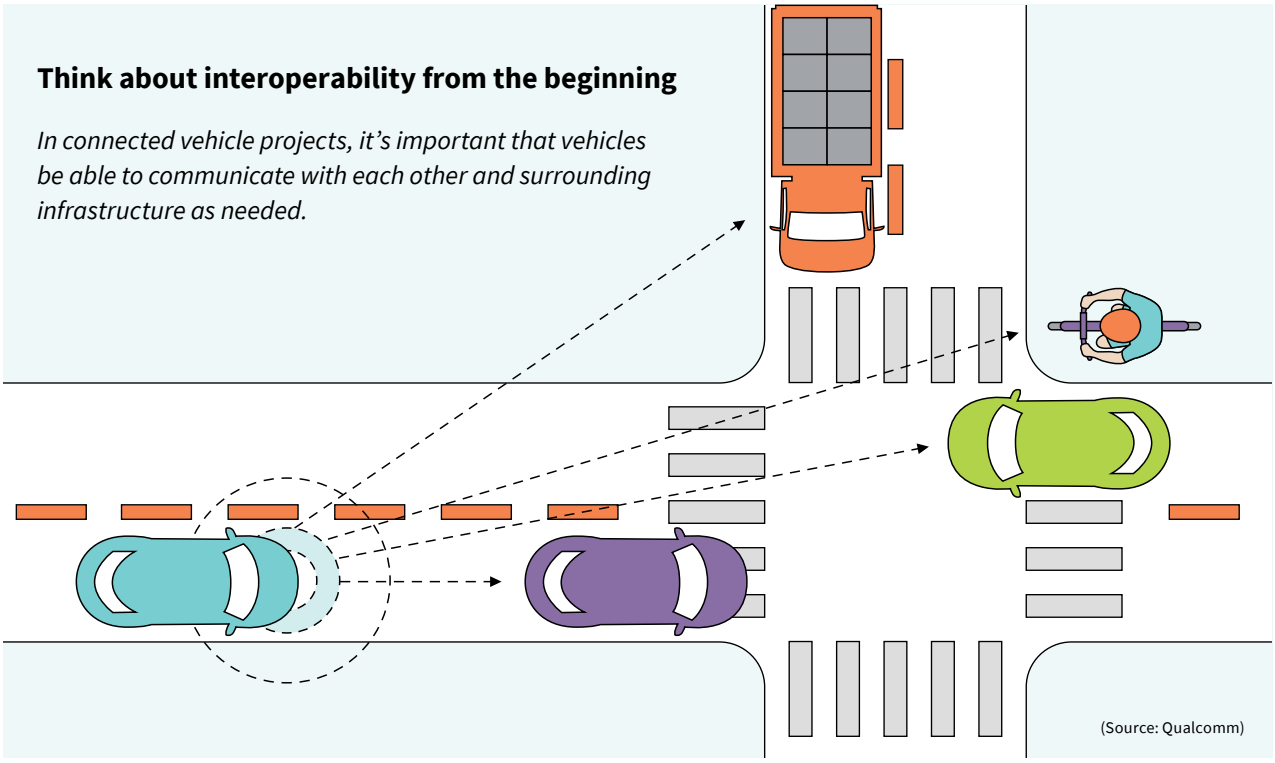
+ Vehicle-to-vehicle (V2V)
+ Vehicle-to-infrastructure (V2I)
+ Vehicle-to-network (V2N)
+ Vehicle-to-pedestrian (V2P)

Via sensors and wireless networks, vehicles and roadway infrastructure become powerful devices for collecting and communicating data. In a V2V application, vehicles in transit exchange position and speed data over a wireless, typically LTE, or mesh network. And in a V2I solution, sensor-based hardware, software and firmware facilitates the wireless exchange of data between vehicles and roadway, safety and support infrastructure.

Combine any of the above on a unified communication platform—but be aware that technologies are not necessarily interoperable. Learn how one pioneering partnership is putting V2X to work on a busy mountain highway.

Think about interoperability from the beginning

In connected vehicle projects, it's important that vehicles be able to communicate with each other and surrounding infrastructure as needed.



(Source: Qualcomm)

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CDOT and Panasonic

Denver, CO

SCENARIO
The Colorado Department of Transportation (CDOT) sought ways to use data for more informed, efficient, cost-effective roadway management.

SOLUTION
CDOT partnered with Panasonic to create a Vehicle-to-Everything (V2X) pilot. Along a 90-mile stretch of the I-70 mountain corridor, connected vehicles shared data and sent information over cellular networks to the CDOT-Panasonic V2X Data Processing Center. The center analyzed this data—along with weather-related information from cameras along the road—and transmitted it back to the vehicles. The goal: help drivers improve safety and operations and support local traffic managers in decisions about roadside signage, traffic lights, emergency alerts and community outreach.

RESULTS
This program, the largest V2X pilot in North America, laid the foundation for more partnerships between Panasonic and DOTs and other V2X initiatives. These include commercial-grade deployments on public roadways, integration of V2X technology into DOT fleets for data collection, the world's first open-architecture V2X digital platform (CIRRUS by Panasonic) and partnerships with automobile manufacturers for quickly scaling and rolling out V2X technology.

Smart and connected vehicles

As connectivity everywhere becomes a basic expectation and automation becomes more common in business and everyday life, smart and connected vehicle projects can help your community keep pace.

> Self-driving cars combined with smart signals can result in up to **90%** less emissions and **21,700** lives saved.

Through a network connection, connected vehicles (CV) share internet access—and data—with other devices inside and outside the vehicle.

Automated vehicles (AV) promise greater productivity, mobility and access by taking human drivers out of the transportation equation to varying degrees. These vary from level 1, where an advanced driver assistance system helps with steering or braking, to level 5, where an automated driving system handles all the driving all the time.

Read how a smart cities laboratory is helping innovators move their CV and AV ideas from concept to commercialization.

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Curiosity Lab at Peachtree Corners

Peachtree Corners, GA

SCENARIO
To move smart transportation technologies from concept to commercialization within communities, organizations need an environment where they can cost-effectively test and demo them.

SOLUTION
Curiosity Lab at Peachtree Corners is a city-owned and -operated living laboratory designed specifically as a proving ground for technology that has "graduated" from a closed laboratory environment. It consists of a 5G-enabled 1.5-mile autonomous vehicle test track and smart cities laboratory located within an existing 500-acre technology park where thousands of people and vehicles interact with the test track and smart city technology every day.

The lab's mobile 5G wireless network may be used in concert with roadside units to support the testing of Vehicle to Everything (V2X) communications. Intelligent traffic cameras and traffic signals along with smart streetlights and data sensors provide video coverage and data collection that can be monitored from a central network operations center.

The lab also features a technology incubator that provides 25,000 square feet of innovation space for early-stage startups and corporate innovators. Strategic partner Sprint provides subject matter experts at no charge to organizations exploring 5G and emerging technologies.

RESULTS
Use of the living laboratory for testing and demonstration is free and comes with no expectation by the city that users must share proprietary information or intellectual property. Ownership, operation and regulation by a single contact—the city—eliminates red tape and expedites the speed with which a company can conduct testing or organize a demonstration.

