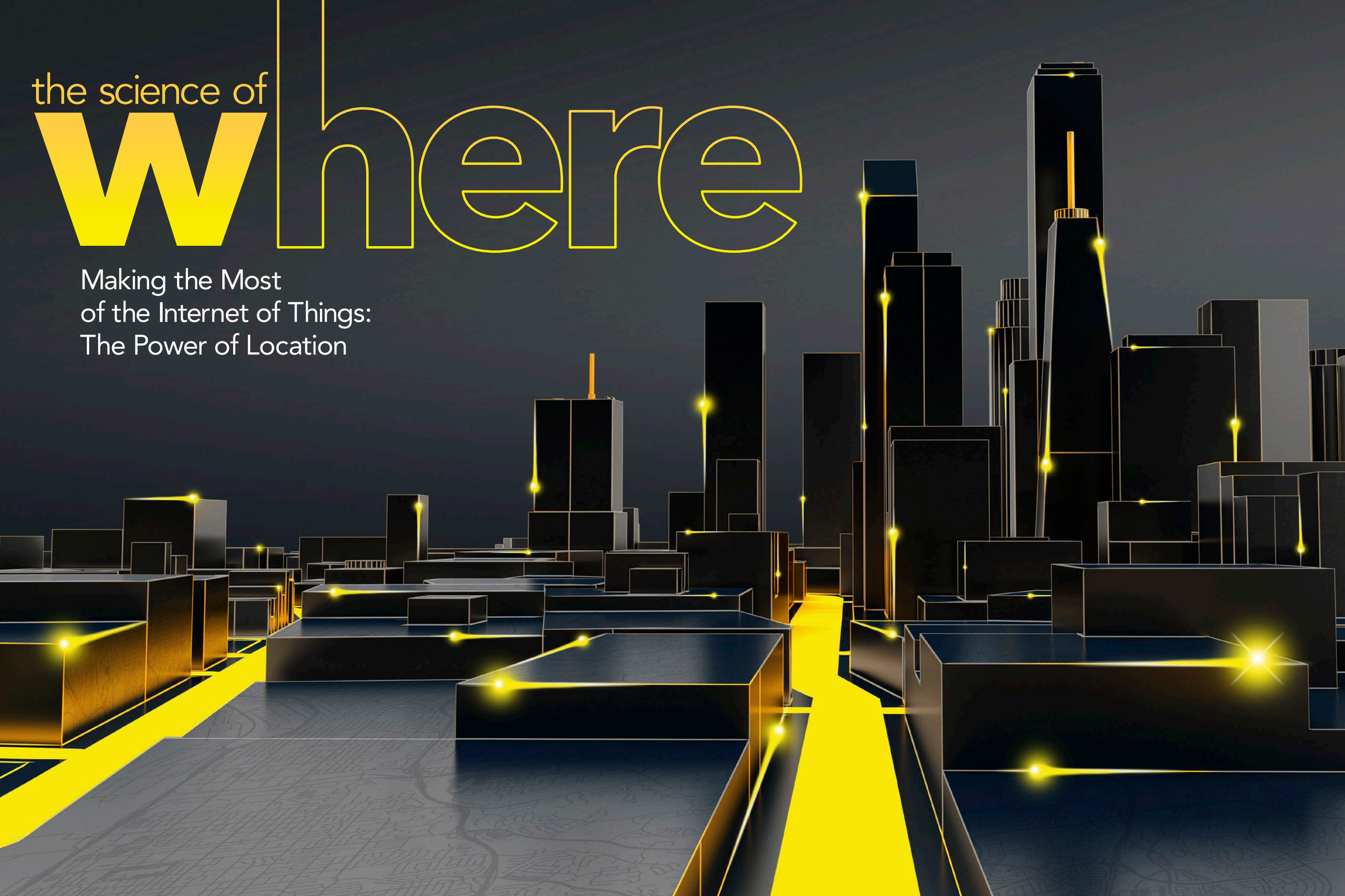
the science of Where

Making the Most of the Internet of Things: The Power of Location



It's important to understand that the value of IoT-generated data is not intrinsic; it flows from what government and citizens do with it.

The Power of Location and the Internet of Things

The Internet of Things (IoT), once just another captivating technology trend among many, is gaining deep traction in industry and government. Today, we are on the cusp of an IoT-driven technological revolution, affecting most if not all industries and mobilizing strategic thinking at every level, from the design engineer to the C-suite. With billions of connected sensors designed into products around the world, the IoT gives governments the ability to collect, process, and analyze vast—and potentially invaluable—datasets. Properly distilled, this data can reveal real, actionable intelligence. Yet for many governments, the path forward remains unclear.

The IoT's potential is tantalizing, but the reality of harnessing its power can be daunting and is always logistically challenging. Nevertheless, a 2017 McKinsey & Company survey found that 92 percent of high-level executives believe the IoT will generate a positive impact over the next three years, with 62 percent stating this impact will be very high or transformative.

Yet more than half of the same group of executives (54 percent) said that their companies actually use only 10 percent or less of their IoT data. And all cited major capability gaps when it comes to the IoT, such as integrating IoT solutions into existing business workflows, managing data, identifying case studies and applications, performing analytical modeling, and determining context for collected data.[1]

Advances in sensor technology, data storage, and highly compact processors have pushed the world to the brink of technological transformation. Estimates are that by 2020, the worldwide installed base of IoT end points will reach 30 billion.[2]

As this connectivity increases, its potential value intensifies. "Metcalfe's Law," originally promulgated with respect to Ethernet, states that the value of a network is proportional to the square of the number of connected users. Extrapolating this widely cited phenomenon to the IoT, as many have—where every node or sensor is a connected user—it suggests potential business value of such immensity as to almost defy quantification.

And the growth of this value-creation network is accelerating. Its underlying infrastructure is finally beginning to achieve real scale, as are the associated economies that allow organizations to experiment and uncover new opportunities and the techniques by which to exploit them.

As the IoT and its applications mature, the future will become increasingly intelligent and automated. Machine-to-machine communication and machine learning, as well as predictive (*What will happen?*) and prescriptive (*What should be done?*) analytics, are already changing the landscape across retail, manufacturing, utilities, and government entities. In the supply chain realm, for example, in-depth simulations using real-time IoT data can identify where disruptions are likely to occur and empower organizations to act in advance. In retail, machine learning will be used to build more powerful, more personalized customer experiences.

