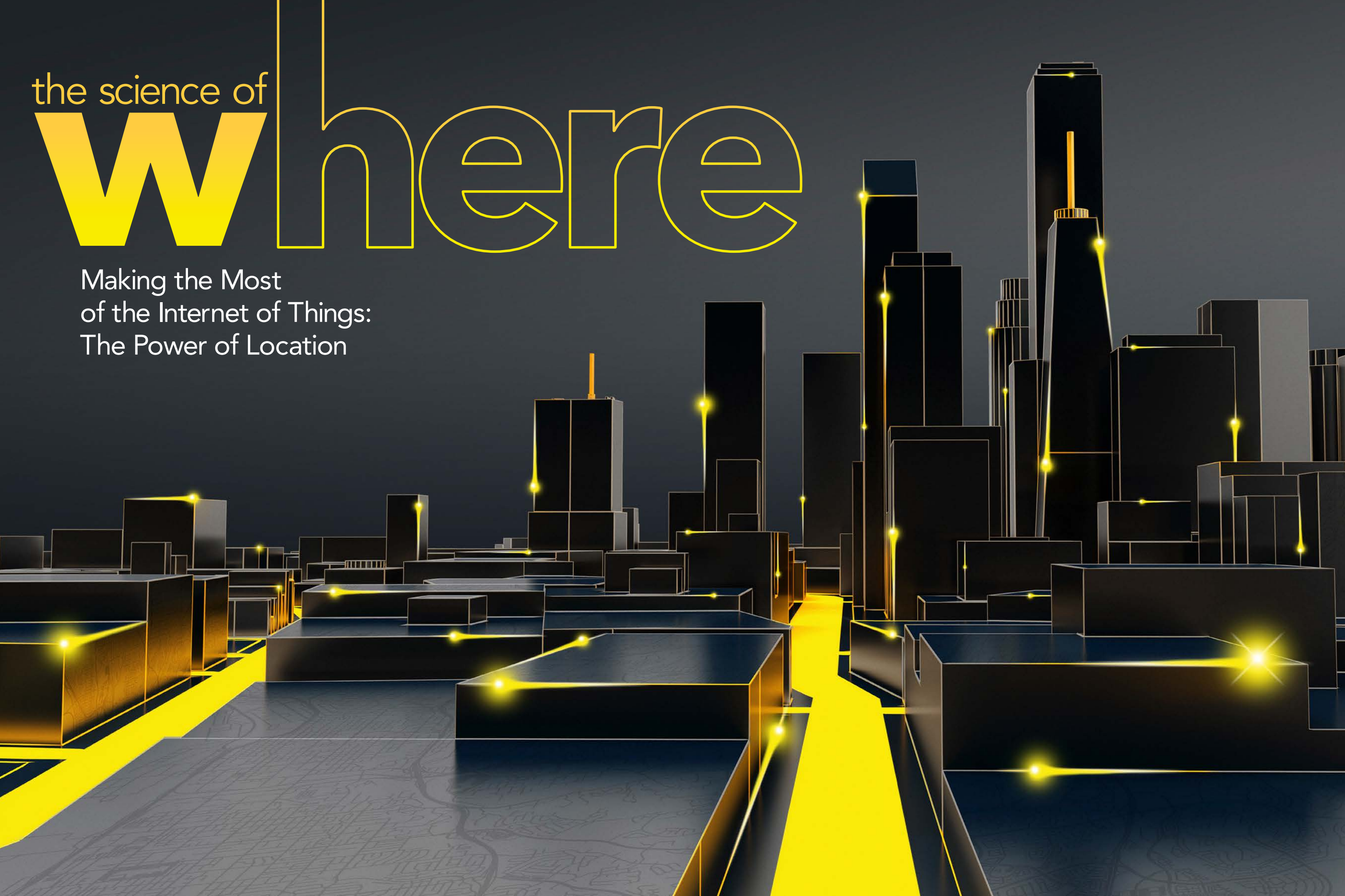
the science of where

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 a business does with it.

The Power of Location and the Internet of Things (IoT)

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 companies the ability to collect, process and analyze vast — and potentially invaluable — data sets. Properly distilled, this data can reveal real, actionable intelligence. Yet for many companies, 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 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 work flows, managing data, identifying case studies and applications, 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 endpoints 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 companies 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 a business does 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 a business.

Once a company 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 customer expectations. Today's sophisticated customers want experiences that require massive real-time and big data analytic 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.

Photo courtesy of UPS.

