Introduction

Our physical, digital, and human worlds are converging at an exponential pace, disrupting nearly every industry and community across the U.S. This Fourth Industrial Revolution is driving rapid urbanization and straining infrastructure that is already in decline. With increasing pressure on state and municipal budgets, civic leaders worry about delivering essential services to their citizens and staying competitive in our ever-evolving data-driven economy.

At the same time, connected citizens are influencing the pace of innovation, pushing leaders to try new approaches and technologies. By digitizing their physical infrastructure, leaders build community resilience and change the very nature of their systems. The result is an agile governance that can flex to respond quickly to changing community conditions and citizen needs.

All communities—including states, municipalities, universities, medical campuses, utilities, telecommunication carriers, and mobility managers—can capture the many benefits of digital technology. Although still early, many communities have started to go digital and are realizing the value of a nimble infrastructure, strengthened service delivery, and enhanced citizen quality of life. To get started, Black & Veatch advises leaders to create a planning roadmap to advance their foundational infrastructure—telecommunications, smart sensors, cybersecurity, and data science and analytics. With a digital foundation, leaders can configure resilient and sustainable operations that evolve alongside innovation no matter how the community changes over time.
The Drive for Smarter Communities

Much like the industrialization of the 19th century encouraged a migration from the country to the city, the internet and all its promise triggered our ongoing urban influx. As innovators started to explore the internet of things (IoT), cities became natural gathering spots for businesses, academia, and research labs so that professionals could work together toward new ideas, technologies, and services. The knowledge-economy transformed city neighborhoods into collaborative innovation districts. Cities became hotbeds of innovation, and their systems became testbeds for pilot technologies.

Since 2000, the U.S. urban population increased overall by 13%. With this increase, 82% of Americans now live in cities, and that number is expected to rise to 90% by 2050. With much of the U.S. infrastructure already in decline, community systems are straining under the population boom, making citizen-centric service, sustainability, and resilience seem like impossible goals.

At the same time, the number of connected devices is scaling into the billions, and citizens are at the epicenter of the new on-demand, data-based economy. As a result, citizens are influencing the pace of innovation and are pushing civic leaders to try new approaches and technologies to enhance service delivery and the quality of life throughout our neighborhoods. By digitizing their physical infrastructure, leaders will create smarter environments to manage their fast-growing populations and realize enhanced resilience and sustainability.

As their Cities Grow, what are U.S. Mayors most concerned about?

<table>
<thead>
<tr>
<th>Economic Development</th>
<th>58%</th>
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<tbody>
<tr>
<td>jobs, and neighborhood vitalization</td>
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<table>
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<tr>
<th>Budgets and Management</th>
<th>49%</th>
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<tr>
<td>issues like transparent planning and operational excellence in government</td>
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<table>
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<tr>
<th>Education</th>
<th>28%</th>
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<tr>
<td>issues like K-12 learning opportunities and college workforce preparation</td>
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<tr>
<th>Infrastructure</th>
<th>56%</th>
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<tr>
<td>issues like free wireless access and public transit</td>
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<tr>
<th>Public Safety</th>
<th>36%</th>
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<tbody>
<tr>
<td>issues like police and fire technology infrastructure and equipment</td>
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<tr>
<th>Energy and Environment</th>
<th>25%</th>
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<tbody>
<tr>
<td>issues like using clean renewable energies, flood control, and conservation</td>
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<tr>
<th>Health and Human Services</th>
<th>34%</th>
</tr>
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<tbody>
<tr>
<td>issues like access to wellness programs, hospitals, and clinics</td>
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The Value of Digital Connections

Our physical, digital, and human worlds are converging at an exponential pace, disrupting nearly every industry and city across the U.S. Leaders know that this disruption signals an opportunity to revolutionize their operations. About 66% of U.S. cities are investing in digital technologies⁶, and industries are changing, too. As of 2016, 70% of all jobs in the U.S. required workers to have moderate to high digital skill, compared to 2002, when only 5% of jobs required high levels of computer literacy⁷.

These trends show that communities are evolving from solely physical operations to a digital platform to stay competitive and capture the many benefits of digitization. For starters, broader use of digital technologies leads to greater productivity and could provide a $365 billion uplift to the U.S. economy⁸.