It's important to understand that the value of IoT-generated data is not intrinsic; it flows from what government and citizens do with it.

The data challenge, however, isn't just about the volume of data. It's also about the velocity and variety of data being created by the IoT. Because of the ubiquity of sensors, the huge volume of data coming at organizations is coming very fast, and it arrives in a variety of formats. So the mission is both to deal with the data and its various attributes, and then also make sense of it to probe it for insight to help grow or expand an organization.

Once an organization determines how to distill data into actionable intelligence, the possibilities for efficiencies and value become almost self-evident. For every organization, however, the challenge remains: how to best refine the raw material of the IoT—its data—into a meaningful asset, one with measurable business value.

Across industries, one of the most critical areas is citizen expectations. Today's sophisticated citizens want experiences that require massive real-time and big data analytics capabilities. Increasingly, it will be crucial to

- Capture, analyze, and store up to millions of sensor events per second.
- Visualize and probe observations about sensor events.
- Perform fast analytics on billions of data points.
- Make sense of objects and devices that are both moving and stationary and also likely have changing attributes. ▶

Story continues on page 6

1 McKinsey Global Institute: *Taking the Pulse of Enterprise IoT*, July 2017.

2 *State of the Market: Internet of Things*, Verizon, 2016.

"There's always a worry about fraud in the chaos of a disaster. With monitors using GIS, we can call up each truck to see its whole route and what it picked up, which eliminates any doubt."

– Scott Fraser, Floodplain Administrator, City of Key West, Florida

Key West Puts Apps in Hands after Hurricane Irma Hits

In the hours leading up to the landfall of Hurricane Irma on the Florida Keys on Sunday, Sept. 10, 2017, a few technologists in the City of Key West's Emergency Operations Center (EOC) began to prepare a mobile data collection app on their phones to track the toll of the storm after it passed.

All waited and wondered what Irma would bring. With a forecast of a five-foot storm surge and winds of 130 miles per hour, devastating damages were expected.

By midday on Monday, the winds had died down enough for a handful of staff to get out and look around.

Every single street in the city was blocked by downed trees. Crews had to zigzag around the trees, utility poles that tipped across streets with dangling electrical wires, traffic lights that hung at eye level, and debris of various size and sharpness that was strewn about. Many of the lowest areas were flooded, with as much as 18 inches of storm surge and rainfall turning roads into rivers.

By all accounts, Key West dodged the horrendous damages that everyone feared. The wind was bad, but flooding fell far short of the forecast. Now, it was time for city employees to get to work putting everything back together. The mobile app allowed the city employees to act as sensors, fanning out over the city to collect data points and pictures to assess the damage.

The new mobile data collection app was quickly put to use to conduct a rapid windshield survey. This preliminary damage assessment establishes benchmarks for degree of damage and insurance coverage and is required by the Federal Emergency Management Agency (FEMA) to determine whether a federal disaster declaration is warranted.

FEMA quickly informed the city that it met the federal disaster declaration threshold, meaning that federal funds would reimburse the city for disaster response and recovery work. The city would gain funds for debris removal and emergency protective measures, as well as to repair roads, bridges, water control facilities, buildings, equipment, utilities, and parks and recreation facilities.

Much of the work was begun immediately by city crews to expedite the city's recovery, with details on the work and cost to be submitted later to FEMA for reimbursement.

"We've learned that we didn't have cost details of the work in the past, and it hurt us," said Scott Fraser, floodplain administrator, City of Key West. "People were so intent on getting things done, and back up and running again, that they didn't record what they'd done."

Fraser kept the crews collecting and expanded the scope based on his success working with FEMA in the past.

"With ongoing data collection, I have a live, running map of the buildings, streets, and vegetation that are impacted, and I can count and report changes," Fraser said.

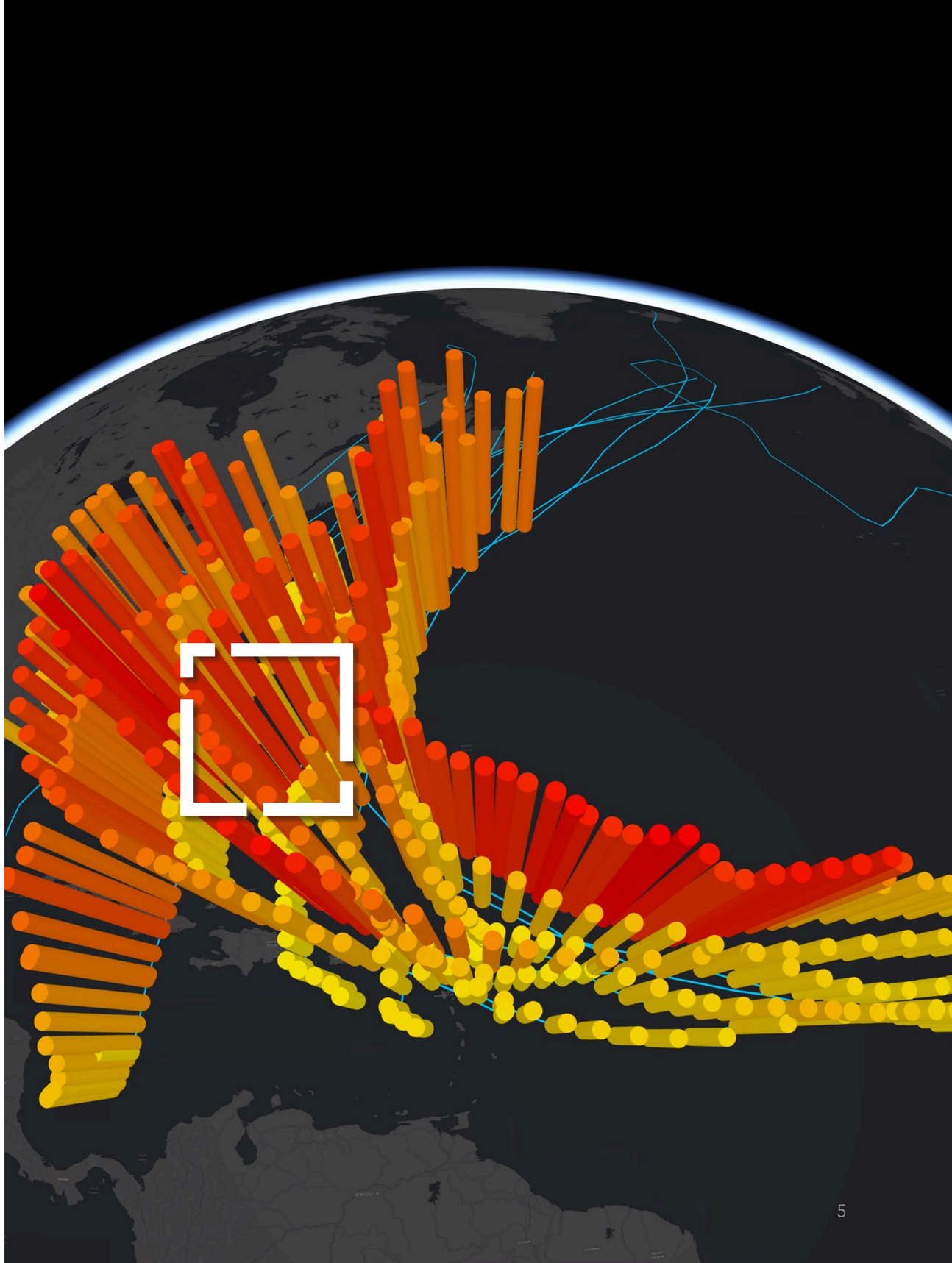
At the height of the data collection effort, there were 12 teams collecting data on the Damage Map. Several specialized teams were formed to address specific problems:

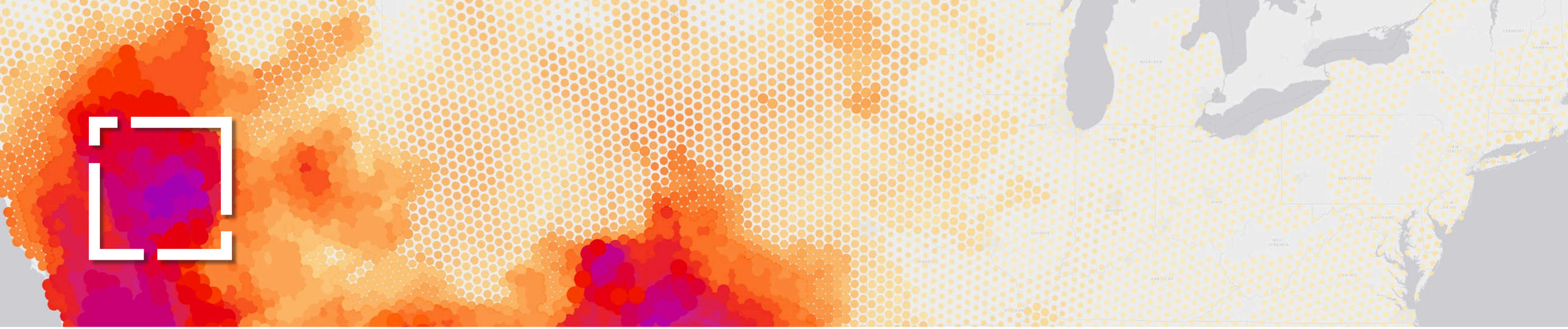
- Signs—A total of 591 street signs were lost during the storm.
- Structural damage—All teams noted where buildings were damaged.
- Sidewalk damage—Damage to sidewalks was correlated to the 10,000 downed trees littering the city's streets.
- Water leaks—The most visible water leaks were noted and then addressed by Engineering.

The city is in the process of submitting several million dollars of debris removal expenses to FEMA. The typical audit involves a spot check of work order tickets. Because the city had a person monitoring and recording what was happening with every debris truck and putting the data into the GIS, it has a comprehensive audit trail to present to FEMA.

Prior to Hurricane Irma, Key West had only dabbled with a data collection app, using it for a few one-person data collection efforts. Given the scale and scope of the hurricane damage and debris data collection efforts, the city is now looking at apps to help improve field processes and workflows. Those that used the app for weeks after the storm are driving this demand.

In the future, Key West hopes to add a crowdsource component to gather information from residents who stay put through storms. Because city resources are limited, working to understand where they are most needed is vital. The city envisions using its citizens as sensors to help with immediate prioritization of activities after a storm.





Putting the IoT in Context

It's easy to think of the IoT as intangible, part of the vast cloud that today largely defines our global computing infrastructure. In fact, each of the billions of sensors generating data exists in physical space. They live in smartphones, in cars, on manufacturing components, on farm equipment and in weapons systems, city streetlights, home thermostats, and countless other technologies.

For the majority of these sensors, location is a fundamental aspect of the data they generate. Without an understanding of where a sensor is located, critical context is lacking; its value is siloed, trapped in spreadsheets and software programs. Location is a proven way to create a framework, to accurately and intelligently deploy big data against real-world problems.

Location data plus time stamp gives organizations the capability to know when and where something is or was.

That's where location technology comes in. The technology starts by combining multiple layers of information—like citizen feedback, business intelligence, and asset management—onto interactive, real-time maps and visualizations. The subsequent spatial analysis can provide unique insights, revealing previously hidden patterns and relationships that drive stronger decision-making for governments. Fed by spatial analytics and real-time data, location technology's applications are broad, ranging from optimizing fleet operations to using real-time field updates for public works to dialing in mixed use for city planning.

There are many examples where location technology combined with the IoT can help achieve successful results, and competitive-minded, forward-thinking organizations are already using the IoT to spur leaps in the following:

- Citizen engagement
- Business processes and workflows
- Maintenance
- Data-driven decisions
- Operations
- Strategy

A closer look underscores how some IoT leaders, especially those in government organizations, have anchored their data analysis strategies in location data.

Traffic

Take one major city, for example, that monitors live traffic data submitted continuously by users of the Waze app—there's a sudden slowdown of traffic, creating congestion. Where are the slowdowns happening? What are motorists saying? Is weather a factor? Was there a public event nearby? Without location, the data holds little value beyond problem recognition. With location, there is context and opportunity to respond with the right resources.

Recently, this city has combined Waze's real-time data service via the Connected Citizens Program with a location technology platform powered by a modern geographic information system (GIS). State-of-the-art GIS allows you to place data in a visual context, which is far more inclusive and powerful. Decision-makers analyze incoming data within the context of location, time, demographics, traffic patterns, and more.

Not only does representing information allow the governments to see the way data is distributed in a specific environment, it also enables the organization to improve operations, inventory, service delivery, and citizen interactions through predictive analysis.

As an example, a heat wave expected in the Southeast next week can cue local government managers to increase emergency staffing near vulnerable populations and inform citizens with mobile alerts that point to government-provided services.