Smart traffic management systems

For walkers, cyclists and drivers; across bus, light rail, train and ferry systems; and in parking lots and shared mobility services, intelligent traffic management systems turn data into access and convenience.

Sensors like low-energy beacon technology, such as iBeacons, and video cameras mounted on street lights and poles gather information. Apps, webcams and electronic displays deliver a real-time view. And wireless networks bring it all together.

Read on for examples across a range of transportation modes.

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SMART TRAFFIC MANAGEMENT IN ACTION

Smart Corridor

Atlanta, GA

SCENARIO
The City of Atlanta wanted to better understand and optimize the traffic on North Avenue, a major east-west artery that carries nearly 29,000 vehicles a day, includes 18 signaled intersections and key bicycle routes, and serves prominent institutions including Georgia Institute of Technology, The Coca-Cola Company and Georgia Department of Transportation.

SOLUTION
The city first installed video cameras to work as traffic sensors. Then it partnered with 360ns, a Georgia company with strong experience in providing intelligent transportation and mobility solutions, to implement Citilog's SmartTraffic-AID image processing application directly on the 84 AXIS M1125 network cameras. The SmartTraffic-AID application communicated with legacy traffic controllers and Surtrac, the city's new traffic management system, to deliver real-time traffic data that enabled real-time adjustments to traffic light timing.

RESULTS
Atlanta's Smart Corridor project improved travel times and reduced waits at intersections. Ultimately, the project will improve quality of life by reducing emissions and pollution in the city.

SMART TRANSPORTATION IN ACTION

Smart Student Shuttle

Milwaukee, WI

SCENARIO
A university aimed to improve its shuttle bus service between campus academic buildings and downtown—particularly long, unpredictable waits for a bus during cold or inclement weather.

SOLUTION
U.S. Cellular partnered with UniteGPS to deploy a fleet tracking solution with smart displays at shuttle stops.

RESULTS
Thanks to these displays, students now can see exactly where a shuttle is relative to their stop and how long the wait is for the next one.

From connected and autonomous vehicles and vehicle-to-everything networks to real-time traffic management and GPS-empowered displays, communities are using traffic data to sharpen decision-making, keep roadways safer and more efficient and help goods and services get where they need to go faster.

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Accessibility App

Springfield, IL

SCENARIO
The city needed better navigation options for people with visual impairments.

SOLUTION
The city commissioned Sensible Innovations to deploy a network for the AWARE mobile app, an audible wayfinding tool. Sensible Innovations worked with certified orientation and mobility specialists to map street corners, create detailed descriptions of street crossings and street blocks, and facilitate easy navigation between historic sites.

The project uses wireless beacons (iBeacons) to provide detailed, real-time walking directions and audible descriptions of downtown destinations. The iBeacons use Bluetooth low-energy technology to send location information from street corners and intermediate locations to the wireless device of the user walking down the street. This constant communication lets AWARE app users orient themselves in relation to their desired destination. Unlike many other similar tools, AWARE app delivers data on downtown facilities: opening and closing times, current exhibits, details about the cost of a ticket and layout description.

RESULTS
As AWARE app users explore the streets of downtown Springfield, they hear details about roads, intersections, historical sites and businesses around them as they walk, negating the need to memorize routes and landmarks and encouraging more confident, independent exploration of the city.

Dig Once could have generated up to **$126 billion** in savings to the national deployment of high-speed internet.

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Making it work in your community: smart transportation

Step 1:
Coordinate your efforts.

If your smart cities project involves new infrastructure and public rights-of-way, it's critical for local officials and agencies to work together in a "dig once" approach.

Why? This approach streamlines telecommunications infrastructure and can generate significant cost savings. The Federal Highway Administration estimates that up to 90 percent of the cost of installing high-speed fiber infrastructure lies in the cost of digging up the roadways, not in the fiber itself. Ways to coordinate efforts include:

- ☐ **Joint trench agreements:** All broadband providers and, in some cases, utilities, install their infrastructure at the same time, in the same trench.
- ☐ **"One-touch" agreements:** These encourage proactive installation of conduit and dark fiber.
- ☐ **Utilities partnerships:** These involve carrying out fiber or conduit installations at the same time as water or sewer projects.

Step 2:
Prepare your strategy.

- ☐ Prioritize a specific transit challenge (e.g., buses, mass transit, rail, etc.).
- ☐ Know the players (agencies, utilities, city DOT, city government) and the dynamics.
- ☐ Read up on these organizations' modernization plans and how they align with your goals.
- ☐ Understand your community's infrastructure plans for electric vehicles and autonomous vehicles.
- ☐ Ask your technology vendor what type of connectivity or network they plan to use.

Step 3:
Prioritize security.

Having cybersecurity practices in place helps to protect residents and keep traffic and goods flowing efficiently. Consider creating a cybersecurity plan during the design phase of your project to keep your transportation solutions secure. Specific to wireless connectivity, smart transportation devices should be certified to CTIA Cybersecurity Certification Level Two or Level Three. This provides proper management, oversight and integration with your existing cybersecurity systems.

Consider certifying:

- ☐ Vehicle traffic monitoring devices
- ☐ Crosswalk safety monitors
- ☐ V2I gateways
- ☐ Fleet safety and performance telematics

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George Karayannis with Panasonic CityNOW talks about Panasonic's Vehicle-to-Everything (V2X) Operations Center. The center processes data for one of the largest connected vehicle (CV) projects in North America, spanning 90 miles of live V2X technology between Golden, Colorado, and Vail, Colorado. Here data is transmitted 10 times per second, providing details from the connected vehicles to the data center. With this data, operators can make informed traffic and safety decisions.

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The Panasonic Smart City Innovation Showcase at Peña Station, which spans an entire city block, demonstrates a wide range of immersive smart city solutions.

Circling the Panasonic and Peña Station parking lots, an autonomous shuttle is making history daily. The first on-road deployment of an autonomous vehicle shuttle in the state of Colorado, the shuttle is 100 percent electric and navigates a one-mile loop every fifteen minutes.

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Smart Utilities

As city managers, local utilities and municipal governments grapple with growing populations, environmental goals and the need to save money and optimize resources, they're making smart utilities projects a top priority.

> Consumers are predicted to realize up to **$2 trillion** in benefits from smart grid adoption over the next 20 years.

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Real-time monitoring and data exchange is generating increased visibility and awareness of electricity, gas and water usage. IoT devices and connected systems are strengthening the overall reliability of power grids—reducing outages, enhancing connectivity and making cities more attractive places for economic development. And communities are exploring the potential of newer innovations such as solar power, microgrids and charging stations for electric vehicles.

Smart utilities projects mitigate costs for residents and communities alike and improve quality of life for everyone. Read on to learn more about the technologies and how they're being leveraged in communities across the country.

Grid management and resiliency

Resiliency is the ability of a network to continue to function and provide an acceptable level of service in the face of challenges, like natural disasters, which may cause power outages, flooding, damaged equipment or other impacts to the network. More resilient power grids start with sensors: networks with data-collecting devices at multiple locations. For example, the sensors on smart meters monitor water and energy usage and alert users of leaks or swings in consumption and billing. Particularly in a large utility network, these sensors can be dynamically managed and retasked in an evolving environment.

