Deloitte.

Wireless Connectivity Fuels Industry Growth and Innovation in Energy, Health, Public Safety, and Transportation

January 2017

Contents

Executive Summary

Wireless connectivity has transformed our world so rapidly that it is sometimes difficult to appreciate how fundamentally it is changing American industry. By fueling economic growth and innovation, these advances yield benefits with far-reaching impacts beyond just the telecommunications sector. Increasingly, industries across our economy are leveraging the wireless platform, charting new paths, becoming more efficient, and creating the potential for extensive economic development and job growth.

Today, 4G wireless technologies and connected devices provide a glimpse into the impact that 5G, the next-generation of wireless connectivity, could have across industry sectors and our economy. This paper explores four major industries, highlighting case studies that demonstrate how wireless connectivity has enabled these industries to grow and evolve. The picture that emerges illustrates the potential of tomorrow's wireless world:

- *Energy:* As estimated by the Electric Power Research Institute, smart grid adoption enabled by wireless connectivity could create $1.8 trillion in additive revenue to the U.S. economy and could save the average consumer hundreds of dollars per year.[1]
- *Health:* Goldman Sachs estimates that connected devices could create $305 billion in annual health system savings from decreased costs and mortality due to chronic illnesses.[2]
- *Public Safety:* Improvements enabled by wireless connectivity have the ability to save lives – a one-minute improvement in response time translates to a reduction of 8% in mortality, as estimated in a study in the Journal of Health Economics – and to reduce crime and the cost of law enforcement.[3]
- *Transportation:* Deloitte estimates that self-driving cars enabled by wireless connectivity could reduce emissions by 40-90%, travel times by nearly 40% and delays by 20%.[4] A 2013 study by the Eno Center for Transportation estimated that self-driving cars could save 21,700 lives and $447 billion per year.[5]

To some extent, the current stage of growth is propelled by improvements in efficiency and other rapid gains. Information that was previously difficult or impossible to acquire is now easily accessible, enabling businesses to better analyze the performance of assets, and more quickly identify opportunities to improve operations.

The next stage of growth will come not just from continued efficiency gains, but also from reductions of failure rates, increased productivity, and new functional capabilities. A fundamental catalyst of this innovation cycle will be the network effects of ubiquitous wireless connectivity brought about primarily by the advancements in wireless technology. Some of these effects are difficult to predict, but their trajectories can be characterized through the use of case examples described in this paper.

Indeed, this next stage of growth will be driven by 5G wireless networks. 5G is expected to provide speeds that are 10x faster than 4G, and with lower latency, which generates significant benefits, particularly in the health industry. 5G will enable the use of numerous devices on the network at once while providing carrier-grade security.[6] 5G will further unlock developments and growth in each of these four industry verticals.

Furthermore, quality of life, economic well-being, safety, and welfare of communities across the country are increasingly tied to wireless technologies. So-called "smart cities" are leveraging faster mobile broadband networks – and the technologies, applications, products, and services they make possible – to more efficiently allocate limited government resources, improve services, and build stronger communities.

It is clear that the communities and industries that offer the most farseeing and flexible platforms and regulatory processes will be the ones that benefit the most from innovation and economic growth. Further, those communities that proactively engage and partner with business will likely be part of shaping this future, helping ensure they also realize the benefits.

Introduction

The following perspectives on the specific industry verticals – energy, health, public safety, and transportation – highlight some of the benefits that have been realized as the result of increased connectivity, speed, improved capacity, and enhanced coverage of wireless networks. These benefits can be categorized in four ways, which are defined below in the context of the industries and use cases studied.

- *Better efficiency:* The increased utilization of assets or time in a business organization.
- *Reduction of failures:* Decreases in 1) the error or failure rate in processes and variability, 2) the asset replacement rate, and 3) the costs of downtime as a result of preventative maintenance.
- *Improved performance*: Leveraging a business or organization's existing assets in ways that ensure new benefits, revenue, or market opportunities.
- *New functionality:* Creation of new devices, assets, or services that may result in 1) expanding customer bases, 2) addressing new markets, and 3) offering new products or services.

	Featured elements	Description	Connectivity enabled uses	Impacts	Types of benefits: Better efficiency	Reduction of failures	Improved performance	New functionality
Energy utilities	**Generation**	Electricity from fossil fuels, renewable energy, nuclear, oil & gas	• Worker communications • Sensors measuring level of output by renewable sources	• Improves worker safety • Enables smooth conversion to grid from renewable sources	✓	✓		✓
	Transmission	High voltage transmission lines, pipelines, and transformers	• Sensors on substations to report outages • Transmission line supply and demand readings	• Lower maintenance costs through better deployment of technicians • Immediate adjustments to changes in demand/supply	✓	✓	✓	
	Distribution	Lower voltage lines for commercial or residential purposes	• Home smart meters with customer portal • Dynamic pricing and customer billing	• Less demand requiring less capex • Consumers save money	✓	✓	✓	✓
Health	**Hospitals/ clinics**	Tier-1 trauma centers, in- and out-patient treatment centers, and smaller clinics	• Digital/mobile patient charts • Tracking of patients and equipment • Internal staff communications	• Better patient and family experience • Integrated records and management	✓	✓	✓	
	Telemedicine	Remote access to doctors	• Diagnostics • Follow up appointments • Specialist physicians	• Preventative care • Reduced follow up related costs • Expanded patient base	✓	✓	✓	✓
	Patient monitoring	Devices worn to track vitals, including blood sugar, tremors, heart beat, or blood pressure	• Wearables (clinical and non-clinical) • Chronic disease management (heart, diabetes, and asthma)	• Identify symptoms and causes • Avoid major health events or worsening of condition	✓	✓	✓	✓
Public safety	**Law enforcement**	Police officers and community peace officers	• Resource tracking and deployment	• Optimize resource deployment • Crime prevention • Faster criminal case processing	✓	✓	✓	
	Emergency responders	Emergency services, fire, and disaster management	• Instant feedback to centralized hub • System-wide information	• Rapid responses • Saving lives • Identifying crises earlier	✓	✓	✓	
	Public health	Food safety, air quality, and resource management	• Sensors to identify pest infestations • Air quality reports	• Reducing potential public health threats • More efficient inspections	✓	✓	✓	
Transportation	**Personal vehicles**	Individual cars, motorcycles, or bicycles	• Vehicle to vehicle/infrastructure (V2V or V2I) communication • Autonomous vehicles	• Reduced congestion • Increased productivity • Lower emissions • Fewer accidents	✓	✓	✓	✓
	Commercial	Delivery, trucking and train freight Fleets or private transportation	• Semi-autonomous vehicles • Tracking of fleet or vehicles and route optimization • Identifying excess space	• Lower costs • Better fleet management • Prioritization of maintenance expenditures	✓	✓	✓	✓
	Public transportation	Light rail, subway, and buses	• Accurate arrival times • Integrated intermodal system	• Enables more choice • Better and new services • Enables new revenue	✓	✓	✓	