However, the value of digital connections is not just monetary. Civic leaders are looking for the best way to communicate with their constituents and deliver services through a digital interface. In a recent survey of more than 3,000 U.S. citizens, 85% indicated that they expect government digital services to match or surpass those from businesses, but more than 40% of citizens were unhappy with government’s digital services⁹. In this light, digital connections help leaders engage with citizens and operate with agile governance to respond quickly to changing community conditions and citizen needs. With this type of system, leaders can generate social and economic benefits for a variety of stakeholders to create true public value¹⁰.

Connected Communities Deliver the Digital Future

Connected Communities use digital platforms, data analytics, and apps to enhance delivery of functions or products toward greater citizen or customer satisfaction. Connected communities include states, cities, municipalities, utilities, government departments, medical campuses and educational campuses.

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Digital Connections
Apply New Technologies
to Old Dilemmas

TO WEAVE INNOVATION AND RESILIENCE INTO A COMMUNITY’S SOCIAL FABRIC.
Foundational Elements of Digital Connections

The cyber and real worlds are profoundly linked in a connected community, which is why communities are developing their foundational digital infrastructure as a first step. In fact, Black & Veatch found that 34% of municipalities rated high-speed data networks as a top priority. With robust foundational infrastructure, the community can more effectively integrate connect-sense-and-respond capabilities into its framework, changing the very nature of its systems.

These capabilities allow communities to reinvent their identity, shedding old status and stigma. Communities become redefined by their new states of functionality and create new community experiences for visitors and citizens. Even though innovation is underway, the potential of digital connections is still emerging, and citizen needs and desires continue to evolve. As civic leaders select projects and draw up plans, it’s important that the digital networks they select can support current smart apps as well as those that evolve and converge over time.

The path and pace of digital transformation varies across communities, but Black & Veatch advises everyone to consider these foundational elements when planning their approach. A holistic planning approach to connected technologies will get each of these elements humming in sync. But, communities must kickstart smart efforts now; innovation waits for no one, and the digital technology ladder will only reach new heights.

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Telecommunications Infrastructure

Wireless and fiber networks are the heartbeat of a connected community because they link the layers of physical devices and systems, data, and sensing to make a connected community possible. It’s important to remember that digital apps have latency, bandwidth, coverage, resiliency, and security requirements. As a result, communities need to plan and design their infrastructure to efficiently interconnect and integrate with its physical assets, like street lights, cameras, utility systems, and related apps.

FIBER

Fiber optics network and deep fiber deployment enables wireless technology and ensures a community can evolve toward the future. Connected community innovation and related economic growth will be limited without deep fiber deployment because high-speed broadband, 5G, and wireless densification cannot be fully developed. Without these capabilities, cities will be unable to leverage IoT technologies and the digital divide in rural and underserved areas will widen.

Within the community network, fiber will also support fronthaul and backhaul from the edge of the network to the core. As communities start to deploy smart technologies, they may need to add fiber connectivity to get the desired functions and expected value. For example, an IoT security camera cannot send captured images to the cloud for real-time facial recognition processing without a robust internet connection, via a direct fiber link or wireless small cell connection, which is also enabled by fiber.

Wi-Fi, 4G LTE, and 5G networks connect the mobile user and smart sensors to the community. Wi-Fi is an important amenity to visitors and citizens, and it can be leveraged to expand connected community apps. Because it provides last-mile connectivity, Wi-Fi helps bridge the digital divide by enabling services in low to medium income and underserved neighborhoods.

Many communities are upgrading to 4G LTE networks for faster wireless broadband speeds to support real-time voice, data, video, and photo capabilities. At the same time, carriers have started to roll out 5G to establish the “next gig thing”, which will allow digital apps and solutions to scale at faster rates than experienced today. 5G may seem far away, but it is expected that 5G subscriptions will begin to lead the market as soon as 2022, while LTE growth declines13. However, these two evolutions will co-exist to benefit both networks: 5G will share 4G’s extensive coverage, available spectrum, and existing infrastructure, and 4G networks will leverage 5G technologies to provide better service14. While it is reasonable for industries to operate their 4G LTE system until they reach their return-on-investment, they must consider 5G when making 4G modifications to protect investments and ensure an efficient transition to 5G.