Denser wireless networks—with hundreds of thousands of small cells—will also make networks more resilient. Policymakers at the federal, state and local levels can

SMART GRID MANAGEMENT/RESILIENCY IN ACTION

Reliability Infrastructure for Economic Development

Montgomery, AL

SCENARIO

Alabama Power, the City of Montgomery, Montgomery County and the Montgomery Area Chamber of Commerce aimed to improve alignment and collaboration on smart community projects.

SOLUTION

The four organizations created the Montgomery Smart Community Alliance and made its first priority increasing the reliability of the electric grid. In the Montgomery Area fiber and reliability project, Alabama Power sectionalized segments of distribution power lines to isolate fault locations and improved crew deployments for troubleshooting scenarios. Alabama Power also provided dark fiber connectivity for buildings at the Montgomery Area Chamber of Commerce and used the same fiber to improve the city's public Wi-Fi network.

RESULTS

The Montgomery Area fiber and reliability project increased the overall reliability of the electric grid—reducing outages from unplanned events and weather—while reducing city connectivity costs, enhancing economic development downtown and improving the overall quality of life for residents and visitors alike.

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help modernize wireless infrastructure siting rules and processes by:

+ Improving access to government and utility facilities and rights of way
+ Setting reasonable and non-discriminatory fees for siting new 5G deployments
+ Creating efficient timelines for reviewing applications to site wireless infrastructure, meaningful remedies for applications that are not reviewed within these timelines and more uniform standards for processing applications to install wireless infrastructure

Data management systems put sensor data to work. Advanced meter reading (AMR) infrastructure, for instance, sends information from water, gas and electric meters to a central database for billing, troubleshooting and analysis. Advanced metering infrastructure (AMI) enables two-way communications between utilities and customers via an integrated system of smart meters, communications networks and data management systems.

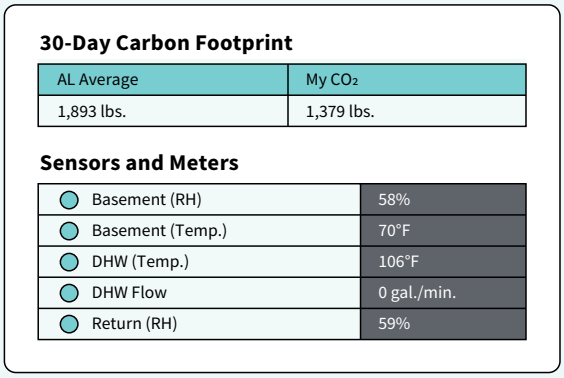
Sensor-powered data management systems also support fault location, isolation and service restoration (FLISR), enabling utilities to quickly locate, then isolate the area of an outage and minimize its impact on customers and the utility.

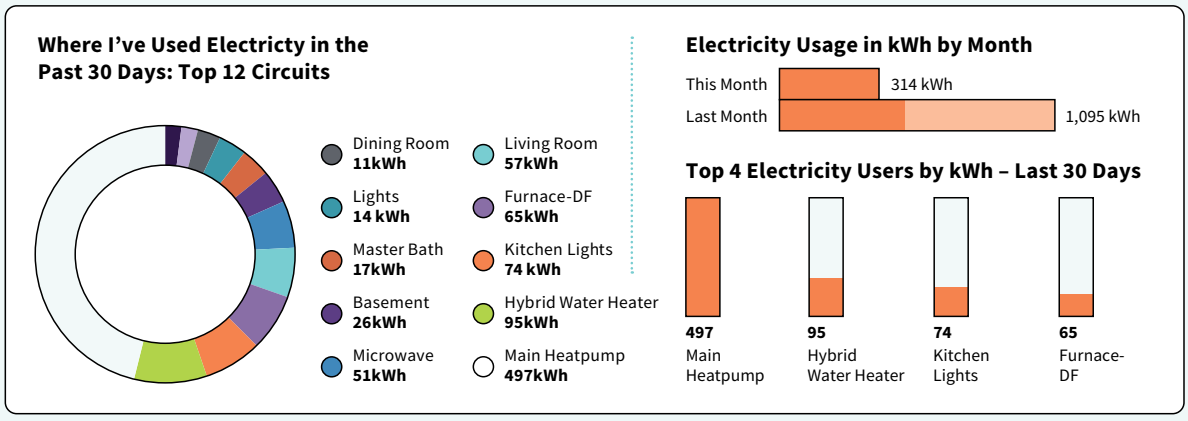
Bringing metering infrastructure, FLISR and more to life are wireless networks, created by the cables and antennas attached to substations, buildings, power and light poles and transmission and distribution towers nationwide. Given easement and right-of-way considerations and capital and maintenance costs, utilities often share these “poles.”

Smart grid management and resiliency projects enhance economic growth and quality of life by restoring power faster. They save time with the automatic collection of consumption information and save money through fewer disputed energy bills. Learn how communities are benefiting in the following scenarios.

Increasing visibility and awareness

In communities like Reynolds Landing, a smart neighborhood in Birmingham, Alabama, smart technologies provide homeowners with reports to track appliance performance and maintenance needs, empowering them with the knowledge to reduce use and increase efficiencies.





(Source: Southern Company)

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Net Zero Microgrid

Denver, CO

SCENARIO

With a booming population, the City and County of Denver and Xcel Energy needed new solutions to address the congestion pains and environmental impacts of growth. Specifically, they sought a way to evaluate emerging technologies, model operational and economic benefits, and test out deployments.

SOLUTION

Xcel Energy partnered with Panasonic CityNOW to deploy a net zero microgrid as part of a living lab for smart cities innovation. Peña Station NEXT is a 400-acre, transit-oriented, public-private development located outside Denver International Airport on the A Line light rail. Stakeholders include the City and County of Denver, Denver International Airport, Xcel Energy, RTD, Colorado Department of Transportation, land developer Fulenwider and Panasonic.

The net zero microgrid required 15 separate contracts, underscoring the importance of stakeholder alignment. Xcel's portion of the investment was funded from R&D funds, and Xcel expects to rate base the assets, or to value the assets toward a specific rate of return, when the initial technology evaluation phase is completed.

The battery in the microgrid supports multiple value streams, including smoothing ramp control and time shifting for integration of solar energy into the grid, peak demand reduction activities, energy arbitrage and frequency regulation.

RESULTS

The microgrid went from concept to completion in 17 months. It features a 1.6 MW solar photovoltaic (PV) canopy above a city-owned parking lot, a 1 MW /2 MWh battery storage system and 259 kW of solar PV on the roof of Panasonic's smart cities headquarters facility. The solar carport currently produces about 5 MWh per day, which makes the development carbon neutral. The solar PV on Panasonic's roof recharges the battery and can maintain operations indefinitely depending on available sunshine when islanded.

Smart energy and sustainability

Through charging stations, distributed energy resources, LED lighting retrofits and more, communities are delivering resilient, future-focused infrastructure that saves money, improves the efficiency of power delivery and contributes to economic growth.

As electric vehicles gain popularity, electric vehicle charging stations keep them running. These include level 1 stations, which can be plugged into a standard outlet and do not require additional equipment; level 2 stations, which must be installed by professional electricians; and level 3 chargers, which deliver 60 to 100 miles of range per 20 minutes of charging.