Source: Deloitte analysis

Energy

Wireless connectivity strengthens energy companies' ability to power our nation's homes, businesses, and communities. According to the Electric Power Research Institute, smart grid adoption, which is enabled by wireless connectivity, could create $1.8 trillion in additive revenue to the U.S. economy, saving the average consumer hundreds of dollars per year.[7]

Improving the efficiency, reliability, and security of the nation's power delivery grid impacts nearly every aspect of the U.S. economy. The electric grid covers the entire country and is comprised of the generation of electricity by power plants and other sources, the transmission of electricity, and the distribution of electricity to homes. Wireless connectivity is reshaping the energy landscape with greater access to real-time information. Connectivity helps augment the energy industry's critical role in the economy, electricity utilities in particular, despite ongoing challenges created by aging infrastructure and sheer complexity.[8] Specifically, wireless connectivity fuels the economy as shown through the following case examples of the activities undertaken across the country:

Benefits Consumers, Businesses, and Communities: The benefits to electric utilities stem from the increased asset efficiency and reduced costs, which directly translate into greater reliability and lower costs for consumers and businesses, and opportunities for investment in new capabilities and technologies, such as renewable energy sources. This impact of wireless connectivity can be felt across the economy – as estimated by Electric Power Research Institute (EPRI), a more efficient and reliable energy grid enabled by a smart grid could create $1.8 trillion in additive revenue for the U.S. economy from 2013-2020.[9]

Balances Energy Supply and Demand: Balancing power supply and demand is a critical role for electric utilities, as any miscalculation can cause safety and reliability concerns by oversupplying power to the system. Electricity supply and demand are largely independent, with utilities serving as the matching function to reach a near perfect equilibrium and ensure stability and reliability for the entire grid. Many causes of variability are unpredictable. For instance, weather is estimated to cause 80% of outages and 90% of electricity-related variability.[10]

Furthermore, the addition of renewable energy poses another challenge, as the energy added is often variable due to the availability of solar or wind inputs to generate energy, independent of the consumption or demand of energy. On the supply side, generation is estimated to be the part of the value chain with the largest source of losses in the system, with transmission as the second most significant source, which means improving the capability of the system could reduce power generation needs, costs, and avoidable losses in the system.[11]

Moving from a predictive system to a real-time reporting system that leverages wireless solutions enables electric utilities to better serve a matching function. For example, in 2011, an earthquake in the Washington, DC metropolitan area tripped sensors connected wirelessly to the grid at two nuclear plants in Virginia, shutting down the supply from these plants for 12 seconds. The U.S. Energy Information Administration reported that the other plants on the grid detected the decrease created in those 12 seconds and automatically generated additional output making up the difference to prevent service disruptions.[12]

A smart grid represents the widespread adoption of communications technology in the energy sector and refers to the technology that being used to provide computer-based remote control and automation, utilizing two-way communication technologies and sensors to gather and relay relevant data.

The Smart Grid Consumer Collaborative estimated that for customers, smart grid adoption could lead to approximate savings of $40 to $100 per year in direct benefits and $50 per year in indirect benefits.[13]

Improves Grid Maintenance and Monitoring: EPRI estimated that the cost of power disturbances due to outages is between $104 billion and $164 billion per year.[14] Outages also cause major disruptions to residential customers and industrial users. Many industrial users are sensitive to any type of outage, which can cause operations to be disrupted and creates the possibility of having to scrap millions of dollars of material in the process. Wirelessly connected sensors allow utilities to monitor the maintenance and status of all of the lines within the system. This real-time monitoring allows electric utilities to accurately deploy technicians to fix and replace equipment due to storm or accidental damage, and provides the basis for optimizing the workforce and capital investments to improve the integrity of the overall system. With wirelessly connected sensors, electric utilities can fix and replace equipment before a critical failure, which potentially translates to further savings of millions of dollars per year.

For example, a report by U.S. Department of Energy (DOE) highlighted the Sacramento Municipal Utility District's (SMUD) implementation of the SmartSacramento project, which involved large-scale deployment of an advanced metering system integrated with existing information technology systems, such as proprietary-based, wireline, and wireless communications technologies. The project utilized a partial deployment of advanced power distribution systems to enable automated grid control and operations. SMUD estimates that this project has reduced outage events by 37% in customer-minutes interrupted from 2009 to 2013.[15]

Protects Workers: Efficiencies can also be obtained across other key components of the grid, including generation and distribution, in addition to reducing energy loss. Many complexities and issues in the energy sector can be alleviated using sensor technology to send information about the status of infrastructure and electricity flows. Nuclear power plants are leveraging next generation wireless connectivity to strengthen on-site communication to monitor equipment, provide redundancies, and address safety concerns. A nuclear facility in South Korea was able to reduce worker radiation doses by 37% through wirelessly enabled radiation sensors and a centralized monitoring system.[16] Similarly, electric utilities are changing how they operate and are moving towards smart automation to improve overall system response time using wireless connectivity.

Reduces Investment Costs: Ubiquitous access to wireless networks allows sensor technology to inexpensively transmit information back to utilities or users on a timely basis. In 2015, a major telecommunications carrier launched a platform for utilities, which uses 4G LTE technology and provides a dedicated wireless backhaul for advanced metering infrastructure. In more than 60% of electric outages, utility companies became aware of the outages from customer notifications, according to industry estimates and stated in the press release announcing the new platform.[17] While most utilities use cellular technologies for aspects of their grid communications, this platform is an example that brings the solution to each smart meter and allows more utilities to undertake smart meters without requiring additional significant communications network investments.

Boosts Generation and Distribution: Bringing electricity into homes and businesses is equally complex, requiring a network of substations, system redundancies, and lower voltage distribution lines. Smart meters provide information for the utilities to dynamically adjust to peaks and demand changes. As of early 2016, more than 50 million smart meters reliant on a wireless connection were installed in approximately 43% of American homes.[18] More recently, these smart meters have been harnessed to provide information about usage to the consumers to directly influence choices to reduce use and cost. This information is accessed through online customer accounts. Some utilities have started to offer in-home meters that convert from kWh to dollars per hour, using the current dynamic price based on aggregate demand.