"We've used operations technology and analytics to allow us to serve customers as they want to be served while also keeping our operations efficient."

– Jack Levis, Senior Director of Process Management for UPS

Real-time Location Analytics Means Operational Efficiency

UPS

The rise of the ecommerce economy creates historic opportunity for delivery company UPS, but the increased volume of online orders and deliveries also presents challenges as packages go to more doorsteps.

UPS delivered 712 million packages globally during the peak holiday shopping season through New Year's Eve in 2016. That represented a 16 percent growth over 2015; however, that volume also included 2.5 million new addresses.

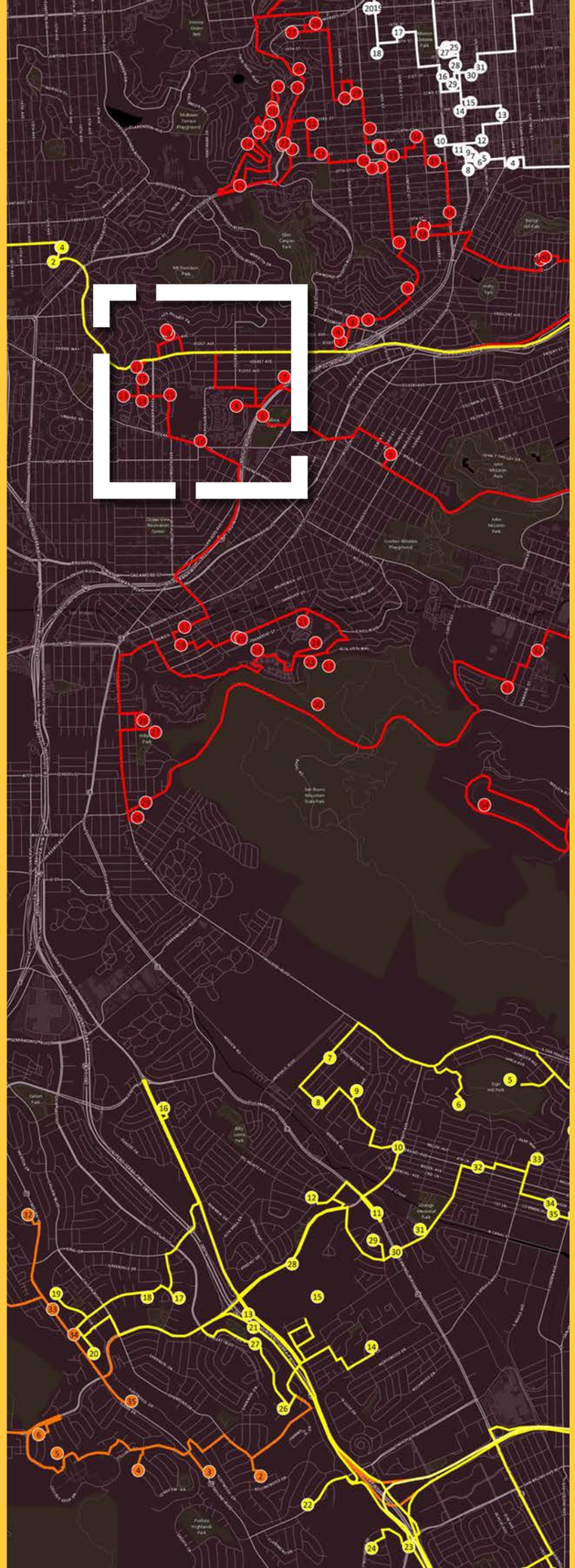
Understandably, delivering an individual toothbrush costs more than the business-to-business shipments of multiple packages going to and from business locations. Unfortunately, toothbrush deliveries are up and B2B deliveries are down. It's the last mile of delivery that costs the most, and to combat these increased costs UPS is serious about making every driver more efficient.

UPS implemented a system called ORION (On Road Integrated Optimization and Navigation), which is powered by geographic information system (GIS) technology. The system acts as a logistics command center, weighing the stops a driver must make against variables such as timed deliveries and fuel usage. With the help of advanced analytics, the system often prescribes delivery routes that look counter-intuitive, but create measurable benefits for the company and its customers.

By avoiding left-hand turns, for instance, UPS eliminated the need to cross traffic, saving time and increasing driver safety. GIS technology helped the company operationalize the no-lefts policy—and many other efficiency measures.

"I'm not a GIS guy and I've never brought a GIS project to the C-Suite," said Jack Levis, senior director of process management for UPS. "I could care less about GIS. I care about business process. We bring GIS inside of process change."