Distributed energy resources are electricity-producing resources directly connected to a local distribution system or connected to a host facility within the local distribution system. Examples include rooftop solar panel systems and small-scale combined heat and power systems.

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LED lighting retrofits upgrade, expand and future-proof a community's lighting infrastructure, saving energy, enhancing safety and increasing a sense of equity and engagement. LED lights last several years longer than traditional lighting solutions, and they can be integrated into systems that enable remote control or automated dimming and lighting.

SMART ENERGY AND SUSTAINABILITY IN ACTION

Smart Lighting Retrofit

Birmingham, AL

SCENARIO

To improve public safety, engage residents and modernize its infrastructure, the city launched Brighter Birmingham. Its goals: retrofit and upgrade seven city parking garages with LED fixtures, upgrade the city's streetlights to LEDs, improve park and architectural lighting throughout the city and upgrade highway lighting to LEDs.

SOLUTION

Implementation began with the parking garage retrofit, identified in an energy audit as the fastest return on investment. The mayor's office worked closely with Philips Lighting, the city council and the parking authority and engaged a local construction company and engineering team. The retrofit used new motion detection sensor technology to improve safety as well as energy savings.

RESULTS

The garage retrofit not only saved money, it contributed to a greater sense of safety and community engagement. Within five days of the first parking deck being completed, garage attendants reported a noticeable increase in utilization. The city financed the retrofits through energy savings and careful use of public funds, eliminating the need for capital expenditures. The contract vehicle can be adjusted to a "lighting as a service" agreement, which would accommodate future technology advancements and yield additional savings and local jobs.

Brighter Birmingham's parking garage retrofits are estimated to save nearly **$375,000** annually in energy and maintenance costs.

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EV Charging Infrastructure

San Francisco, CA

SCENARIO
San Francisco needed a network of charging stations to serve a growing number of electric vehicles.

SOLUTION
Black & Veatch, whose vehicle-charging infrastructure portfolio includes more than 163 MW of capacity in North America, partnered with San Francisco-based Volta Charging to significantly expand Volta's network of free public charging stations in the city. Black & Veatch assisted with engineering, design and permitting. The partnership worked together to obtain dozens of local government permits, address the needs of businesses where stations are located, and consider variable construction requirements at every physical location.

RESULTS
In some cases, new charging stations were brought online in roughly a month. With this project, Volta joins a growing list of industry leaders leveraging Black & Veatch's ability to execute seamlessly on large-scale, geographically dispersed projects.

With automatic metering and grid management systems, electric vehicle charging systems, smart lighting and beyond, communities and utilities are working together to use resources more cost-effectively, accommodate energy efficient technologies and create the resilient services that attract people and businesses. Read on for guidance on starting your own smart utilities projects.

In 2017, Volta charging stations provided **7.91 million** free electric miles, displacing **174,000** gallons of gas.

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Making it work in your community: smart utilities

Step 1:
Know what you're working with.

- ☐ Does the city have any government-owned utilities that service residents?
- ☐ How much of the city's infrastructure is leased or shared by utilities?
- ☐ What are the modernization/IoT plans for the local utilities?
- ☐ What is the current relationship between the city and local utilities?
- ☐ Are there regular strategic planning meetings?
- ☐ What are the current financial arrangements between the city and utilities?
- ☐ What are the plans for future smart grid, distribution network and renewables projects?

Communities and utilities can leverage existing networks of poles and wires and existing rights-of-way to expedite deployment and reduce costs. For instance, utility poles, including light poles, can be used to mount various devices that enable other "smart" services. Partnerships with the wireless industry can provide the connectivity to power smart utility projects like:

- ☐ Remote-controlled LED street lighting
- ☐ Small cell sites
- ☐ Wireless LAN access points
- ☐ Audio sensors for gunshot detection
- ☐ Cameras for capturing photos of vehicle license plates
- ☐ Traffic enforcement
- ☐ Tracking systems for stolen vehicles/fugitives/Amber Alerts

Step 2:
Get the technical specifications.

Is end-to-end encryption required?

- ☐ If a device is monitoring or controlling the grid or has access to critical information, enhanced end-to-end security features should be considered.
- ☐ End-to-end encryption can be built into the configuration as routers are deployed.
- ☐ If you are deploying modules/embedded chipsets into equipment like relays, capacitator banks and meter cans, the encryption must be developed and incorporated by the equipment manufacturer.

Are devices protected?

- ☐ Devices should be sourced for FIPS Level 2 certification and supply chain protection.
- ☐ Ask who will have access to devices, from manufacturing to delivery.

How will you ensure system reliability?

- ☐ See if you will need a quality of service arrangement to ensure prioritization of utility traffic.
- ☐ Pay attention to antenna configuration, which is critical to increasing reliability, throughput, and capacity. Consider MIMO and cross-polarized antennas where applicable.

Step 3:
Prioritize security.

Security is paramount for reliable, resilient smart utility services. Implementing a cybersecurity plan during the design phase of your project can help keep your smart utility assets safe. Specific to wireless connectivity, smart utility devices should be certified to CTIA Cybersecurity Certification Level Two or Level Three. This provides proper management, oversight and integration with your existing cybersecurity systems.

Consider certifying:

- ☐ Gas meters
- ☐ Electricity meters
- ☐ Industrial gateways

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Southern Linc President and CEO Tami Barron shared Southern Company's plan for net zero carbon emissions by 2050 and provided an overview of their smart city priorities, including advanced grid requirements, modernization of electricity production, and innovating their telecommunications infrastructure.

Reynolds Landing includes 60 homes powered by a community solar-powered grid. The microgrid is made up of solar panels, battery storage and a backup natural gas generator.

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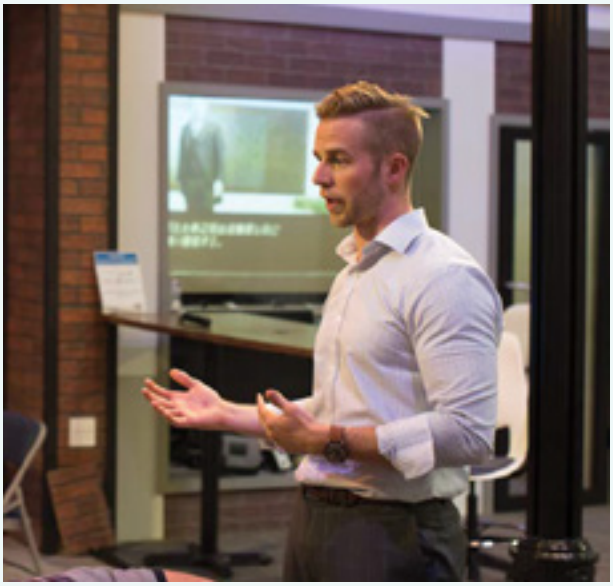
In Denver, construction company Black & Veatch is collaborating with Arrow Civil—a general contracting firm—and cell site pole manufacturer Comptek to replace traditional light poles with 5G-capable smart utility poles and advance the deployment of next-generation wireless networks. Mike Hoganson with Comptek Technologies is pictured.



Colorado's streamlined permitting process for small cell infrastructure has enhanced the ability of organizations to quickly deploy poles and get small cells online.