For example, a DOE report discussed Florida Power & Light's (FPL) project aimed at decreasing losses and demand, using a large-scale deployment of advanced smart meters, distribution automation, an electricity pricing pilot, and advanced monitoring equipment for the utility's transmission system. Advanced metering infrastructure, enabled by cellular technologies, supports a standardized two-way communication link between smart meters, access points on the grid, and distribution automation systems. Over three million of FPL's customers have received smart meters as a part of the project. FPL has achieved 98% of its transmission improvement goals and 50% of its distribution improvement goals, saving some customers $1,200 per household annually in 2012.[19]

Enables Consumer Education: Utilities are also harnessing smart meters to better educate and inform consumers – empowering them to reduce their energy bills. A Washington Post article reported that Oklahoma Gas & Electric (OG&E) installed more than 820,000 smart meters in its service areas through a voluntary enrollment program. Utilities use a combination of cellular and mesh wireless networks, but the backhaul system typically uses the cellular system infrastructure. The program communicated consumption and provided a direct way to monitor energy usage and costs, helping OG&E customers in the program save, on average, $191 per year on their electricity bills.[20]

Health

Wireless connectivity provides for innovations in telemedicine, patient monitoring, and data collection in the health care industry, partially saving the system $305 billion annually from decreased costs and mortality rates from chronic illnesses, according to a Goldman Sachs estimate.[21]

Health care expenditures in the United States rose to $3.2 trillion in 2015, or approximately 18% of the GDP.[22] Health care costs are rising, driven by many factors, including the aging population, severity of illnesses, the inefficiencies and complexities of the system, and lack of transparency or available data. The United States spends nearly twice as much per capita as any other developed nation on health care, but has lower life expectancy and higher levels of chronic diseases.[23]

Wireless connectivity enables remote access and telemedicine, while providing improved care and health outcomes. This increased access reduces unnecessary costs and ensures that time and distance are not barriers to early interventions and preventative care. Goldman Sachs estimates that the total annual savings opportunity for the health system that will be achieved through digital health adoption is $305 billion, with two-thirds from chronic disease management and remote patient monitoring.[24]

Consumers are increasingly attracted to these telehealth and smart monitoring trends, as they empower them to make better choices and access better care. Deloitte's 2016 Survey of U.S. Health Care Consumers shows that nearly 70% of healthcare users are interested in some form of connected healthcare services, 50% of health care users responded positively to the idea of telehealth,[25] and an American Hospital Association's report on telehealth indicates that:

- 74% of U.S. citizens would use telehealth services
- 70% of U.S. citizens would be comfortable communicating their health needs over a device
- 30% of U.S. citizens use computers or smartphones for medical or diagnostic information[26]

Expands Reach of Health Care: Telemedicine requires that both the physician and the patient have a secure, low-latency connection. With ubiquitous cellular coverage, this connection can be realized in rural areas, enabling greater access in all areas of the country.

Telemedicine is being embraced by hospitals around the country; the American Hospital Association's annual survey showed that 52% of hospitals in the United States used some form of telehealth in 2013.[27] Telemedicine is only one part of the picture, as patient monitoring has continued to evolve and grow exponentially. For instance, a Healthcare Information and Management Systems Society (HIMSS) study reported that leading medical professionals from the University of California Davis Health System implemented a program that utilizes clinical telehealth and telemedicine. As of 2016, the program reduced rural to urban transfers by an estimated 31%, saving rural emergency departments an average of $4,662 per hospitalization.[28] The increased access to specialists and more experienced professionals from remote locations reduces the need for transferring and improves the quality of care offered closest to the patient.

HIMSS published a case study on Dignity Health in San Francisco, an integrated health care organization, which utilizes a telemedicine network that enables physicians to connect with patients at remote care sites through a secure internet connection. The system allows the organization to have a larger customer base beyond San Francisco, and centralized located scheduling services allow for quicker response times and help more patients.[29]

As of 2016, Dignity Health's program was reported to save an estimate of $20,000-$70,000 per bed per year, reduced sepsis shock from 45% to 20%, and halving the average ventilator stay to 1.4 days. Patients were able to get preventative care earlier and identify major issues faster.[30]

Reduces Mortality Rates: In the United States, chronic heart failure impacts nearly 6 million people per year. Telehealth programs have created an estimated 20% decrease in mortality and a 50% reduction in medical costs associated with chronic heart failure.[31] A Brookings report highlighted a program implemented in Massachusetts, the Connected Cardiac Care Program, which uses a combination of remote monitoring, social media, and data management applications to provide telehealth services, including centralized telemonitoring, self-management, and nurse intervention. The program has resulted in a 51% reduction in heart failure readmissions and 44% reduction in non-heart failure readmissions, leading to cost savings of $8,155 per patient. The accrued savings in the six years since its launch is over $10 million.[32]

Helps Manage Chronic Diseases: The Centers for Disease Control estimate that the incidence of diabetes increased fourfold from 1980 to 2014 and now affects approximately 29 million Americans, with 86 million diagnosed with prediabetes.[33] The disease is a significant contributor to rising health costs in the United States. Companies are addressing this trend; in 2015, a major medical device manufacturer

A Brookings report highlighted the State of Mississippi's Diabetes Telehealth Network (DTN), which is aimed at addressing the diabetes epidemic. DTN provides patients with remote care management, resulting in cost savings of $339,184 for 100 patients enrolled in that project and projected Medicaid savings of $189 million annually.[34]

launched a smartphone app for patients using its continuous glucose monitor to receive alerts. Results are uploaded every five minutes to the smartphone app, allowing patients greater control over diabetic episodes.[35]

Advances Medical Research: The wearables and remote patient monitoring market is expected to reach $612 billion by 2024 with expected sales from providers of $50 billion and consumers of $200 billion.[36] The National Institutes of Health (NIH) has created a precision medicine initiative – involving detailed personal medical information retrieved from wearables and implants – that will enable research for a wide range of diseases to detect correlations between genetic environmental exposures and outcomes.[37]

Specific conditions and illnesses are being addressed through the use of wearables. As reported in a NIH study, the Michael J. Fox Foundation is pioneering work on devices that track the tremors associated with Parkinson's disease.[38] Wearable motion sensors provide reliable data in real time that help doctors determine whether patients are deteriorating and diagnose the root causes of symptoms.[38]

Creates Operational Efficiencies for Hospitals: Hospitals are increasingly using wireless connectivity to provide operational efficiencies. Studies find that more information was documented when a mobile device was used and more diagnoses are captured.[39] In 2015, Mercy Hospital in St. Louis announced that it opened the world's first Virtual Care Center, which houses 330 employees and existing telemedicine efforts, such as SafeWatch. The Virtual Care Center connects medical personnel with patients where they live, at one of Mercy's traditional hospitals, or at another physician's office.[40]

Sparks New Possibilities: With more reliable and faster real-time access, next generation wireless connectivity enables innovations in imaging, diagnostics, data analytics, and treatment. This is made possible through the use of devices, such as clinical wearables and remote sensors, as well as many others that monitor and electronically transmit medical data, such as vital signs, physical activity, personal safety, and medication adherence. For patients suffering from serious or chronic health issues such as cardiovascular disease, diabetes, or cancer, remote monitoring devices can track vital signs and glucose levels and electronically transmit this information to health care providers. For healthy patients seeking information and willing to pay out-of-pocket for devices today, wearables and monitoring technology can provide much needed information to help stay healthy.