UPS operates a think tank of mathematicians and engineers that have leveraged operational analytics to pioneer efficient approaches to goods delivery. They are tasked with finding incremental improvements that magnify across the operation for compounding cost savings. ▶



Saving just one mile per driver per day over one year can save UPS up to $50 million. ORION has been credited with annual savings of 100 million miles. This equates to a savings of 10 million gallons of fuel, a corresponding 100,000 metric tons of carbon dioxide emissions, and as much as $400 million worth of fuel and maintenance costs.

UPS uses GIS to support daily origin-destination calculations that assess where packages are coming from and where they need to be by the end of the day. These results are injected into custom UPS routing algorithms that then generate package delivery routes for each vehicle.

"We've used operations technology and analytics to allow us to serve customers as they want to be served while also keeping our operations efficient," Levis said.

UPS has made the move up the analytics value chain from descriptive analytics (where am I?), past predictive analytics (where am I headed?), and on toward prescriptive analytics (where should I be headed?). As they ascended this hierarchy of analytics applied to their business processes, their business gains have grown.

Sensors, Data, Efficiencies

UPS doesn't gain all their prescriptive analytics efficiencies by solving only location-related problems.

"We have 200 sensors on all of our vehicles," Levis said. "When a vehicle or a part starts to behave differently than its peers, we understand that a breakdown is about to occur. This allows us to wait until a vehicle tells us it needs to be repaired rather than replacing parts proactively. We reduce breakdowns and repair costs simultaneously through analytics."

A similar sensor-based approach is applied to driver behavior. Sensors on the ignition, transmission, and seat belts each provide feedback for driver course correction. To maximize both safety and efficiency, drivers should not back up, seat belts should always be fastened when in motion, and trucks should never idle during deliveries.

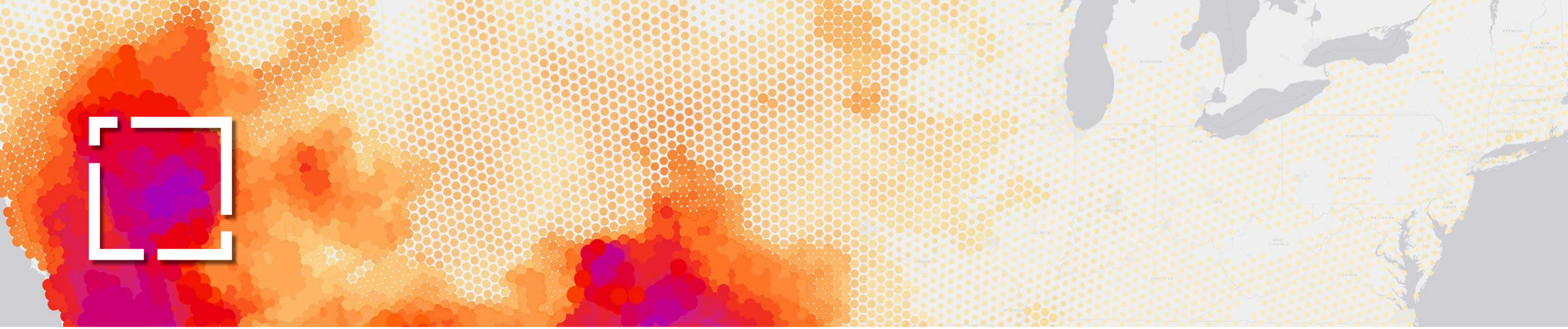
Each UPS driver is equipped with a Delivery Information Acquisition Device (DIAD), which is a custom-designed handheld that directs deliveries and collects details about each delivery. These handhelds have contained a GPS chip for more than a decade, which provides the means to guide navigation and track trucks in traffic so that the system can learn from the conditions on the road. ORION is constantly evaluating the best route based on real-time information and delivering updates to drivers through the DIAD.

The accuracy of street network data is a critical link to operational efficiency. If a road is closed for repair, drivers need to know before they confront a barrier. UPS, the world's largest express and package delivery company, uses Esri's location technology in custom applications for editing street networks based on what drivers experience.

"We have multiple GPSs on every vehicle, and we use that to help us create maps that are more accurate than any," Levis said.

In addition to driver efficiency improvements, ORION has also enabled more personal service. The UPS My Choice® service allows consumers to see their incoming deliveries, choose delivery preferences, reroute shipments, and adjust delivery locations and dates as needed.