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Leaders at the Panasonic Smart City Innovation Showcase at Peña Station explain how the program is powered by a microgrid.

Looking out from the Panasonic rooftop, a canopy of solar panels covers a city-owned parking lot as part of the facility's onsite microgrid.

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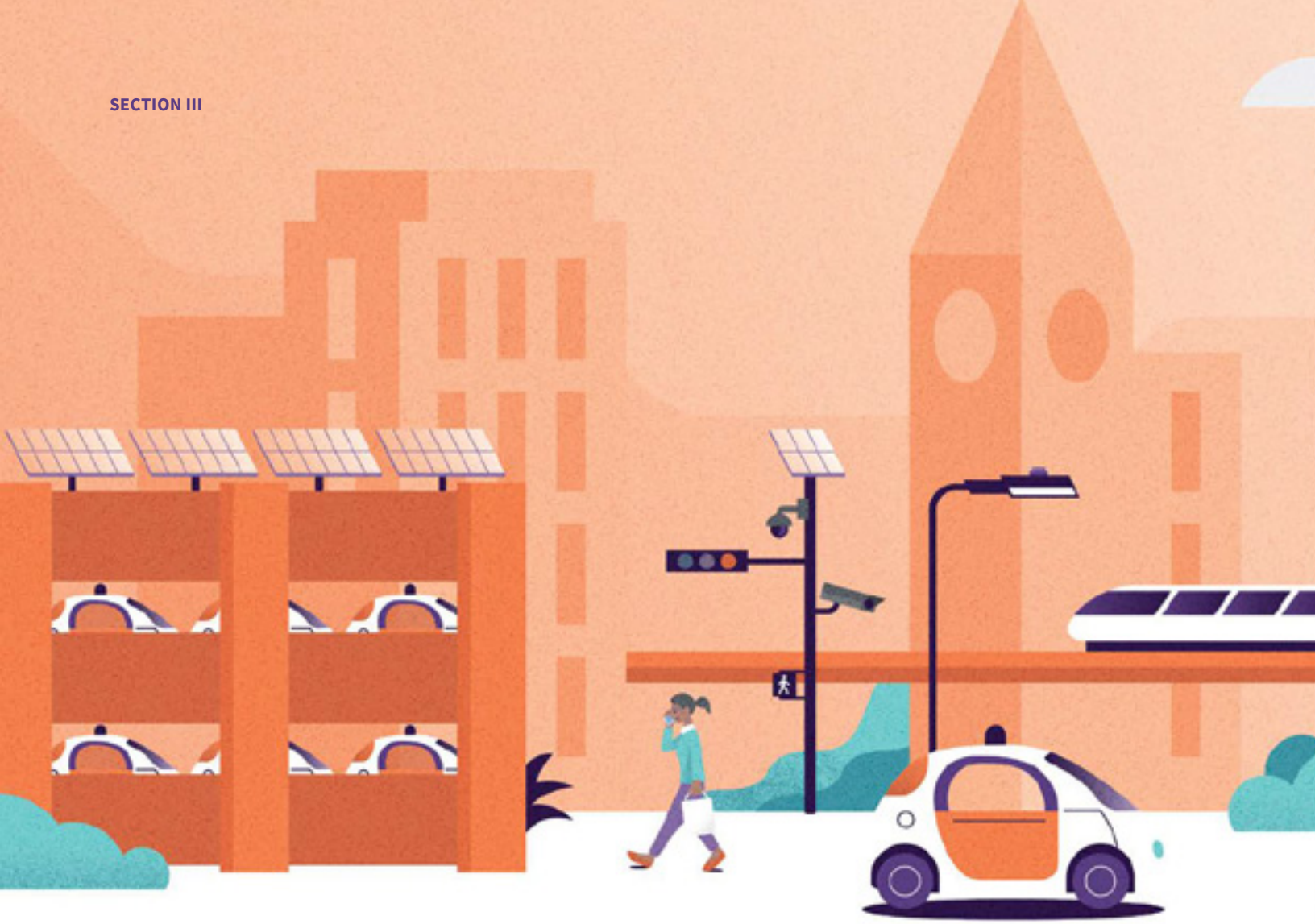

Starting Your Smart Cities Journey

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Across locations, technology types and goals, smart cities projects share many commonalities. These include guidance and best practices for evaluating community needs, obtaining funding, forging vendor relationships and more.

Read on for questions to ask and steps to consider when developing your strategy, establishing your foundation and implementing your procurement/request for proposal (RFP) process.

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Your Strategy

To set your community up for smart cities success, narrow your scope, prioritize your projects and line up funding sources. This requires a comprehensive evaluation of past projects, pain points, processes, people and funding possibilities. Here are some questions for getting started.

Past projects

- ☐ What smart projects have already been executed? What were the results, positive and negative, particularly in the area of data sharing?
- ☐ Have technology platforms been launched that serve more than one department or agency? How successful were they?

Pain points

- ☐ What are your community's main pain points related to public services, transportation and utilities?
- ☐ Does the pain point affect only one part of your community or does it cross municipal boundaries?
- ☐ Which public and private entities does the pain point involve?
- ☐ Do you have a relationship with a public or private entity that can be leveraged again?

Processes

- ☐ Does a common smart cities vision exist in your community?
- ☐ What are your current constraints in procurement—e.g. difficulties collaborating across departments?
- ☐ Do you have open policies for data and processes for governance?
- ☐ Do you have a marketing plan? Think about how you plan to share updates publicly to raise awareness, increase visibility and build momentum.
- ☐ Do you have a modernized infrastructure plan?

People

- ☐ Do you have an assigned smart cities champion?
- ☐ Do you have relationships with local universities or innovation councils?
- ☐ Does your project deliver value across the community or only to a specific segment?

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Joining forces for project financing

Several partnership options are available with various finance structures and return on investment requirements:

+ **Cross-sector development partnerships:** Public, private, and/or nonprofit institutions in which partner organizations commit various resources and agree to work cooperatively toward common development goals.

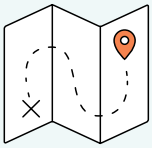
+ **Public-private partnerships:** Here government agencies and the private sector work together to deliver goods or services to the public.

+ **Private and public (federal and state) grant opportunities:** A government department, corporation, foundation or trust gives a qualifying nonprofit entity, educational institution, business or an individual funding they don't have to pay back.

Define the scope for funding opportunities

Step 1

Research the financing strategies for your city's projects.

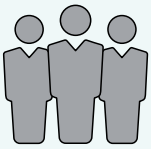


Step 2

Map these against your project's needs: automation, data connectivity, data exchange/sharing, electronic information.

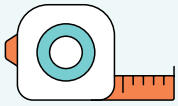
Step 3

Find out how project financing is granted in your community, including the process for renewals.



Step 4

Assemble your leadership team, including partners in the private sector and academia as applicable.



Step 5

Determine your project parameters by finding out your city's budget for funding franchise initiatives and operating budget for voice, data, video, etc.

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Your Foundation

How is your city connected?

As IoT devices autonomously capture data, intelligently self-configure to events in their environment and become active participants in public, commercial, scientific and personal processes, broadband availability will be key to success. These networks will be the backbone of your project's infrastructure.