Wireless connectivity's role as a catalyst in the health industry is clear in reducing costs across the system, providing incentives to patients to obtain care sooner, empowering patient choice, and providing for new functionality from medtech to hospital integration to patient services.

Public Safety

Wireless connectivity enables public safety personnel and departments to better protect and serve communities. A Journal of Health Economics study on the Salt Lake City EMS services found that a one-minute improvement in response time translates to a reduction of 8% in mortality, which means efforts to better coordinate responses or automatic deployment could save lives.[41] Wireless connectivity can also reduce crime and the cost of law enforcement, as shown through trial deployments of predictive policing programs across the country.

From predictive policing that helps reduce crime to providing real-time alerts giving first responders a more comprehensive understanding of unfolding emergencies, the technological gains of next generation wireless technologies are critical to helping citizens and communities enjoy enhanced public safety.

Wireless technology is enabling police departments to protect more neighborhoods with fewer personnel, improving patrolling techniques, and enhancing community engagement. Enhanced connectivity capabilities, enables public safety to rely on proactive policing techniques and deterrents. Advancements in wireless connectivity have the potential to demonstrably improve public safety by empowering public safety services – emergency responders, law enforcement, and public health – to carry out their missions more safely and effectively.

Advancements in public safety technology have largely focused on addressing declining government budgets and shifts in local tax bases, which have placed additional pressure on communities to do more with less.

Addresses Budgetary Pressures: Scheduling and deploying resources to provide public safety coverage amid budget pressures presents additional problems for many communities. For example, article highlighted that since 2006, the Denver Police Department has received a nine percent increase in emergency calls – responding to more than 500,000 calls in 2015. Compounded with budget cuts and fewer police officers, the Denver Police Department reported that it had postponed purchasing any new police cars.[42] But Denver's advanced wireless camera system, the High Activity Location Observation (HALO), was placed at key locations to extend the reach of the police force. HALO paid for itself in 18 months and allowed for more efficient investigations and capabilities, including the identification of license plates 1.5 blocks away.[43] Next generation communications technologies enable police departments to more efficiently cover the entire city.

Reduces Crime and Improves Officer Safety: The future of policing will take a stronger preventative approach, allowing police to do more with fewer resources and relying directly on data and algorithms to guide the deployment of resources. A predictive policing pilot program deployed by the Los Angeles Police Department (LAPD) builds on efforts in the last decade to focus on common crime hotspots by dynamically predicting new ones.[44]

PredPol estimated that the LAPD's Foothill Division saw a 20% drop in crimes from January 2013 to January 2014 and experienced a day without crime on February 13, 2014, due in part to the adoption of predictive policing analytics. In the Foothill Division, crimes were down 13% in the 4 months following the rollout of predictive policing analytics (while levels in the rest of the city remained flat). With this success, the LAPD expanded the pilot from three to 14 of 21 divisions by October 2015.[45]

The City of Atlanta launched a predictive policing analytics program, which allows police departments to layer data onto the existing wireless camera system feeds to predict when and where crimes may occur, enabling police officers to anticipate problems, preemptively deploy, and prevent future crimes. PredPol estimated that the results of the pilot program – deployed in two zones in July 2013 – showed aggregate crime decreases of 8% to 9%. The Atlanta Police Department has seen aggregate crime rates drop by 19%, attributing a significant portion of the sustained reduction to the deployment of this program.[46]

"The Los Angeles Police Department is leading the design of the next generation police fleet, maximizing the value of next generation wireless communication networks, which will enable the 'connected officer' to send and receive mission critical information timely, reliably, and with almost no latency. These innovations will improve officer safety."

Maggie Goodrich
Chief Information Officer, Los Angeles Police Department

Improves Decision-Making: The Internet of Things (IoT), a key trend in next generation wireless technology, will enable and empower emergency responders to be more responsive and effective. For example, emergency response vehicles can now be connected to the internet wirelessly with enough bandwidth to support high-resolution display monitors and to receive multiple inputs simultaneously. With this improved capability, emergency responders can develop fuller pictures of situations and provide better intelligence to decision makers. Connected sensors within disaster areas can wirelessly relay real-time information to ensure emergency managers make decisions based on the most recent, comprehensive information. A Journal of Health Economics study on the Salt Lake City EMS

system reported that a one-minute improvement in an emergency response translates to an eight percent improvement in mortality one day after the initial incident.[47]

The real-time tracking of emergency responders using IoT enables supervisors to make quicker and better decisions. Uses of IoT include:

- Tracking radio frequency identification (RFID) tags on equipment and GPS location of people and automobiles
- Controlling drones and other video surveillance remotely
- Monitoring integrated real-time weather data and personnel onsite managing the situation on high bandwidth connections

Creates Operational Efficiencies: Public safety professionals can capitalize on operational efficiencies that allow them to better perform their mission and save money. As reported, the Florida Department of Highway Safety and Motor Vehicles (DHSMV) partnered with an equipment manufacturer to install dedicated network antennae for video upload, allowing videos captured in police cars to be collected and used in criminal trials and proceedings. The new antennas reduced upload times from 3 hours to 20 minutes, which was estimated by the manufacturer to save the department $1.1 million in annual overtime.[48]

Integrates Public Health and Safety: Connected devices, reliable connectivity, and the resulting advanced analytics can empower emergency responders as well as public health officials to respond preventatively. For example, the City of Chicago announced that it had partnered with the Argonne National Laboratory and the University of Chicago to launch a city-wide pilot called the "Array of Things" (AoT) in 2016.[49] This initiative consists of 500 lamppost-mounted sensors, enabled by a major telecommunications carrier's network, which monitor air quality and other conditions to:

- Identify potential pest infestations
- Track variables increasing the incidence of asthma attacks
- Detect urban flooding to prevent damage and improve city services
- Provide real-time weather and climate updates
- Recommend the safest and least congested walking routes, depending on the time of day
- Obtain details about factors critical to the health of the city's environment and infrastructure

Once the sensor-based nodes collect the information, the data is transmitted over a secure wireless network to a central database server at the Argonne National Laboratory and then made available to the public.[50] Ultimately, the goal of AoT is to provide real-time, location-based data to detect changes and trends over time to improve the quality of life.