Community permitting policies are linchpins of infrastructure deployment needed to expand 4G and roll out 5G. These networks require extensive work involving rights-of-way, poles, ducts, and neighborhoods to deploy antennae, small cells, and other technologies to densify the networks. Communities that ease permitting and site access to enable technology deployment may see big dividends—a city the size of Chicago could see 90,000 new jobs and a $14 billion economic boost related to 5G technology enablement. Even a small city like Saratoga, CA, could see 300 new jobs and a $50 million boost15. Knowing this, many communities have already started to evaluate their policies to encourage network technology deployment, and these states will be the first to see significant economic and consumer benefits16.

Smart Sensors

Recent LTE and 5G advances and standards have lowered the cost and energy needed to integrate many types of sensors in a community. It takes many diverse types of sensors, like fixed, human, and remote sensors, connected by a network to adequately support smart management. A connected community includes many sensor nodes, so communities need to understand the energy demand of sensors, as well as data ownership and privacy, especially if the sensors collect personally identifiable information.

The purpose of sensors is to gather data about the community to make accurate decisions in real-time for responsive and effective management. For this reason, the location of the sensor is critical. Many communities are including spatial data with their sensors via a GIS interface to capture critical locational information. For example, a sensor that indicates flooding is only useful if the location of the flooding is also conveyed.

Data Science and Analytics

How a city collects, shares, and uses data is a critical consideration. Communities that build a culture of transparency will have an easier time knocking down department silos and creating open data policies, which are essential to adopt data-sharing platforms and the technologies they enable. But, be prepared—connected communities produce a lot of data. To keep from being overwhelmed, cities need to consider big data architecture and interoperability alongside telecommunications. This will help them organize data sources, ensure systems work together, sync with an analytic process, and inform data monetization. It’s helpful to manage and govern data as a core component of operational systems and to prioritize data integration and processing through a network operations center.

Analytics platforms that offer dual functions can be valuable. Some platforms merge seamlessly with project management tools to collect, organize, and manage applications and end users during technology deployment. For example, Atonix Digital™ Program Management, powered by ASSET360®, a cloud-based analytics program, performs life-cycle optimization and data-driven decision-making after deployment.

Cybersecurity

With multiple points of entry, a digital system is at heightened risk for cyberattack. This explains why cybersecurity is the top priority of Chief Innovation Officers across U.S. cities, prompting 60% of cities to obtain cyberinsurance. Fortunately, digital platforms can be designed to establish cybersecurity protections and standards across the system, which means security is embedded within apps and interconnected devices to protect data as it is transferred across connected systems.

As communications systems evolve, leaders must adopt responsible cybersecurity measures that are flexible and scalable to grow with a community. A smart way to start is to conduct cyber-asset inventories. By quantifying risk, cities can prioritize and justify investments in cyber-protection and establish protections and protocols to protect community and citizen information.
Digital Engagement for Greater Citizen Quality of Life

While the smart community conversation frequently centers on digital technology, the essence of a digitally connected community is people. A community’s digital platform unlocks communication pathways, enabling citizens, leadership, and smart devices to connect and share information in entirely new ways. This “distributed insight” helps leaders understand what’s happening across neighborhoods and make better decisions. Communities are already making digital connections and elevating their essential city services like public safety, healthcare, mobility, education, and utilities. Even more, they are preparing their networks for the inevitable future innovation.
Public Safety systems are integrated for faster, coordinated response.

Public safety is integral to a connected community and directly impacts quality of life, but it is not a single-system initiative—it involves emergency services, police, fire, medical personnel, and traffic management. For this reason, many communities are deploying interoperable, integrated communication networks to securely link these essential systems (including P25 radio systems) and IoT devices for faster, coordinated incident response.

A shared digital platform optimizes emergency response to quickly route calls and first responders. GIS location services show the call locality, even if issued from a mobile phone. These systems are also synched to collect data from sensors, video feeds, aerial drones, and body cameras, which is processed at the edge to give first responders immediate access to real-time information. With these inputs, commanders can visualize the event, gain greater situational awareness, and make life-saving decisions faster. A digital foundation is flexible so leaders can add systems over time for greater connection and responsiveness across the community. Some cities are connecting school systems to the first responder network to ensure rapid and informed response to active shooter situations.