Longer-term and ongoing practices help different departments identify opportunities for building resiliency strategies into infrastructure, health, and safety planning. They can prepare for extreme weather situations, growing populations, and economic changes.

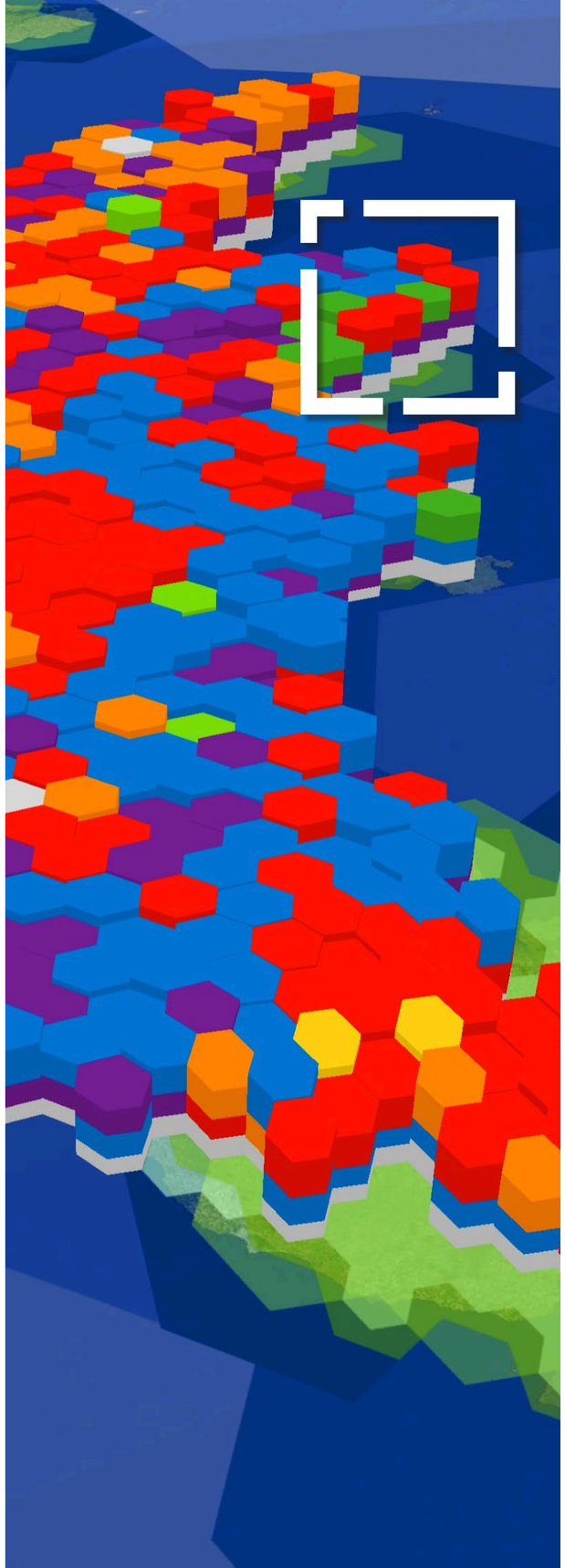
This illustrates how the IoT provides just one major city with deep insights that guide operational decision-making. But local governments of all sizes, in any geography, can use real-time location data to enrich citizen experiences, move forward with major initiatives, and improve quality of life. ▸

The Utility of Real-Time Data with the IoT

There is clearly a very powerful set of tools and capabilities that helps state, regional, and local governments of all sizes deal with the IoT data. It's the fusion of information together with different technologies in different domains that is making it so very powerful. Dashboards with real-time data can be applied in other powerful ways:

- Local governments use real-time social media feeds, such as Twitter, to gauge feedback and monitor social sentiment about local issues.
- Economic development managers leverage data to attract new business to their community.
- Public works managers monitor field crews, infrastructure performance, and capital improvement projects.
- Law enforcement and fire departments monitor incidents as they happen to respond quickly and effectively.

What the Internet of Things means is that we have a still-emerging source of valuable real-time data. And because location is such a crucial facet of the IoT data, many state and local governments find that a modern GIS fed by real-time data can be an effective tool for daily operations, empowering decision-makers and stakeholders with the latest information they need to drive current and future ideas and strategies.



Making the IoT Work for You

As sensor-laden products, systems, people—and by virtue of mobile communications devices—become sources of nearly unlimited information with the Internet of Things, data becomes a more crucial asset for every government every day. But remember, data per se is not in and of itself valuable. A recent article in *Harvard Business Review* puts it succinctly: "[Product data's] value increases exponentially when it is integrated with other data, such as service histories, inventory locations, commodity prices, and traffic patterns."[3] Without grounding data in a larger locational picture, its deep contextual value is lost.

In fact, without a context-driven and intuitive framework for analysis, much of the value in big data is unavailable for holistic decision-making. The IoT is capable of creating connections between previously disparate objects; people; patterns; and, ultimately, decisions. But without the means to visualize and act on those connections, the power of data is muted. And location data, newly ascendant within the wide array of available IoT-generated data types, promises to be one of the most powerful and effective vectors by which those connections are defined.

A coherent and cohesive IoT strategy is essential no matter the industry. Whether your organization is just beginning to explore the potential of the IoT or is actively experimenting with and benefiting from its power, proactive engagement is key.

One common barrier is culture and the commitment to data-driven decision-making. There has to be incentive. There has to be encouragement from top executives and elected officials. And for that there has to be the proper valuation of data. Then, there needs to be a decision to make the investment in technology and tools.

Organizations that passively observe this revolution, waiting for the perfect answer to reveal itself, risk an insurmountable competitive disadvantage.

Those who engage with the IoT phenomenon now can not only realize immediate benefits but can also actively influence the direction of the IoT itself—to their own advantage. Only by mapping their direction strategically and partnering with the right IoT leaders for the journey can organizations reach their full potential—and ultimately realize their vision and success. ■

3 Heppelmann, James and Michael Porter. "How Smart, Connected Products are Transforming Companies." *Harvard Business Review*, October 2015.

How Smart Cities Use IoT to Drive Innovation

Boston, MA, USA
Los Angeles, CA, USA
and Wellington, New Zealand

What does IoT mean for government?

Many local and state governments are embracing IoT to improve everything from traffic flow and energy efficiencies to public safety. The core values of IoT for government include

- Real-time operational awareness.
- Faster and more efficient response.
- Improved government services.