Transportation

Deloitte estimates that self-driving cars, enabled by wireless connectivity, could reduce emissions by 40% to 90%, travel times by nearly 40%, and delays by 20%.[51] A study estimates that self-driving cars could save 21,700 lives and $447 billion per year.[52]

Wireless connectivity improves the speed at which people and goods move along the road safely. An integrated transportation ecosystem is being accelerated by enhanced connectivity, a trend that is expected to continue and will push innovation in the transportation ecosystem. Benefits can be seen across the entire transportation ecosystem and modalities – from public transportation to trucking to individual drivers and riders. Next generation wireless technology is building a platform for widespread adoption of smart roads and infrastructure, while simultaneously recalibrating the transportation value chain, from manufacturers to end users.

While autonomous cars do not require wireless connectivity, being able to communicate to vehicles beyond a short-wave radio range will improve the overall transportation experience.

Reduces Congestion, Travel Time, and Delays: Next generation wireless technology has the potential to further improve these outcomes in the transportation sector by enabling the shift into self-driving cars and vehicle-to-infrastructure communication. Ubiquitous connections, made possible by cellular technologies, will enable software updates to occur automatically and access to networks even in remote locations.

A study estimated that even if only 10% of vehicles were self-driving, U.S. traffic deaths could decrease by 1,100 per year, saving $38 billion per year. If 90% of vehicles were self-driving, traffic deaths could decrease by an estimated 21,700 per year, saving $447 billion per year.[54]

Ford estimates that self-driving vehicles, one of the key innovations generated by next generation wireless technology, can save 37.5% in travel times and reduce delays by 20% for end-customers.[53]

The Atlantic Magazine estimated that the average American commuter spends 38 hours per year in traffic, collectively causing urban Americans to travel 5.5 billion more hours and purchase an extra 2.9 billion gallons of fuel at a cost to the U.S. economy of $121 billion per year.[55] According to the U.S. Department of Transportation (DOT), rural households drive more than urban or suburban households and utilize delivery services to access goods that are often not available locally.[56]

Enables System-Wide Improvements: Greater wireless connectivity pushes transportation services to work more efficiently and allows commuters to make their working and personal lives more productive. The first major benefit to commuters has been in improved efficiency. In the past decade, drivers and riders have been able to access new functionalities and services through their smartphones, examples including:

- Real-time mapping of traffic and road hazards
- Parking reservation services in ramps and on streets
- Urban bike sharing programs
- Ride sharing services
- One-way and day-long car sharing
- Accurate arrival times of public transportation

Deloitte estimated that vehicle emissions will decrease by 40% to 90% annually due to wide-spread adoption of autonomous vehicles, and ride sharing and automation will recover 100 billion hours of productive work that is otherwise used for commuting or driving.[57]

Improves Road Safety: As wireless communications technologies evolve, the transportation ecosystem will benefit by improvements in road safety and traffic efficiency. Augmented and virtual reality applications leveraging on-board sensors from other vehicles can fill blind spots and equip commuters with “see through” capabilities. Reliable identification and localization of vulnerable road users (VRUs) through satellite-based analytics can enhance the decision-making and safety of drivers. Data streams from connected road infrastructure like cameras and sensors can be utilized by on-board applications and algorithms to better plan routes.

Enhances Commercial Trucking: The commercial trucking industry also stands to benefit from enhanced wireless connectivity capabilities. For instance, Scania, a Swedish truck and equipment manufacturer, has partnered with the research and development department of a telecommunications equipment manufacturer to enhance wireless technology for use in the trucking industry. Scania has designed and developed wirelessly connected trucks that use on-board computers to send information to fleet management systems and workshops. This new era of wireless connectivity will enable trucks to be driven in convoys close to one another to improve the flow of traffic, real-time updates provided to the drivers about road blocks, obstacles, weather conditions, and other safety hazards, system-overrides to take over steering and breaking functions, and reduction of air drag leading to lower fuel consumption and exhaust emissions. The new 5G networks will only increase the opportunities available for this type of technology, as more capabilities are introduced to the market.[58]

Builds Platform for Smart Cities: Cities are leveraging wireless connectivity and taking an ecosystem approach to transportation. Recently, DOT announced that Columbus, OH, was selected as the

winner of the DOT Smart City Challenge, which will give the city $40 million in federal grant money and $10 million from private sources, plus the $90 million the city raised from private partners, to upgrade its transportation system.[59] Columbus' approach integrates wireless connectivity in every aspect of its system, including:

- Planning for autonomous cars and fleets
- Facilitating connections on buses and trains to create access for lower-income residents
- Utilizing a mobile phone enabled universal payment system
- Allocating shuttles for those who are in the most need of prenatal care

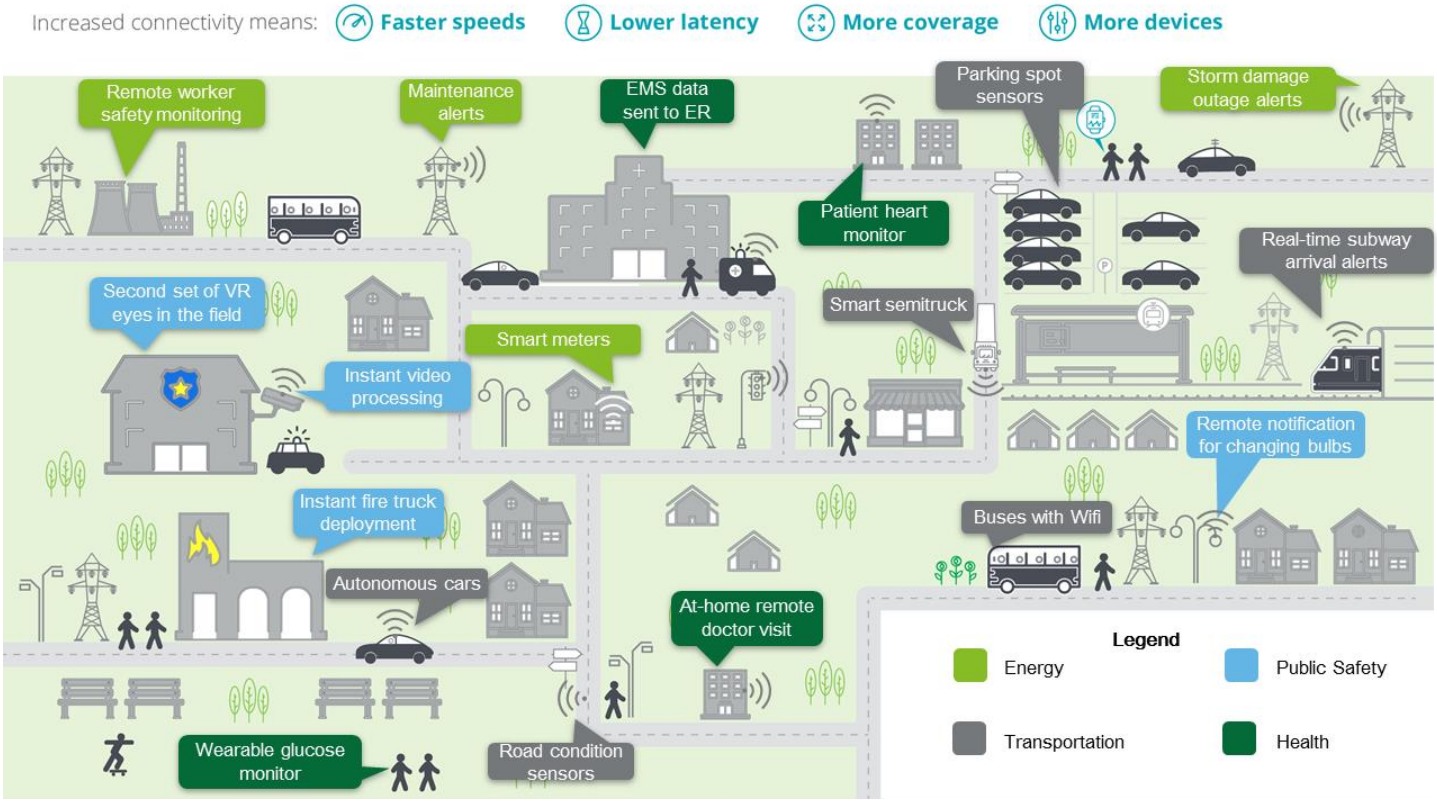
Overall, as further advancements in wireless connectivity continue to impact the transportation ecosystem, industry experts foresee progressively lower costs of transportation, fewer accidents, and new technologies. New business models, like shared ownership of fleets of autonomous vehicles, may emerge as a logical extension of these innovations. Ultimately, these changes could potentially benefit consumers through improved efficiency, better health and safety, and innovative transportation services.