As IoT evolves, communities will connect multitudes of sensors and devices across their geography to create an advanced, two-way communication platform that enhances public safety and first responder operations:

- Smartphones become real-time public safety tools. Leaders use crowdsourced data to know community conditions and issue real-time messages like recommended evacuation routes.
- Data analytics illuminates crime patterns. Leaders effectively deploy patrols and steer citizens and visitors away from dangerous areas.
- Connected traffic systems use vehicle-to-vehicle and vehicle-to-infrastructure technology to get real-time traffic data to preempt signals and clear roads for emergency vehicles.

THE IMPACT OF INNOVATION

If a city like New York deploys these digital technologies in Real-Time Crime Centers...

- Predictive Policing
- Crime Mapping
- Digital Emergency Response Optimization
- Intelligent Traffic Signals

... then crime incidents could drop by 18.2% and emergency response time by 25.4%20

Communications Infrastructure Creates Digital Common Ground

Businesses are planning for their own digitalization. Communities with advanced networks, public Wi-Fi, and innovative systems are attractive to employers and support a skilled labor market. Communities that enable advanced communications systems, could add 2.2 million jobs and about $420 billion in annual gross domestic product, spread across small, medium, and large U.S. communities\(^{21}\). Since economic development often gives way to creative space development, communities can revitalize neighborhoods by bringing people together through a purposeful intermingling of art, culture, and technology.

An advanced communications system is data-driven. This inspires local government departments to topple data silos and use analytics platforms to increase operational efficiencies, optimize service delivery to citizens, and predict trends across community systems like utilities and public transit. Decision-making and operations become agile, efficient, and reflective of real-time conditions across the community. By establishing open data platforms and Wi-Fi hubs, local governments develop a digital common ground through apps and programs that help citizens feel more connected to their local government and to their community\(^{22}\).

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Connected Mobility Compliments Public Transit

A new mobility is emerging—one that is centered on multi-modal options and data exchange. With limited resources, communities are using technology to do more with existing assets:

- Crunching public transit data helps managers modify bus routes to match ridership and develop integrated multi-modal travel options.
- Real-time apps help people plan an optimal commute using bike-share, scooters, carpool, and last-mile transport.
- Streetlights outfitted with low-power, low-cost sensors use real-time traffic data to optimize traffic flow and reduce delays by 20%.

Communities are expanding communication networks to support mobility apps and the transportation-as-a-service business model. This model is evolving to include electric autonomous vehicles, as options for last-mile transit shuttles and cost-efficient trucking fleets.

A fully autonomous vehicle will generate 4,000 gigabytes of data in 90 minutes of driving, which necessitates ultra-low-latency networks and data centers to enable rapid edge computing and the deep learning models that inform autonomous driving.

Contrary to concerns, the American Public Transportation Association found that shared modes of travel do not compete with, but rather complement, public transit. With this assurance, communities are developing on-demand ride-sourcing and bike-sharing, in addition to public bus, train, and walking routes. As a valuable outgrowth of transit centers, transit-oriented development is springing up to revitalize neighborhoods, increase ridership, and provide access to walkable, mixed-use development.

To evolve connected mobility, communities will need to develop tech-enabled innovations—interactive reservations, dynamic dispatch and vehicle routing, app-based payments, and vehicle arrival tracking—that make use of integrated networks, vehicle-to-everything connections, and data gathering.

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Healthcare and Education Campuses
Transcend Time and Place

Medical campuses are primed for innovation. In fact, U.S. healthcare has barely scratched the surface of technological innovation, capturing only 10-20% of the digital potential identified two years ago\(^\text{28}\). Looking ahead, integrated networks and ultra-low-latency communications support state-of-the-art services and higher-level patient engagement through healthcare apps like smoking cessation programs as well as remote check-ups and patient monitoring. These apps engage at-risk populations that may have otherwise gone without treatment, like those with limited mobility, aging populations, or home-bound patients.

From this view, medicine functions beyond the bounds of time and place. Medical campuses operate with a global perspective—specialists from around the world are accessible for real-time clinical discussions, teaching seminars, and patient consultation. To better manage crises, emergency rooms and trauma specialists share an integrated, digital communications platform with police, fire, ambulances, and helicopter crews to receive mission-critical information and prepare for medical response even before the patient arrives.