Boston, Massachusetts, Los Angeles, California, and Wellington, New Zealand, are three cities using real-time awareness fed by networks of live Internet of Things sensors to improve outcomes and strengthen decision-making in their cities.

Whether addressing emergencies, civic engagement, or municipal operations, IoT data grows even more valuable when it is combined with location information.

When you fuse IoT-generated data with real-time location analytics, you can filter data to focus on what is most important, issue alerts, and drive data-based decision-making for both urgent situations and the long term. ▸

More Adaptive Event Management

As tragedy shook the Boston Marathon in 2013, first responders across the city lacked the connectivity and real-time data necessary to coordinate effectively. Without a system that integrated real-time information, it was impossible to relay critical updates and orders among thousands of individual first responders, race participants, volunteers, and spectators.

"The Boston Marathon bombing in 2013 showed us what data we needed to have online and not just on paper," said Desiree Kocis, geographic information system coordinator at Massachusetts Emergency Management Agency (MEMA).

By the 2014 Boston Marathon, things had changed significantly. Public-facing, IoT-enhanced web maps showed live event details such as the race route, the locations of medical facilities, and law enforcement staging areas. Integrating data streams from thousands of sensors, devices, video feeds, and locations enabled Boston officials to better address critical aspects of the race, including tracking personnel and resources in real time and shifting public safety assets where needed.

Even the runners became outfitted with data-producing sensors. Before the race, all participants received bibs containing individually registered microchips. These chips transmit a runner's time and location data every five kilometers, which is then processed in real time. Doing so allows officials to keep track of active racers, enabling security and medical resources to be reallocated accordingly.

Not only does IoT integration support marathon officials in accounting for all participants in motion, it also serves as the foundation for information being shared quickly and easily among the public, event security, and emergency responders.

The ability to see the course and the city's deployed assets proves essential on race day when 60 different agencies, including state and local police as well as the Federal Emergency Management Agency (FEMA), use this common operating picture powered by GIS-based location technology to orchestrate an event that draws a worldwide audience and more than half a million spectators.

A shared dashboard view contains an at-a-glance accounting of live data feeds with maps that allow users to zoom in to areas of interest, charts showing the number of runners at different mileposts, gauges that display average runner pace, and histograms that parse runner progress over time.

The dashboard view displays 20 static layers that can be turned on or off as needed to show helicopter landing pads, National Guard staging areas, or medical facilities. In case of an emergency, all responders involved can quickly zoom in to emergency shelters to see status changes, capacities, key contacts, and phone numbers.

On race day, 300 people use the dashboard at the Multi-Agency Coordination Center (MACC). Additional crews on the ground use applications on phones and tablets to access information when needed, such as locating nearby medical facilities when a runner falls or gets injured.

With the app, responders tracked police cars, ambulances, and other emergency vehicles in real time. So when a runner needed medical attention, the app—working online or offline—could locate the nearest ambulance or medical station.

All aspects of the event, and a city's reaction to the influx of people, benefit from this improved awareness. When people come into the city for any large event, their needs must be accommodated alongside citizens and businesses that need to carry on their daily tasks.

Safety was the impetus for Boston's adoption of real-time awareness, but all city service providers and Boston citizens have benefited.

Transit is one area that has to deal with increasing demand. Plans are in place to adjust the number of buses and provide crowd control at subway stations. The real-time awareness lets everyone see how those plans are performing in order to make adjustments that keep everyone moving.

The year following the Boston bombing marked record-high participation from runners and spectators under the rally cry: Boston Strong.

If the bombing attack left participants and spectators fearful, if it made police and public officials feel powerless, the Boston Marathon Dashboard could take away some of that fear and give people back a sense of control.

Since its implementation in 2015, the sense of control has only increased, parlaying the increased awareness for additional citywide events and lending a shared understanding for additional city departments with missions outside of public safety. ▸

Achieving Intelligent IoT Integration

The City of Los Angeles has embraced the IoT to drive civic innovation. Departments across the city have turned to stand-alone sensors and sensors in devices to generate data around the clock. The city's sensors and devices can be found in police cruisers, sanitation vehicles, traffic signals, at the airport, and even in streetlights.

To track, route, and maintain its fleet more efficiently, the Los Angeles Solid Resources Collection Division (SRCD) follows more than 700 trucks with automatic vehicle location (AVL) technology.

AVL, in conjunction with millions of city trash cans embedded with RFID (radio-frequency identification) tags, helps officials monitor trash collection and the progress of each route on a map. Additionally, vehicle sensors inform maintenance schedules by capturing the percentage of engine wear and tear and such metrics as how many lifts each hydraulic arm has performed.

Listening to each vehicle and applying analytics to the signals that the sensors send allow the city to conduct repairs when needed rather than proactively replace parts according to a set schedule. Analytics allows the city to reduce breakdown and repair costs simultaneously.

Since 2014, Los Angeles Department of Public Works Bureau of Street Lighting has been replacing sodium-vapor streetlights with LED smart lights. The city initiated this effort to save money on electricity, calculating energy savings from the city's 215,000 streetlights at $9 million annually.

Patrick Cross, information technology manager for the Bureau of Street Lighting, points out that smart applications of the IoT aren't concerned exclusively with cost efficiency.

"That smart lighting both saves energy and reduces maintenance costs is of great appeal, but delivering a higher level of customer service and satisfaction is a priority as well," Cross said. "Before, it took a citizen making a complaint to discover that a light went out. Now, we're aware of when and where any streetlight in the network needs attention and can ensure [that] city lights are functioning properly before anyone notices they might not be."

Public Works staff gain real-time awareness of the smart light's location and condition, as well as information pertinent to its upkeep.

Considerable time savings accrue when field crews know precisely where to go, what work needs to be completed, and which tools they'll need to complete the job on the first attempt.

The lighting replacement effort soon expanded to embrace additional sensors. The city installed smart poles that contain 4G LTE wireless technology to improve cell phone coverage, leasing this capacity to cell phone carriers. The effort increases the city's revenue while also creating its own communications network.

The gas company leases the city's network to gather signals from its smart meters, using the poles as communication hubs that then send this data to the central office. This eliminates the need to drive throughout the city to gather these signals and provides up-to-date information about problems in its network.

The city has taken a similar approach to use its smart poles as network nodes for sensing. It has added traffic and parking sensors to the poles to monitor the flow of traffic and give citizens information on available parking spots in busy areas of the city.