The GIS-powered ORION system has greatly aided UPS on its last-mile efficiency, while helping drivers get to each additional doorstep. As deliveries and road miles continue to increase, you can be sure that UPS engineers and mathematicians are tweaking the algorithms and pouring over all the data to save more miles. Sensors with location data provide the feedback needed to add flexibility and fast response times to meet today's ever-increasing customer demands. ■



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 exist 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 timestamp 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 customer relationship management, 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 businesses. Fed by spatial analytics and real-time data, location technology's applications are broad, ranging from optimizing supply chain management, to using real-time field updates for utilities, to dialing in product mix for retail, to 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:

- Customer engagement and loyalty
- Business process and workflows
- Maintenance
- Product development
- Operations
- Strategy

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

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

Retail

Take one global food-service provider, for example, that collects and monitors waves of IoT data from app users—there's a sudden uptick in mobile cold beverage sales. Where was the surge? What were the demographics? What was the weather that day? Was there a public event, a local promotion? Without location, the data holds little value beyond measuring simple revenue increase. With location, there is context and opportunity to drive growth.

For the last several years, this Fortune 200 food-service provider has chosen to work 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, psychographics, traffic patterns and more.

Not only does representing information visually allow the business to see the way data are distributed in a specific environment, it enables the company to improve operations, inventory, supply chain and customer interactions through predictive analysis.

As an example, a heat wave expected in the Southeast next week can cue the company's regional managers to increase optimal inventory at affected stores and geo-target nearby customers with mobile ads for a new cold beverage.

Longer-term and ongoing practices help the company identify winning retail locations, anticipate and exploit global raw product yield and supply trends, and track shipments of raw product from its multiple countries of origin.

This illustrates how the IoT provides just one large retailer with deep insights that guide operational decision-making. But retail organizations of all sizes no matter their size or geographic reach can use real-time location data to enrich customer experiences, select profitable sites, and increase incremental sales. ▸

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Understanding Customers in Real Time

Seattle City Light

How do you connect with the modern customer? That is a question the communications team at Seattle City Light asks every day. Like other utilities, the power provider serves dynamic customers whose preferences, technologies, and relationships with the utility are highly diverse. Enhancing these relationships requires a strong understanding of how more than 400,000 customers want to communicate—especially during power outages.

To improve two-way communication with customers, Seattle City Light adopted a geographic information system (GIS)-based solution that helps them stay on top of grid events and customer concerns in real time.

A map-focused social engagement platform gives the tenth-largest public power system in the US real-time aggregate outage reports, customer sentiment feedback, weather event data, situational awareness, logistics support, and analytics. The cloud-hosted solution integrates with the utility's outage management system (OMS).