In a similar way, the education industry wields connectivity like a pen to rewrite business models to better support students through linked systems and industry collaboration, and to gain efficiencies through automation and data-driven operations. U.S. legislative staff for higher education are concerned about declining university enrollment and employability of graduates\(^\text{29}\), which makes shared learning spaces, like innovation centers, a timely idea. In these centers, students, faculty, and startups are placed into the same multi-disciplinary landscape to encourage innovative encounters with like-minded collaborators. Through technology integration and transfer, innovation centers help develop new partnerships with research institutions and cutting-edge companies, which help students learn from the best and brightest in their fields.


Utilities are Making a Transformational Shift

Utilities are going digital to lessen the impact of market pressures, like obsolete and aging infrastructure and customer demands for digital services. Through digital architecture and sensors, utilities capture data from consumers and their systems to remotely monitor power and water flow and automatically adjust operations. These responsive systems help electric utilities prevent outages and integrate distributed energy resources (DERs) like solar and electric vehicles. Water utilities identify system leaks using sensor data, and initiate proactive flood management using data analytics to recognize flood patterns using river flow and rainfall data.

Both electric and water utilities are digitizing to provide a more sustainable future. The U.S. Department of Energy looked at the benefits of smart grids at the national level. They estimated that if every utility had a smart grid by 2030, then the U.S. could see an 18% reduction in carbon emissions, either directly through use of smart grid technologies that impact carbon emissions or indirectly by supporting greater participation in renewables and energy efficiency programs. Similarly, an audit of 246 U.S. water utilities showed a combined 130-billion-gallon water loss through leakage in just one year. Even more staggering is the realization that there are over 50,000 water utilities in the U.S. By applying smart management capabilities, utilities are using data analytics tools to monitor losses, pinpoint failing infrastructure, conduct proactive maintenance, and reduce these massive water losses.

As connected communities plan for their sustainable future, partnering with utilities is a smart move. Utilities are also making a transformational shift towards digitization and can provide insight on infrastructure as well as share equipment, crews, and rights-of-way access. Perhaps most valuable, they are part of community and already have a relationship with its citizens.

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**THE IMPACT OF INNOVATION**

- **18%**
  Reducing carbon emissions by this amount is equal to eliminating over 198 million cars from the road for one year.

- **42 billion**
  Gallons of water withdrawn daily from sources for U.S. use.

- **5.9 billion**
  Gallons of water per day lost due to leakage, poor accounting, and unbilled consumption.
Smart Community Moneyball

Moneyball is the art of finding value where others do not see it. In other words, when it comes to funding and financing smart community and community broadband projects, it pays to think creatively and look at all viable options. Black & Veatch’s 2018 Strategic Directions Smart Cities and Utilities Report showed that cities think Public-Private Partnerships (PPP) are an effective way to pay for enhanced infrastructure projects. And since PPPs can be customized in numerous ways, these contracts open the door to creative arrangement that is valuable to both the public and private entities.

**Partnership Stats in the United States**

- **60.5%** Percentage of U.S. cities surveyed that say PPP is their top financing model
- **35** Number of U.S. states with legislation enabling PPP
- **18** Number of states with finalized PPP deals in U.S.
- **20%** The amount of cost savings from using a PPP over traditional procurement model

**5 Ways to Save with PPP**

- **Costs:** lower construction/operating costs
- **Speed:** faster project delivery
- **Risk-Sharing:** private entity assumes some or all risk
- **Maintenance:** contract can include maintenance requirements
- **Innovation:** access to cutting-edge technologies and expertise for optimized features

**3 Other Smart Ways to Pay**

- **Traditional Procurement:** models based on ROI calculations for the smart project savings.
- **State/Federal Grants:** they contribute capital to the project.
- **Asset Leasing:** lease city assets to generate funding. For example, lay fiber optic conduits when streets are trenched and lease the conduits to generate revenue.