As you begin your smart cities project, evaluate connectivity in your community.

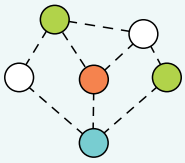
- ☐ Look at the networks and contracts: fixed broadband, mobile wireless service and/or others. How many are there and for what services?
- ☐ Evaluate your residents' connectivity. How many have broadband/wireless?
- ☐ Does your community understand the economic impacts of broadband availability?
- ☐ What are the plans for future broadband and 5G?
- ☐ What kind of permits do you require? Who could benefit from a "dig once" policy?

With a basic understanding of how city systems are connected, you'll be able to evaluate which type of network to use to connect your project.

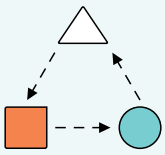
Think about your coverage and range needs. To decide what level of network connectivity you will need for your project, consider the distance, robustness and security required to power your application.

How fast does your network need to be? Uplink or upload speed refers to how fast a network receives data from a device. Downlink or download speed is the reverse—how fast a network can send data to a device. The important thing is to think about whether speed will be a critical performance factor for your smart cities technology. Smart streetlights may not need lightning-fast networks, but your emergency response department's drone fleet might.

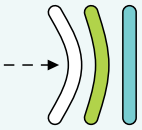
Things to bring up with your smart cities vendor



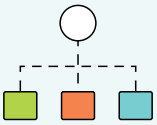
Connectivity



Interoperability

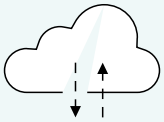


Resiliency



System management

Emergency services



IT considerations

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How will you secure your services?

Security, privacy and resiliency are essential to smart cities success.

Security can be impacted by physical factors, like technology placement, or invisible ones, like the security of underlying networks and systems. From inception, your project should be secure by design with privacy built in. Such proactive security measures protect your connected infrastructure and critical information.

Additional security measures, such as certifying the devices powering your IoT ecosystem to meet certain standards, may be a logical next step. The CTIA IoT Cybersecurity Certification Program provides a common baseline of validated cybersecurity functions and compatibility standards that allow certified devices to be securely managed and integrated into community systems.

Develop a cybersecurity plan. This plan should include:

- ☐ A programmatic approach to evaluating cybersecurity control and effectiveness
- ☐ A published cybersecurity roadmap
- ☐ A platform for 24/7 continuous cybersecurity monitoring
- ☐ An operations team to identify risks and test response capabilities
- ☐ Ongoing observations of simulated attacks to discover and mitigate gaps in threat detection

For privacy, understand and create a plan for using and storing sensitive data—on an individual citizen level as well as a macro community level.

To ensure resiliency, plan how you will manage outages, back up systems and mitigate security concerns. Also keep resiliency in mind when you evaluate different technologies, with consideration to prerequisites, maintenance challenges and lifecycle timelines.

Evaluate risks. Perform an initial security risk assessment of systems and services. Are some a higher security concern than others?

CTIA certification levels of security for IoT devices

Level 1 Device Examples

GPS Trackers

GPS Dog Collars

Washing Machines

Level 1

Meets the needs of consumer-grade devices.

Elements include:

- Terms of service and privacy policy
- Password management
- Authentication test
- Access controls
- Patch management

Level 2 Device Examples

Mobile Payment Devices

Security Systems

Connected Streetlights

Level 2

Well suited for business and enterprise-managed devices.

Elements include:

- Level 1 elements
- Audit log
- Encryption of data in transit
- Multi-factor authentication
- Remote deactivation
- Secure boot
- Threat monitoring
- IoT device identity

Level 3 Device Examples

Traffic Controllers

Gas Meters

Industrial Router

Level 3

Offers features designed to protect infrastructure-managed devices.

Elements include:

- Level 2 elements
- Digital signature validation
- Encryption of data at rest
- Tamper resistance
- Design-in features

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Establish requirements. Determine the security requirements for each smart municipal service or project, along with privacy principles for how data will be treated.

Secure your environment. Work with service providers and equipment vendors to understand what they're doing to keep networks and devices secure. Create safeguards and protocols for incorporating new IoT devices and networks. You should also make a plan for how you will respond to a breach.

Maintain security posture. Set up regular tests to assess security and resiliency responses. Schedule recurring network risk assessments and penetration tests across the smart cities network ecosystem.

How will you manage assets and data?

One big part of a smart cities project is accurately monitoring and maintaining project assets, from infrastructure to light poles, and the data they produce, like traffic flows.

Here communities can deploy low-cost, low-bandwidth devices that use GPS to precisely determine the locations and condition of city-owned assets. Asset management solutions usually require engagement of city planning, transportation and IT departments and an overarching process for maintaining electronic files, databases and records with the asset description, service year, location to the nearest street address or GPS coordinates and other relevant information.

7 steps for managing assets and data

1. Create an asset management database and plan, complete with timeline and success criteria.
2. Give key departments assignments for asset identification, collection and tagging by criteria such as age, size, location, appearance and last maintenance.
3. Create a standard data curation process to ensure consistency across asset information and classes.
4. Determine a set of common field requirements for populating and building performance reports.
5. Use tools such as secure web portals and mapping (visualization) software to make the process secure, user-friendly and engaging.
6. Keep your city-owned asset database current, and maintain working knowledge with a review process for validating asset information.
7. Assign access, permissions and guidelines, and consult with a cybersecurity firm for other ways to secure this valuable information.

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Your Procurement Process

Successful smart cities projects start with the right vendors. To improve your chances of a strong vendor match, evaluate the following:

Experience: How extensively has the vendor deployed smart cities commercially or demonstrated a proof of concept? The length of a customer list correlates to the depth of the vendor's experience and knowledge of how their product performs in various environments. Contact their references and ask about product performance, issues and ROI. Would they change any part of the process? Did they have a positive response from users after deployment?

Security: What experience does the vendor have with risk analyses and security certifications? The National Institute of Standards and Technology (NIST) is an agency within the U.S. Department of Commerce devoted to promoting industry innovation. NIST has put together various cybersecurity and privacy standards and best practices for use by industry. To learn more about how your city can evaluate cybersecurity, risk and supply chain issues, NIST's resources, including their Cybersecurity Framework and Special Publications 800-161, 800-171, 800-30 and 800-37, may prove useful.

Working together for interoperability

Smart cities projects are a team sport, so evaluate how well your vendors and their solutions play with others. How interoperable are the vendor's solutions with other smart cities offerings? Does your vendor have strategic partners? Often strategic partners working together can address interoperability issues and other challenges more effectively than a single provider on its own.

Operational costs: Ask about the estimated 10-year lifecycle cost for projects with a similar scope. Be sure to include installation, operations, support, upgrades and training.

Research competitors to compare capabilities and prices. Who are the vendor's biggest competitors? What is the vendor's unique value proposition? A strong value proposition can help you justify the vendor's costs, particularly if you need a unique solution for your needs.

Tips for RFP success

Ready to start reaching out to vendors? To maximize the quality of the responses:

- ☐ Know your current situation, and make a clear ask.
- ☐ Consider a phased approach, starting with a high-impact area then deploying more widely in phase two.
- ☐ Consider distributing a request for information first. This will help you write a better RFP.
- ☐ Especially for more complex solutions, consider hosting open forums, roundtable discussions or Q&A sessions for vendors, city leaders and personnel.