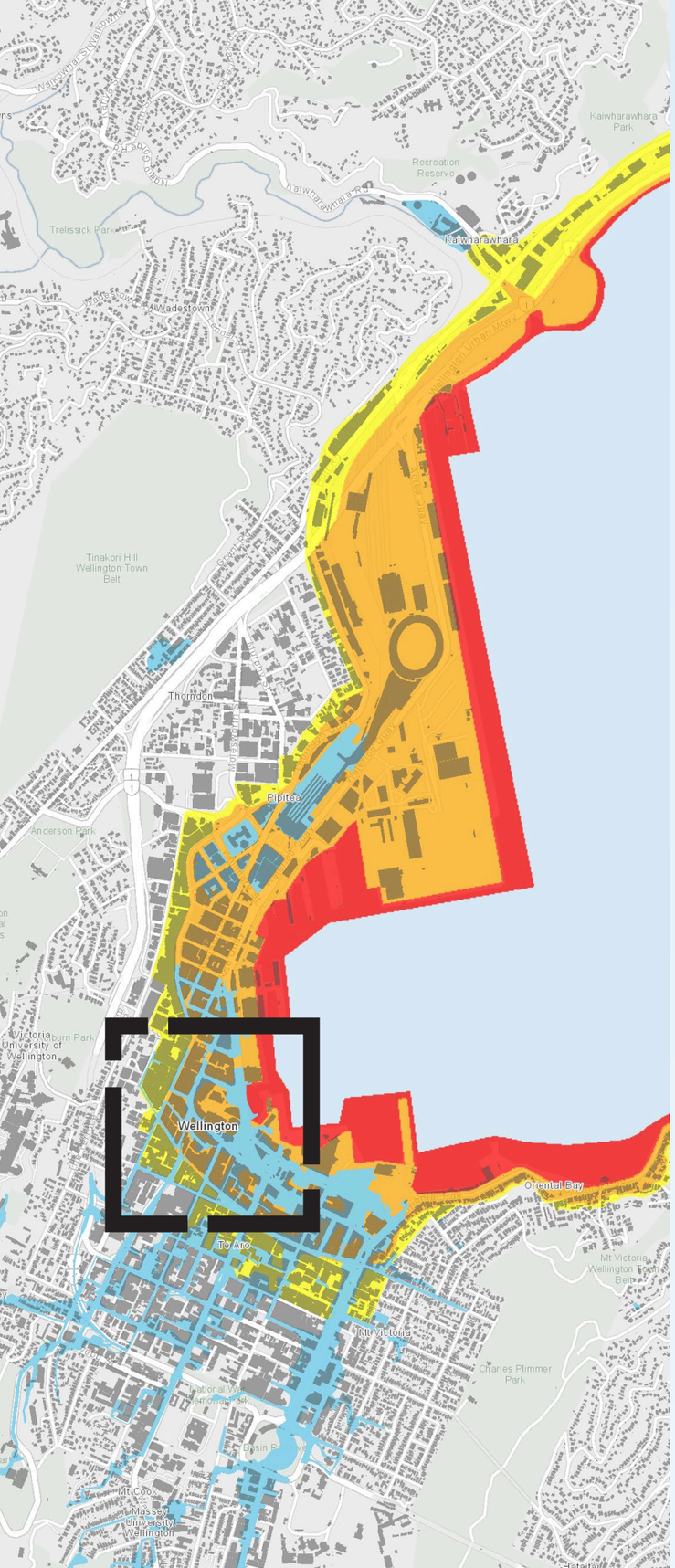
The city also harnesses volunteered data from the smartphones and tablets of citizens—engaging its citizens as sensors to inform the city's management.

The city encourages place-based feedback from citizens with the MYLA311 app. The app allows citizens to report illegal dumping, potholes, graffiti, dead animals, leaks in pipes, homeless encampments, and any services not yet completed.

The city's move to a mobile app for 311 services consolidated four key service management systems into one integrated whole—allowing residents, city departments, and civic hackers to access all requests and status updates in one place.

"The new system enables real-time field-level data management that allows tickets to be updated and closed in the field," Eduardo Magos, a senior systems analyst in the city's Information Technology Agency, told GovTech.

Centralizing reporting and easing the sharing of information promises to make the city more efficient and responsive to citizen needs. Whether from sensors or apps, the city's growing streams of location data are visualized on maps and analyzed for trends to keep the pulse of livability and civic engagement across Los Angeles. ▶



Improving Disaster Response and Recovery

Technology and innovation fuel New Zealand's capital city, Wellington, which locals have dubbed Silicon Welly. The city's investment in locally grown sensing and mapping proved critical after the Kaikoura earthquake that hit the city just after midnight on November 14, 2016. Residents on both the south and north islands of New Zealand were awakened by a 7.8 magnitude earthquake that was one of the most complex earthquakes ever recorded, with 21 fault lines rupturing over about 110 miles (180 kilometers).

Sandwiched between a protected harbor and a mountain range formed from an active tectonic fault line, Wellington's geography, coupled with its remoteness from the rest of the world that fosters the need to be resilient to disaster, forced city officials to take a long look at how the city operated.

City officials had been turning to IoT technology to better understand how people used and related to the city. An innovative combination of video and acoustic sensors monitor begging, substance abuse, and homelessness—feeding sensor data into a system that listens and tags keywords to locations to create maps with insights into day-to-day, street-level patterns and trends. Acoustic sensors in parks detect the sound of breaking bottles, alerting cleanup crews before the glass cuts any children. Similar sensors in nature preserves detect the birdsong of threatened species, recording their location and frequency to monitor bird numbers and movement.

On an everyday basis, the city uses increasing volumes of data coupled with analytics to better manage operations. It can look closely at its traffic patterns on a real-time basis and adjust traffic signals to improve traffic flow. Parking sensors help the city monitor car parks and show citizens where they can find open spaces.

Following the Kaikoura earthquake, the city mobilized its sensing capabilities coupled with its detailed maps to answer questions like: Were vulnerable people okay? Where had buildings been self-evacuated by their occupants? And what had happened seismically to the building stock?

City council innovation officer Sean Audain said that Wellington's focus on optimizing IoT-generated data has influenced citizens and politicians alike. "Once we had information flowing back to us, we could use three-dimensional capabilities to show the Minister of Civil Defense an environment he could understand and what the actual problems were," Audain said.