Creates New Emerging Business Models: Business models in transportation will continue to evolve as wireless connectivity changes the very foundation of what transportation offers. New models will incorporate cross-industry cooperation between original equipment manufacturers and telecommunications operators to lower barriers for new sources of data to enter the ecosystem, improving commuter experience through enhanced local dynamic maps. As a result of these emerging business models, opportunities are already being created that deepen engagement with drivers through augmented or virtual reality dashboards.

Case Study

These changes reshaping the energy, public safety, transportation, and health industries – as well as those being felt across almost all sectors of America – are not taking place in disjointed isolation. Rather, they are interconnected and in many respects complementary, with advances in one industry often inspiring or creating demand for advances in other industries. The potential represented by next generation wireless technologies can be seen by envisioning how the four industries studied here could work together in response to a natural disaster, such as the wildfires that devastated portions of eastern Tennessee in late 2016. What follows below are a few examples of how wireless technology could be leveraged by these industries to save lives, property and communities in responding to future wildfires or similar disaster

Figure 3: Ecosystem of Connectivity – Increased connectivity drives innovations across every aspect of our economy



Source: Deloitte analysis

Energy: Energy companies are receiving data that allows them to manage the grid much more efficiently. Small distribution centers, previously unmonitored, now have sensors reporting problems. The grid turns itself off intelligently, detecting outages and downed lines far more precisely, so that power is cut off to a limited area, rather than a larger neighborhood. This data also enables crews to be quickly and efficiently dispatched and power to be more quickly restored after a disaster, allowing the community's recovery to begin.

Health: Ambulances can be routed in real time away from hospitals that have reached capacity or from roads blocked by the fire, and instead sent to hospitals that have the best capabilities to help. The detailed conditions and medical needs of patients are transmitted to hospitals in advance. The emergency room doctors and augmented artificial intelligence medical support are providing real-time support for basic and advanced life support techniques, specifically curated for individual patients through direct links to the patients' medical history. The technology allows for more precise logistics management, including the preparation and shipment of supplies, equipment, and medical personnel to the locations where they are needed most.

Public Safety: Fire commanders are receiving real-time data from firefighters wearing sensors, collecting data about the temperature of the fire, the amount of smoke being generated and localized readings of wind speed and direction. Remote sensors and cameras at ranger stations augment the information, allowing a 360-degree situational view to be stitched together for other respondents and decision makers. The

incident command center has a direct link to data analytics at new National Weather Service ground stations with precise information to conditions and the latest micro-forecasts. Police and other first responders have real-time information about vulnerable residents, including seniors or a recent heart transplant patient living alone in threatened areas, and children at day care centers, allowing for quick evacuation and lives to be saved.

Transportation: Roads with sensors embedded in the pavement detect when a fire is getting too close, sending notification to cars that certain routes are too dangerous, and directing them instead to safer escape routes, without diverting public safety officials to close the road. Cars traveling along various routes relay information about road conditions, congestion, and hazards to trailing cars using vehicle-to-vehicle communication, and trailing vehicles are dynamically rerouted to the nearest evacuation center based on location and prevailing fire conditions.

Conclusions

The Tennessee example is just one of many recent natural disasters for which the preparation and response could have been potentially improved with more ubiquitous coverage, increased adoption of new technologies, and deployment of next generation wireless technologies.

Realizing this future – and the benefits for energy, health, transportation, and public safety industries described above – will require a number of gaps to be addressed in the following ways:

- Making the permitting and regulatory process more efficient. In some cities, for example, small cells are regulated as if they were large cellular towers, with corresponding license requirements, fees and paperwork that inhibit the rollout of innovative wireless technologies
- Establishing public rights-of-way policies that allow the responsible deployment of small cells near consumers in urban areas
- Lowering costs and fees required to install new wireless infrastructure, as many municipalities carry fee structures that deter investment
- Adapting the siting process to provide more flexibility in placing wireless infrastructure, particularly small cells, in urban areas
- Continuing to support innovation in manufacturing and research to development the next generation of devices and equipment

The bottom line is that communities will miss out on opportunities if action is not taken to streamline the deployment of the wireless infrastructure required for 5G and smart cities.