Include in your RFP:

- ☐ Timeline and budget constraints. Ask for pricing, and consider asking for options within a certain price level if your budget is limited.
- ☐ Deployment expectations
- ☐ A list of current vendors whose services will be impacted
- ☐ A summary of relevant assets and the health of those assets
- ☐ Infrastructure you plan to leverage or need to replace

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Your RFP Checklist

Make sure you have all your technical requirements covered.
You can use this checklist as a starting point.

☐	**Alarms/alerts**	Particularly for a utility management, public infrastructure or traffic management project, how does the vendor plan to handle remote monitoring and critical event detection?
☐	**Certifications**	What industry standards and certifications (3GPP, IEEE, 5GAA, NIST, ETSI, etc.) will your technologies, such as network devices, need to achieve, and how does the vendor plan to address this?
☐	**Cloud infrastructure**	If your project will be hosted in the cloud or manage data or handle analytics in the cloud, what cloud services and support does the vendor offer?
☐	**Cybersecurity**	How does the vendor plan to protect hardware, software or electronic data from theft, damage, disruption or misdirection of services? This includes achieving cybersecurity certification for devices touching your network and setting a baseline set of cybersecurity standards.
☐	**Data analytics**	What processes does the vendor have in place for inspecting, cleansing, transforming and modeling data and relaying it to you? The information that fuels a smart cities project is only as good as your capacity to interpret and respond to it.
☐	**Data ownership**	How does the vendor plan to handle possession of and responsibility for information, including data ownership, compliance and access management procedures?
☐	**Data retention**	What is the vendor's data retention policy? Does it align with your requirements (e.g., compliance with state and federal regulations), and what kind of plan and personnel will you need to collect and manage the data you need?
☐	**Equipment**	What type of equipment does the vendor plan to use to implement your project? Is it compatible with your existing/planned infrastructure, and does it meet your resiliency and sustainability standards?
☐	**Key Performance Indicators (KPIs)**	What kind of KPIs will the vendor use to evaluate the success of its service/solution?

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☐	**Lifecycle management**	How does the vendor manage the product lifecycle—from inception through design, manufacturing and service to disposal/end of life?
☐	**Maintenance**	What is the vendor's policy for hardware, network and software maintenance and support? Does this include preventive and remedial services? How much does it cost and how will you be charged (e.g., per incident)?
☐	**Managed services**	If you need to outsource certain processes and functions to augment your internal resources, what managed services does the vendor offer, and how much will they cost?
☐	**Metrics**	What measures, including and beyond KPIs, does the vendor plan to use to report key behaviors, activities and performance? How frequently will these be reported?
☐	**Operations**	How does the vendor ensure efficiency and high performance?
☐	**Physical infrastructure**	How will the vendor help you leverage current infrastructure?
☐	**Redundancy**	Duplicating or backing up critical components and functions, referred to as redundancy, is key to network reliability and system performance. What redundancy services does the vendor offer?
☐	**Reliability**	Reliability is a must-have feature for telecommunications networks, especially in public safety projects. How does the vendor plan to ensure reliability?
☐	**Support**	Help with specific problems is often an ongoing cost. What type of support does the vendor offer, and how much will it cost?
☐	**Systems integration**	How does the vendor plan to bring together components, subsystems, computing systems and software applications to act as a coordinated whole? What kind of experience does the vendor have in this area, and how will the vendor ensure that systems interact and perform as expected?
☐	**Universal design/ accessibility**	How does the vendor plan to make products and services usable by all individuals and communities? Evaluate the ability of a given technology to enhance access to services.
☐	**Use cases**	Can the vendor provide examples of previous deployments involving similar technologies, applications and goals?

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Glossary

Accessibility
The extent to which smart technologies can help a city improve access to resources for all individuals.

App/mobile application
A type of software designed to run on a mobile device, such as a smartphone or tablet.

Application agents
Used in end-to-end, peer-to-peer networking in IoT architecture, application agents move intelligence to the edge of a network, helping organizations manage traffic, respond in real time to changing IoT conditions and provide local client services.

Application programming interface (API)
A set of definitions, protocols and tools for building application software.

Artificial intelligence (AI)
Machine intelligence that supports accelerated, real-time decision-making.

Attribute data
Additional information about spatial features within a GIS environment. For example, a fire station's location is spatial data, and the station name and contact number are attribute data.

Bandwidth
A range within a band of frequencies or wavelengths, or the amount of data that can be transmitted in a fixed amount of time.

Beacon technology
Small network transmitters that identify, track and interact with connected systems via Bluetooth low energy. Often used indoors, beacons transmit small amounts of data up to 50 meters.

Bluetooth low energy (BLE)
A wireless personal area network that gives devices with reduced power consumption and cost a communication range similar to standard Bluetooth.

Broadcast towers
Provide mounting space for FM radio, AM radio and antennas for television and wireless. Typically found in rural areas or on mountaintops, they can weigh up to 15 tons and take up to 300 acres of ground space.

Cellular/cell site
Where a wireless antenna, transmitter and base station provide wireless service in a geographic area.

Chirps
Protocols that allow the "things" in IoT to communicate and exchange data.

Cloud computing
Internet-based computing and storage services which allow software storage and information to be available on demand to any computer or other device.

Connected devices
Also known as smart devices, these electronic devices and components make up the Internet of Things. Many have built-in sensors and/or actuators and collect data to help users or other devices make informed decisions and monitor or affect outside events. These devices generally connect to other devices or networks and operate to some extent interactively and autonomously.

Constrained Application Protocol (CoAP)
An application layer protocol used in resource-constrained devices that allows internet connectivity and remote control.

Dark fiber
Data is transported over optical fiber networks by passing light through the cables; if there is no data being transported, there is no light, which means that the fiber is "dark." Therefore, dark fiber is essentially optical fiber infrastructure (cabling, switches and repeaters) that is not in use.

Direct messaging
A messaging mechanism in which the sender and receiver are directly connected or can exchange

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messages through one or more intermediate hops. Messages are routed or forwarded without ownership.

Edge computing
Allows data from devices to be analyzed locally, at the "edge" of the network, before being sent to a data center or cloud, which significantly reduces latency. By providing processing capacity and content delivery nearer to devices than with a traditional central data repository, edge computing can reduce backhaul traffic and improve network efficiencies.

Embedded devices/systems
A computer with a dedicated function within a larger mechanical or electrical system.

Endpoint device
An internet-capable device on a TCP/IP network.

Fiber/optical fiber
When data and voice telecommunications signals are transmitted by light over fibers made of glass. Fiber is an alternative to copper wire and preferred over electrical cabling for jobs requiring high bandwidth, long distance or immunity to electromagnetic interference.

Fog computing/fog networking/fogging
Architecture that uses edge devices to route a substantial amount of computation, storage and communication locally over the internet backbone, with different intelligence and compute power than in edge computing.

Geofencing
A technology that creates virtual boundaries around a physical area, usually through a combination of GPS and RFID tags, in order to trigger an action on a connected device.