**6 Smart Reasons to Partner With LOCAL UTILITIES**

- They are part of the community
- They understand city infrastructure
- They have a relationship with citizens
- They are committed to safety and reliability
- They own rights-of-way
- They have equipment and crews for infrastructure deployment

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Jumpstart the Community’s Shared Vision

The first step of any journey is planning the route. A planning roadmap helps communities define their goals, determine which technologies will help achieve those goals, and develop success criteria to support the entire journey. A planning roadmap guides all connected community projects, like traffic and transit innovation; connected campus design in healthcare or education; integrated networks in public safety; and utility modernization.

Across the board, it’s important to start now because multi-faceted, capital-intensive digital infrastructure projects require careful coordination and can have long lead times for financing, engineering, permitting, and construction. As part of the planning process, these nine guidelines help communities shape their state of mind towards project success.

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Select a Champion: Communities that designate an Innovation or Sustainability Officer get an advocate who will build relationships, explore advantageous financing, and engage citizens.

See the Future: Create a planning roadmap towards the digital future to understand pain points and set objectives of digitization.

Boost Digital Skills: Understand which digital skillsets are needed to meet objectives. Plug the skills gap by setting aside funding and/or hiring critical positions.

Topple Internal Silos: Open data enables combining and analytics for greater digitization value. Examine data governance and enable cross-department data exchange.

Think Big. Start Small: Long-term planning is important, but easier projects with high return-on-investment, like smart streetlights and digital kiosks, create momentum, stakeholder enthusiasm, and support for bigger infrastructure improvements.

Form Strong Partnerships: Engage stakeholders to align with the community’s common vision. Non-traditional partnerships are often the key to overcoming complex issues and finding a financing arrangement that works.

Weave Initiatives into the Social Fabric: Leverage technology to connect citizens to the community and their neighborhoods, like digital kiosks that deliver Wi-Fi to underserved areas or digital apps that enable citizens to report issues and track projects.

Promote Smart Multi-tasking: Use existing assets in new ways to increase citizen engagement. For example, streetlights provide light as well as digital signage, video cameras, internet connectivity, and smart sensors.

Plan for Data: Connected devices will be numerous and geographically dispersed. Plan for distributed computing, data storage, management, and security.
THE CONNECTED COMMUNITY PLATFORM

A connected community is supported by layers of technologies and applications that converge to form The Connected Community Platform. Here’s a quick look at how the digital technologies discussed in this eBook come together.

DATA SCIENCE AND ANALYTICS
Software that makes sense of digital data.

SMART SENSORS
Distributed sensing devices capture data from multitudes of endpoints in real-time.

TELECOMMUNICATIONS
Networks that connect the community.

CYBERSECURITY
Multi-layered digital security to protect stored and transactional data.

APPLICATIONS
Smart devices, systems, and technologies that help leaders run their digital world.

DATA SCIENCE AND ANALYTICS
Program Management, powered by ASSET360®
Predictive analytics
Monitoring
GIS/GPS
DER analytics

SMART SENSORS
Body-cameras
Audio and video feeds
Traffic sensors
Mobile sensors
Environmental sensors

Telecommunications
Fiber
Broadband
4G LTE and 5G wireless
Wi-Fi
P2S radio systems

APPLICATIONS
Public safety
Energy
Mobility
Healthcare
Education
Smartphones
Smart kiosks

Smart parking
Smart lighting
Integrated traffic management
Network operations center
Connect Your Community

As communities continue to grow and essential systems and services become overloaded, it’s clear that communities are looking at digitization as a lifeline. They are primed to make digital connections, which allow leaders and citizens to build and deliver the digital future together.

Connected community plans and projects are as unique as each community that initiates them. But, communities all have one thing in common: a desire to create true public value. For leaders, digital connections open an opportunity for enormous technological innovation across their systems, creating a platform for greater efficiency and delivery of vital citizen services. The community will orbit citizens and visitors, who will feel safe in their neighborhoods and bonded to their community through connected services that reflect their changing needs. For technology integrators like Black & Veatch, a digitally connected community is about adaptability and resilience. With breakthrough communications networks and digital infrastructure, communities will evolve alongside future demands and technology innovation.

Though still early, some communities have already launched digital technologies and are seeing innovation change their communities for the better. Through good planning and partnerships, leaders will weave technology into the social fabric of their communities to vastly improve services and systems, create a stronger bond with the citizens, and amplify quality of life.
Information ahead of innovation.

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