Sources

1. “What a Smart Grid Means to Our Nation’s Future,” U.S. Department of Energy and Litos Strategic Communications, 2009, http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/Policymakers.pdf.
2. David H. Roman and Kyle D. Conlee, “The Digital Revolution Comes to US Healthcare: Technology, Incentives Align to Shake Up the Status Quo,” Goldman Sachs Equity Report, Internet of Things Volume 5, June 29, 2015, http://massdigitalhealth.org/sites/mehi/files/documents/eHealth_Cluster/The%20Digital%20Revolution%20comes%20to%20US%20Healthcare_GoldmanSachs_2015.pdf.
3. Elizabeth Wilde, “Do emergency medical system response times matter for health outcomes?,” Journal of Health Economics, July 2013, Vol. 22(7), pgs. 790-806, https://www.ncbi.nlm.nih.gov/pubmed/22700368.
4. Scott Corwin, Joe Vitale, Eamonn Kelly, and Elizabeth Cathles, “The Future of Mobility: How Transportation Technology and Social Trends are Creating a New Business Ecosystem,” Deloitte LLP, 2015, https://www2.deloitte.com/content/dam/Deloitte/ru/Documents/manufacturing/dup-future-of-mobility.pdf.
5. Daniel J. Fagnant and Kara Kockelman, “Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations for Capitalizing on Self-Driven Vehicles,” Eno Center for Transportation, 2013, https://www.enotrans.org/etl-material/preparing-a-nation-for-autonomous-vehicles-opportunities-barriers-and-policy-recommendations/.
6. Thomas K. Sawanobori, “High Band Spectrum: The Key to Unlocking the Next Generation of Wireless,” CTIA, June 13, 2016, http://www.ctia.org/docs/default-source/default-document-library/5g-high-band-white-paper.pdf.
7. U.S. Department of Energy and Litos Strategic Communications, 2009. Ibid.
8. “What the Smart Grid Means to You and the People you Serve.” U.S. Department of Energy, 2009, https://www.smartgrid.gov/files/sg_utilities.pdf. Matthew H. Brown and Richard P. Sedano, “Electricity Transmission: A Primer,” National Council on Electric Policy, June 2004, http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/primer.pdf.
9. U.S. Department of Energy and Litos Strategic Communications, 2009 Ibid.
10. Glenn Finch, “Weather analytics: A new dimension for business,” IBM Big Data & Analytics Hub, October 15, 2015, http://www.ibmbigdatahub.com/blog/weather-analytics-new-dimension-business.
11. Jordan Wirfs-Brock, “Lost In Transmission: How Much Electricity Disappears Between a Power Plant and Your Plug?,” Inside Energy, November 6, 2015, http://insideenergy.org/2015/11/06/lost-in-transmission-how-much-electricity-disappears-between-a-power-plant-and-your-plug/.
12. “Electric Systems Respond Quickly to the Sudden Loss of Supply or Demand,” U.S. Energy Information Administration, November 21, 2011, http://www.eia.gov/todayinenergy/detail.php?id=3990.
13. “Smart Grid Economic and Environmental Benefits: A Review and Synthesis of Research on Smart Grid Benefits and Costs.” Smart Grid Consumer Collaborative, October 8, 2013, http://smartgridcc.org/wp-content/uploads/2013/10/SGCC-Econ-and-Environ-Benefits-Full-Report.pdf.
14. M. Samotyj, “The Cost of Power Disturbances to Industrial and Digital Economy Companies,” Electric Power Research Institute, June 2001, EPRI-1006274, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002000476.
15. “Sacramento Municipal Utility District SmartSacramento Project,” U.S. Department of Energy Office of Electricity Delivery and Energy Reliability, November 2014, https://www.smartgrid.gov/files/SMUD_Project_Description.pdf.
16. “Monitoring Radiation Remotely, in Real Time,” EPRI Journal, 2015, http://eprijournal.com/monitoring-radiation-remotely-in-real-time/.
17. Jeff St. John, “Verizon’s Cellular Plan: The Smart-Meter-as-Smartphone Network,” GTM, July 29, 2015, https://www.greentechmedia.com/articles/read/verizons-cellular-plan-the-smart-meter-as-smartphone-network.
18. Chris Mooney, “Why 50 Million Smart Meters Still Haven’t Fixed America’s Energy Habits,” The Washington Post, January 29, 2015, https://www.washingtonpost.com/news/energy-environment/wp/2015/01/29/americans-are-this-close-to-finally-understanding-their-electricity-bills/ .
19. “Smart Grid Solutions Strengthen Electric Reliability and Customer Services in Florida,” U.S. Department of Energy Office of Electricity Delivery & Energy Reliability, July 2012, https://www.smartgrid.gov/files/FPLcasestudy.pdf.
20. Chris Mooney, January 29, 2015, Ibid.

21. David H. Roman and Kyle D. Conlee, 2015, Ibid.

22. “National Health Expenditure Data,” U.S. Centers for Medicare and Medicaid Services, 2015, https://www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/nationalhealthexpenddata/nhe-fact-sheet.html.

23. David Squires and Chloe Anderson, “U.S. Health Care from a Global Perspective: Spending, Use of Services, Prices, and Health in 13 Countries,” The Commonwealth Fund, October 2015, http://www.commonwealthfund.org/publications/issue-briefs/2015/oct/us-health-care-from-a-global-perspective.

24. David H. Roman and Kyle D. Conlee, 2015, Ibid.

25. Leslie Korenda, Claire Boozer Cruse, Greg Reh, “Will Patients and Caregivers Embrace Technology-Enabled Health Care?,” Deloitte University Press, August 30, 2016, https://dupress.deloitte.com/content/dam/dup-us-en/articles/3164_Technology-enabled-health-care/Technology-enabled-health-care.pdf.

26. “Trend Watch: The Promise of Telehealth for Hospitals, Health Systems and Their Communities,” American Hospital Association, January 2015, http://www.aha.org/research/reports/tw/15jan-tw-telehealth.pdf.

27. American Hospital Association, January 2015, Ibid.

28. “Connected Health Case Study: Connected Health, No Longer Disruptive – UC Davis Health System,” Healthcare Information and Management Systems Society (HIMSS), February 10, 2016, http://www.himss.org/connected-health-case-study-connected-health-no-longer-disruptive-uc-davis-health-system.

29. “Connected Health Case Study: Dignity Health: Increasing Timely Access to High Quality Care Leveraging Telemedicine,” Healthcare Information and Management Systems Society, February 15, 2016, http://www.himss.org/file/1298591/download?token=q6hB0LJC.

30. Healthcare Information and Management Systems Society, February 15, 2016, Ibid.

31. Andrew Broderick, “Partners Healthcare: Connecting Heart Failure Patients to Providers Through Remote Monitoring,” The Commonwealth Fund, January 2013, http://www.commonwealthfund.org/~/media/files/publications/case study/2013/jan/1656_broderick_telehealth_adoption_partners_case_study.pdf.“ Mortality Benefit of a Fourth-Generation Synchronous Telehealth Program for the Management of Chronic Cardiovascular Disease: A Longitudinal Study,” Journal of Medical Internet Research, May 13, 2016, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4909389/. RJ Krawiec, Jessica Nadler, Elan Tye, Jennifer Jarboe, “No Appointment Necessary: How the IoT and Patient-Generated Data Can Unlock Health Care Value,” Deloitte University Press, http://dupress.deloitte.com/dup-us-en/focus/internet-of-things/iot-in-health-care-industry.html.