Ground space
The area that wireless carriers lease from property owners to build cell towers/sites and place shelters, generators and additional equipment.

Guyed tower
Used in telephony, radio, television and paging, a straight rod of up to 2,000 feet supported by wires attached to the ground.

High-band spectrum/millimeter wave
Spectrum above 24 GHz, travels shorter distances than mid-band spectrum but with the greater capacity. Wireless providers have begun to use high-band spectrum for mobile broadband.

Industrial internet
The integration of machine learning, big data technology, sensor data and machine-to-machine communication automation, based on the premise that smart machines can more accurately capture and communicate data for faster problem-solving and increased overall efficiency.

Instrumentation
The processes and equipment used to indicate, measure and record physical quantities.

Information and communications technology (ICT)
The telecommunications equipment, computers and associated enterprise software, middleware, storage and audiovisual systems that enable users to access, store, transmit and manipulate information.

Integrated services
An architecture that specifies the elements to guarantee a network's quality of service.

Internet Protocol (IP)
The language a computer uses to create a "network of networks" and provide access to the internet.

Interoperability
When product or system interfaces are able to work seamlessly together within a defined set of other products or systems.

IoT cloud platform
A cloud platform with services, such as development tools and data analytics capabilities, that simplify the integration of cloud platforms and IoT devices.

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Jitter/packet delay variation (PDV)
The variability in ping over time, usually noticed as buffering or other interruptions when streaming and gaming.

Latency/ping
The reaction time of a connection, or how quickly a device gets a response after a request has been sent out.

Lattice or self-support tower (SST)
Typically used in telephony, a freestanding tower 200-400 feet tall with a triangular base.

Legacy systems
Old or outdated computing methods, hardware, technologies, computer systems or application programs.

Licensed spectrum
Forms the core of today's mobile broadband networks, providing clear protection from interference that enables high-quality, reliable wireless service.

Lightweight protocol
Any protocol that has a lesser and leaner payload when transmitted over a network connection.

Long-range communication protocols
Universal long-range radio frequencies for multi-generation wireless standards such as 2G, 3G, 4G and 4G LTE.

Low-band spectrum
Spectrum below 3 GHz, with limited capacity yet the ability to span large geographic areas.

Low-power devices
Designed to use less electric power than traditional devices and necessary to the future success of IoT. As sensors become more advanced, devices will need to be able to operate for longer periods of time without manual maintenance.

Low-power wide-area network (LPWAN)
A network that allows long-range communications at a low bit rate.

Machine-to-machine (M2M)/distributed systems
Connected devices that communicate freely, usually in industrial and manufacturing applications.

Mesh network
A type of network topology in which a device transmits its own data and serves as a relay for other nodes. It's the most efficient path for data traveling through routers.

Messaging protocols
Different ways information is transferred and communicated across devices, the cloud and data storage.

Mid-band spectrum
Spectrum between 3 GHz and 24 GHz, travels shorter distances than low-band spectrum but with greater capacity.

Monopole tower
Typically used for telephony, a single tube tower, usually 100-200 feet, with exterior-mounted antennas.

Multi-agent system
A network of multiple agents that interact or communicate with each other toward a specific objective.

Narrowband Internet of Things (NB-IoT)
Standards-based LPWAN radio technology for IoT devices and services. It delivers indoor coverage, low cost, long battery life, high connection density and significantly improved power consumption, system capacity and spectrum efficiency. It uses a subset of the LTE standard with bandwidth limited to a single narrow band of 200 kHz.

Near field communication (NFC)
Communication protocols and technical standards that enable an electronic device (usually a portable device such as a smartphone) to establish radio communication when within 4 centimeters of another mobile device or a nearby system.

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Open data
Data that is freely available for use and republishing without copyright, patent or other restrictions.

Operability
The measure of how well a software system works in production in the public cloud, a co-located data center, an embedded system or a remote sensor that is part of an IoT network.

Packet loss
Percentage of packets lost compared to packets sent over the internet, usually as a result of poor signal/line quality.

Personal area network
A single-user network created through the interconnection of information technology devices.

Ping/latency
Measured in milliseconds, how quickly a device gets a response after a request is sent. A fast ping means a more responsive connection.

Platform
The computing environment within which a piece of software is executed.

Platform as a Service (PaaS)
A cloud computing service that provides a platform for developing, running and managing applications.

Predictive analytics
A range of statistical techniques—such as predictive modeling, machine learning and data mining—used in forecasting.

Publish/subscribe (pub/sub) messaging queuing protocol
A form of topic-focused authenticated and authorized user messaging.

Radio access network (RAN)
With capacities up to 5G, a major component of wireless telecommunications. It uses radio connections to connect individual devices to other parts of a network. A RAN resides between user equipment (a mobile phone, a computer, any remotely controlled machine) and provides the connection with its core network.

Radio frequency (RF)
Portion of the electromagnetic spectrum that is used for telecommunications. The bands used for wireless communication range from about 20 kHz to 300 GHz.

Radio frequency identification (RFID)
A three-component (antenna, transceiver, transponder) technology that uses electromagnetic coupling and radio frequency to identify objects and persons.

Real-time operating system (RTOS)
A hardware and software system designed to guarantee the completion of a task within a certain time constraint and respond very rapidly to continuously occurring external events. An RTOS is often used in safety-critical systems and in the creation of IoT devices.

Reference architecture
A type of software architecture that provides reusable templates for a particular domain.

Release management
The ability to quickly deploy changes to a software system, recover from disaster and adapt to changing technical and business challenges.

RF mesh
A wireless communications network with radio frequency nodes organized in a flexible mesh topology, driven by connections between neighboring nodes.

Service provider
A third party or outsourced supplier for telecommunications (TSPs), applications (ASPs), storage (SSPs) and internet (ISPs).

Small cell
Compact (pizza box/backpack-sized), discreet mobile phone base stations that operate in licensed

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spectrum with lower RF power and capacity than a macrocell. Often mounted on light poles, the sides of buildings or indoors in stadiums, transport hubs and other public areas, they are usually owned and installed by mobile network operators.

Smart infrastructure
Smart technologies integrated into fundamental facilities and systems.

Store and forward
A messaging mechanism in which a broker gets ownership of a message from the sender, stores the message for reliability, then delivers the message to the receiver.

Structured data
Elements of data that can be organized and standardized by how they relate to one another and the properties of associated real world entities.

Systems integrator
A person or company that brings component subsystems together into a whole and ensures that they work together.

Transmission Control Protocol/ Internet Protocol Suite (TCP/IP)
A basic client/server model communication protocol for the internet and private networks.

Universal design
The practice of designing hardware, software, networks and smart technologies that are usable by all people regardless of language, age, literacy, size or disability.

Unlicensed spectrum
Does not require users to have a FCC license, but equipment must be certified and comply with technical requirements. Users of unlicensed spectrum are not afforded interference protection and must share the airwaves.

Unstructured data
Information without a predefined data model.

Wearables
Connected devices with sensors worn on a person's body.

Zigbee
An open standard for wireless communication that uses low-power digital radio signals, used for personal area networks that require a low data transfer rate, energy efficiency and secure networking.

Z-Wave
A wireless protocol for home automation that uses a low-power radio frequency technology specifically designed for remote control applications.

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