With all this data displayed in real time, 3D scenes became vital for calculating safety zones—cordoned-off areas around unstable and collapsing buildings. They also allowed the Emergency Operations Center (EOC) to put these zones into context so decision-makers could view the surrounding streets to see what else needed to be blocked off and which areas could remain open for public use.

The 3D model coupled with inputs on street-level activities allowed the city to put the event in perspective. Doing so conveyed that the cordoning and closure of the entire central business district was not necessary. This averted a potentially enormous disruption to lives as well as the loss of economic activity.

In addition to harnessing sensors, Wellington has engaged the public with open data. It has shared its data online and has organized hackathons, inviting citizens to access and make use of the city's data to create apps.

The open data effort has greatly increased constituent engagement and has fostered a growing interest in real-time mapping. The city's IoT data has proved to be of greatest interest, which, in turn, prompted officials to lobby for funds to improve their data feeds.

Apps fueled by open data and sensor feeds include

- GeoNet, a real-time geologic hazard monitoring system to detect, analyze, and respond to earthquakes, volcanic activity, landslides, and tsunamis.
- ThunderMaps, a hazard reporting application that combines police incidents, fire alerts, earthquakes, weather hazards, and traffic accidents to prepare citizens and keep them safe.
- Truckometer, a monthly, map-based economic report that uses the volume of state highway traffic as an indicator of the momentum of the country's economy.

Wellington actively experiments with new sensor technology and advanced analytics as part of its Smart Wellington 2040 initiative. The city views this program as an economic development initiative, helping to train its creative citizens, fostering new technologies, and leading to new companies that can export tools and skills to other regions—reducing Wellington's distance from the rest of the world. ■

Next Generation Automobiles and Smart City Initiatives

Mobileye

It is estimated that a motorist makes 400 observations, 40 decisions, and one mistake for every two miles driven. The US-based National Safety Council puts this in perspective with its own statistics that says motor vehicle accidents resulted in more than 4.6 million injuries and 40,000 deaths in the United States last year. While this can be traced to a variety of factors including distraction, fatigue, aggression, and impairment, the fact remains—far too many vehicular accidents occur on the roadways.

With recent advances in sensor technology that have been implemented both along roads and in vehicles, there is a belief that real-time alert systems will mitigate traffic collisions by giving drivers a greater awareness of accident potential and sufficient time to take action.

One of the leaders in advanced driver assistance system (ADAS) technology is Mobileye, which develops camera-based products that have been embedded in millions of vehicles across the globe. The technology is not only providing critical road safety capabilities, but that same data is also being applied by municipalities to enhance their smart community initiatives.

Mobileye's technology uses visual sensors that repeatedly scan and identify common highway features, obstacles, and conditions including lane markings, speed limits, road conditions, weather, pedestrians, accidents, obstructions, and other roadway-related information. Distances to these traffic constraints are continually recalculated in real time, and potential dangers are conveyed to the driver with visual and audio alerts. The system employs computer vision, an application of artificial intelligence that extracts cognitive information from digital images and videos and emulates the manner in which humans process and respond to visual information.

The technology deployed includes a number of traffic monitoring capabilities and the resultant safety features including autonomous emergency braking, blind spot monitoring, lane centering, forward collision warning, intelligent speed adaptation, night vision, pedestrian detection, road sign recognition, and other functions. The extensive amount of data collected to support these features is processed on the fly using onboard technology that is capable of computing trillions of mathematical calculations per second. ▶

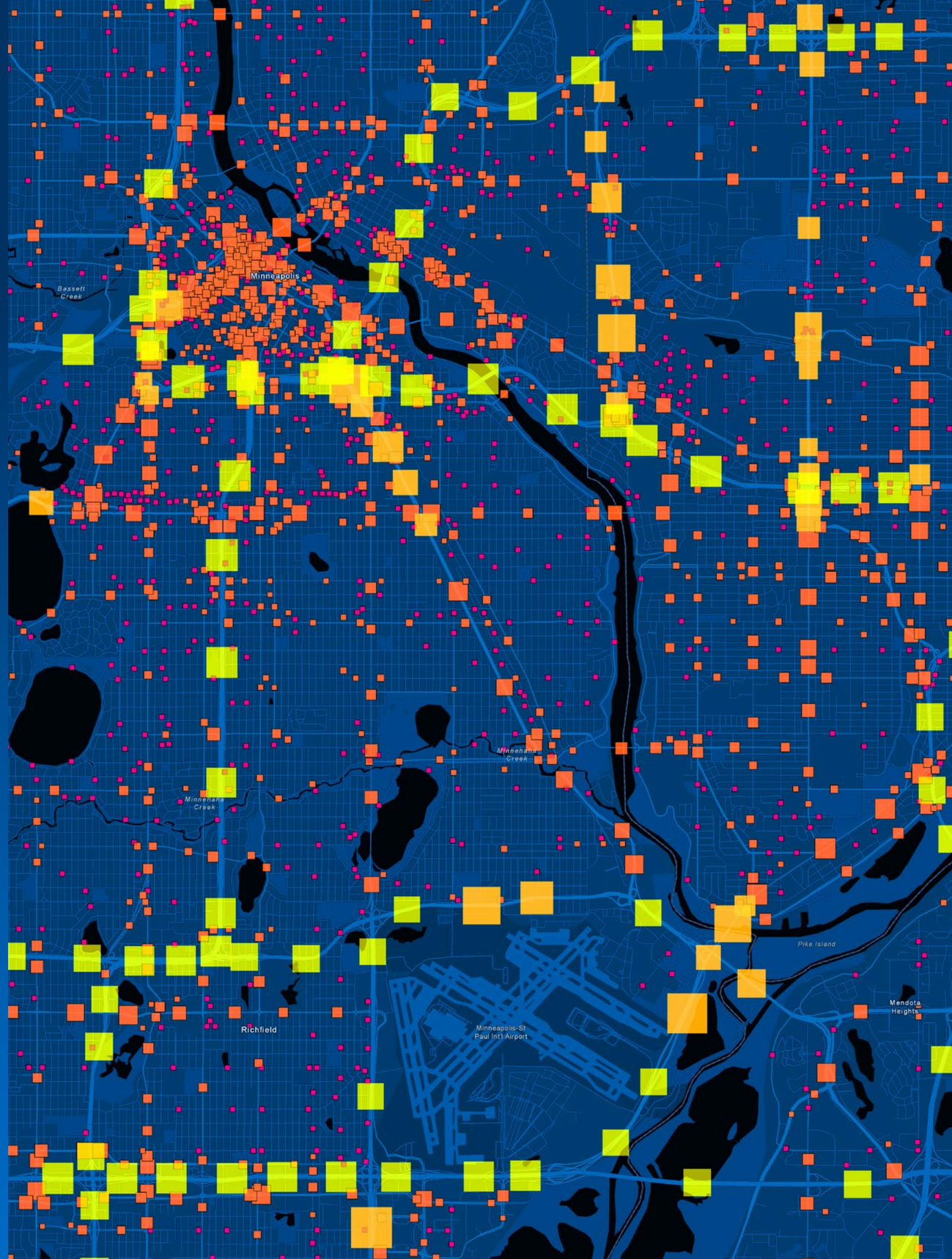
The spatial analysis capabilities in Esri's software is being used on the data collected by Mobileye's ADAS to expand its functionality and provide cutting-edge location intelligence, refined visualization, and enhanced mapping capabilities. **By synthesizing this network of sensors into a common unified map, cities can now have a type of situational awareness that was previously unavailable.**