32. Darrell M. West, “How 5G Technology Enables the Health Internet of Things,” Center for Technology Innovation at The Brookings Institution, July 2016, https://www.brookings.edu/wp-content/uploads/2016/07/How-5G-tech-enables-health-iot-west.pdf.

33. “Number (in Millions) of Civilian, Non-Institutionalized Persons with Diagnosed Diabetes, United States, 1980-2014,” Centers for Disease Control and Prevention, December 1, 2015, https://www.cdc.gov/diabetes/statistics/prev/national/figpersons.htm.“ 2014 National Diabetes Statistics Report.” Centers for Disease Control and Prevention, May 15, 2015, https://www.cdc.gov/diabetes/data/statistics/2014statisticsreport.html.

34. Darrell M. West, July 2016, Ibid.

35. Jeanne Whalen, “FDA Approves Medtronic’s New Automated Insulin Pump,” The Wall Street Journal, September 28, 2016, http://www.wsj.com/articles/fda-approves-medtronics-new-automated-insulin-pump-1475093556.

36. Heather Mack.“Report: Global market for connected wearables, health devices expected to reach $612B by 2024.” Mobi Health News, August 11, 2016, http://www.mobihealthnews.com/content/report-global-market-connected-wearables-health-devices-expected-reach-612b-2024.

37. “The Precision Medicine Initiative Cohort Program –Building a Research Foundation for 21st Century Medicine,” National Institutes of Health, September 17, 2015, https://www.nih.gov/sites/default/files/research-training/initiatives/pmi/pmi-working-group-report-20150917-2.pdf.

38. Ana Lígia Silva de Lima, Tim Hahn, Nienke M de Vries, Eli Cohen, Lauren Bataille, Max A Little, Heribert Baldus, Bastiaan R Bloem, and Marjan J Faber, “Large-Scale Wearable Sensor Deployment in Parkinson’s Patients: The Parkinson@Home Study Protocol,” Journal of Medical Internet Research, Vol 5(3), e172, July-September 2016, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5018102/.

39. P. Divall, J. Camosso-Stefinovic, and R. Baker, “The Use of Personal Digital Assistants in Clinical Decision Making by Health Care Professionals: A Systematic Review,” Health Informatics J, March 2013, https://www.ncbi.nlm.nih.gov/pubmed/23486823.

40. “Mercy Opens World’s First Virtual Care Center,” Mercy Saint Louis Missouri, October 6, 2015,

https://www.mercy.net/newsroom/2015-10-06/mercy-opens-worlds-first-virtual-care-center.

41. Elizabeth Wilde, July 2013, Ibid.
42. Noelle Phillips, “After Deep Cuts During Recession, Front Range Law Enforcement Agencies Still Digging Out While Trying to Keep Up With Colorado’s Population Boom,” The Denver Post, December 5, 2016, http://www.denverpost.com/2016/12/05/denver-growing-population-law-enforcement/.
43. Esme Vos, “The Cameras Work: Denver’s wireless video surveillance,” MuniWireless, June 14, 2010, http://muniwireless.com/2010/06/14/denver-wireless-video-surveillance/.
44. “Scientifically Proven Field Results,” PredPol, 2015, http://www.predpol.com/results/.
45. PredPol, 2015, Ibid.
46. PredPol, 2015, Ibid.
47. Elizabeth Wilde, July 2013, Ibid.
48. “Public Safety, Justice, and the Internet of Everything,” Cisco, 2014, http://www.nascio.org/events/sponsors/vrc/Public%20Safety%20Justice%20and%20the%20Internet%20of%20Everything.pdf.
49. Robert Mitchum, “Chicago Becomes First City to Launch Array of Things,” UChicagoNews, August 29, 2016, https://news.uchicago.edu/article/2016/08/29/chicago-becomes-first-city-launch-array-things.
50. “Ideas You Can Use: Chicago’s ‘Array of Things’ Project,” Smart Cities Council, July 19, 2016, http://smartcitiescouncil.com/article/ideas-you-can-use-chicagos-array-things-project.
51. Scott Corwin, Joe Vitale, Eamonn Kelly, and Elizabeth Cathles, 2015, Ibid.
52. Daniel J. Fagnant and Kara Kockelman, 2013, Ibid.
53. Orion Jones, “Ford Predicts Self-Driving Cars Will Cut Traffic by 2017,” The Big Think, Inc., 2015, http://bigthink.com/ideafeed/ford-predicts-self-driving-cars-will-cut-traffic-by-2017.
54. Daniel J. Fagnant and Kara Kockelman, 2013, Ibid.
55. Adam Werbach, “The American Commuter Spends 38 Hours a Year Stuck in Traffic,” The Atlantic Magazine, February 6, 2013, http://www.theatlantic.com/business/archive/2013/02/the-american-commuter-spends-38-hours-a-year-stuck-in-traffic/272905/.
56. “2010 Status of the Nation’s Highways, Bridges, and Transit: Conditions & Performance,” U.S. Department of Transportation Office of Policy and Governmental Affairs, 2010, https://www.fhwa.dot.gov/policy/2010cpr/chap1.cfm.
57. Scott Corwin, Joe Vitale, Eamonn Kelly, and Elizabeth Cathles, 2015, Ibid.
58. “5G Creates New Opportunities for Connected Vehicles,” Scania, February 25, 2016, https://www.scania.com/group/en/5g-creates-new-opportunities-for-connected-vehicles/.
59. Rick Rouan. “Columbus awarded $50 million in Smart City grants.” The Columbus Dispatch, June 21, 2016, http://www.dispatch.com/content/stories/local/2016/06/21/Columbus-Smart-City-grant.html.

Contacts

Brett Haan
Principal
Deloitte Consulting, LLP
bhaan@deloitte.com
+1 571 814 7380

Jack Fritz
Senior Manager
Deloitte Consulting, LLP
jacfritz@deloitte.com
+1 312 218 6097

Brett Olson
Manager
Deloitte Consulting, LLP
brolson@deloitte.com
+1 571 814 0845

Erica Sivertson
Senior Consultant
Deloitte Consulting, LLP
esivertson@deloitte.com
+1 612 244 0897

Marketing inquiries
Ays Aytolu
Senior Manager
Deloitte Services LP
+1 408 704 2246
aaytolu@deloitte.com

Press contact
Anisha Sharma
Senior Manager
Deloitte Services LP
+1 212 492 4427
anissharma@deloitte.com

Deloitte.

About the Report

This report was made possible through CTIA's sponsorship, but the contents and analysis of the report were included at the sole discretion of Deloitte. CTIA is an international nonprofit membership organization that has represented the wireless communications industry since 1984. The association's members include wireless carriers, device manufacturers, suppliers as well as apps and content companies.

About Deloitte