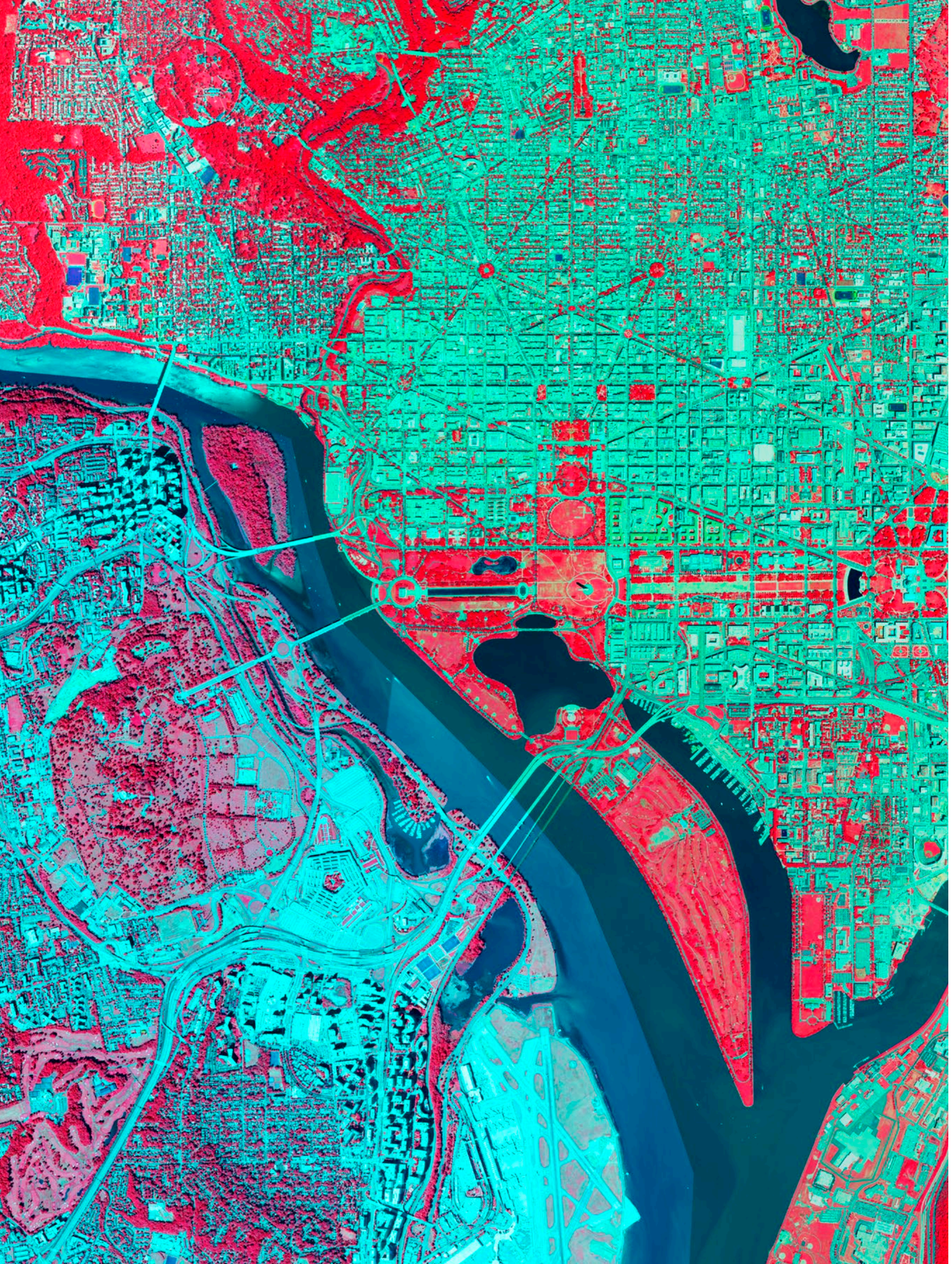
"Vehicles equipped with this technology can function together as a fleet of powerful sensors that are actively moving around the city, continually collecting imagery and data," said Jim Young, business development head at Esri. "The data collected provides the opportunity for the real-time monitoring needed for a number of community initiatives including public safety and emergency response. We can provide it, overlaid with other data layers to city officials, in a dashboard to support better civic engagement."

When combined with other geospatial data maintained by the city, this information can stimulate cross-disciplinary collaboration among local traffic planners and engineers, police officers, and policy makers in support of smart community initiatives. Vision Zero is one such initiative that is gaining support in cities throughout the world. It was first implemented in Sweden in the 1990s to eliminate all traffic fatalities and severe injuries while increasing safe, healthy, equitable mobility for all.

"Currently, we are developing connected ADAS systems," said Nisso Moyal, director of Business Development & Big Data at Mobileye. "What this means is that we will be able to alert drivers not only to a potential collision that has been detected by the onboard camera itself but also to dangerous conditions that are on the roadway ahead, such as a sharp curve or an accident 500 meters up the road that has been identified by another vehicle equipped with our technology."

In the future, Mobileye is planning to make greater use of artificial intelligence in the autonomous car system it is developing so that the cars using the system can respond more quickly and intelligently in emergency situations and during times of heavy traffic. The technology is intended to go beyond rule-based decision-making by analyzing and learning from the data it collects and the decisions it makes based on that data, which will allow it to develop more human-like response skills. ■





About Esri

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