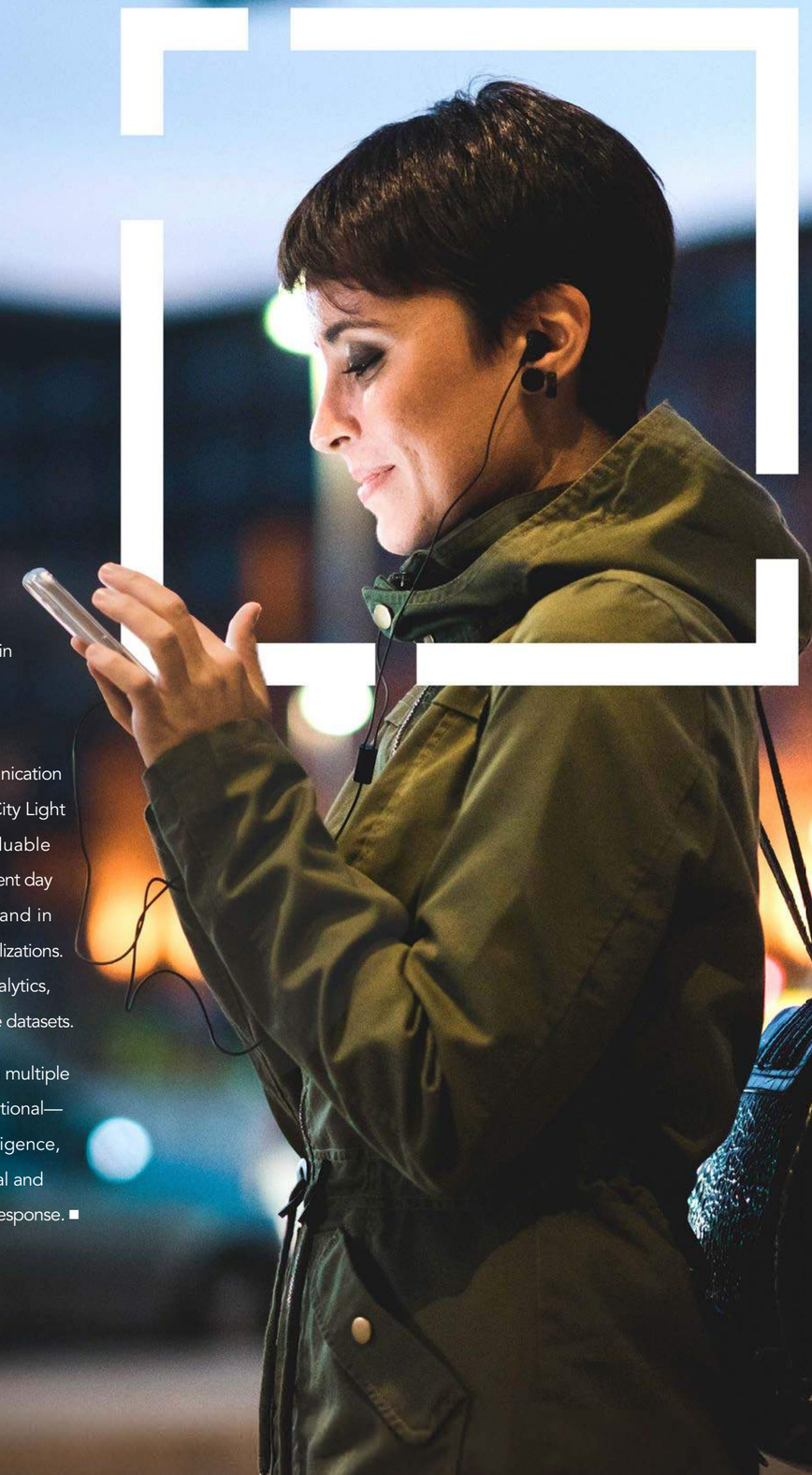
Seattle City Light can mine social media data in the context of location, and generate powerful visualizations while engaging with customers. The map-centered solution combs social media channels for specific terms and topics related to the utility, such as grid reliability, the brand, smart grid, and renewables integration. When someone communicates via social media about any of these topics, staff get real-time notifications so they can act fast.

The data is presented on a mapping dashboard, showing when and where customers engage with the utility. And it's not just social data—the platform also displays information ranging from demographics and consumer behavior statistics to natural environment datasets and sensors. The communications team can view and analyze this information and interact with customers via Seattle City Light's social media channels. Outage information flows into the utility's OMS to help speed response.

In one place and in real time, staff in the field can visualize outage data, customer communications, and imagery. Weather information helps the utility predict when outages will occur and notify customers in potentially impacted areas via their preferred method of communication.

Analyzing and understanding customer communication generates nontraditional datasets for Seattle City Light to use as a historical baseline. With this valuable information in hand, the utility can evaluate present day events in comparison to previous outages and in combination with asset locations and other visualizations. Staff can create maps, scenes, apps, layers, analytics, and data and share them with existing enterprise datasets.

With its ability to merge, visualize, and analyze multiple sources of data—both traditional and nontraditional—Seattle City Light has fortified business intelligence, strengthened communications with commercial and residential customers, and driven faster outage response. ■



Utilities

Utilities provide essential services and require massive infrastructure and coordination from local, state and often national-level suppliers. With vast networks of power lines, water and gas pipes, meters and employees, utilities can benefit significantly from the IoT by collecting real-time data across assets, visualizing it, and integrating it with existing systems to reveal underlying conditions, anticipate potential service disruptions, and streamline workflows.

To reduce waste (non-billable water loss) and to streamline the identification of leaks, one of the largest utility districts in the Southeastern US installed a sensor network to collect real-time data from flow meters, tanks and pump stations. The utility layered the new IoT data onto an existing GIS system. Now operations staff can see instantly where water flow is excessive relative to normal use patterns. Staff can then trace a potential leak to a subzone, specific pipe segment and even an individual valve.

By visually layering IoT data onto detailed above-ground and subterranean system mapping, the utility created an overarching, real-time view of their assets. Without mapping, the sensor data gave only water level readouts and coordinates — with no insight into exact location or condition, and allowing only basic inference on potential user impact. Without the IoT, the organization had relied on manual practices to discover and isolate leaks — an extremely inefficient, often truly "hit-or-miss" process.

Today, the leak discovery process has been reduced from months to 72 hours. The system is projected to save the utility $1 million annually.

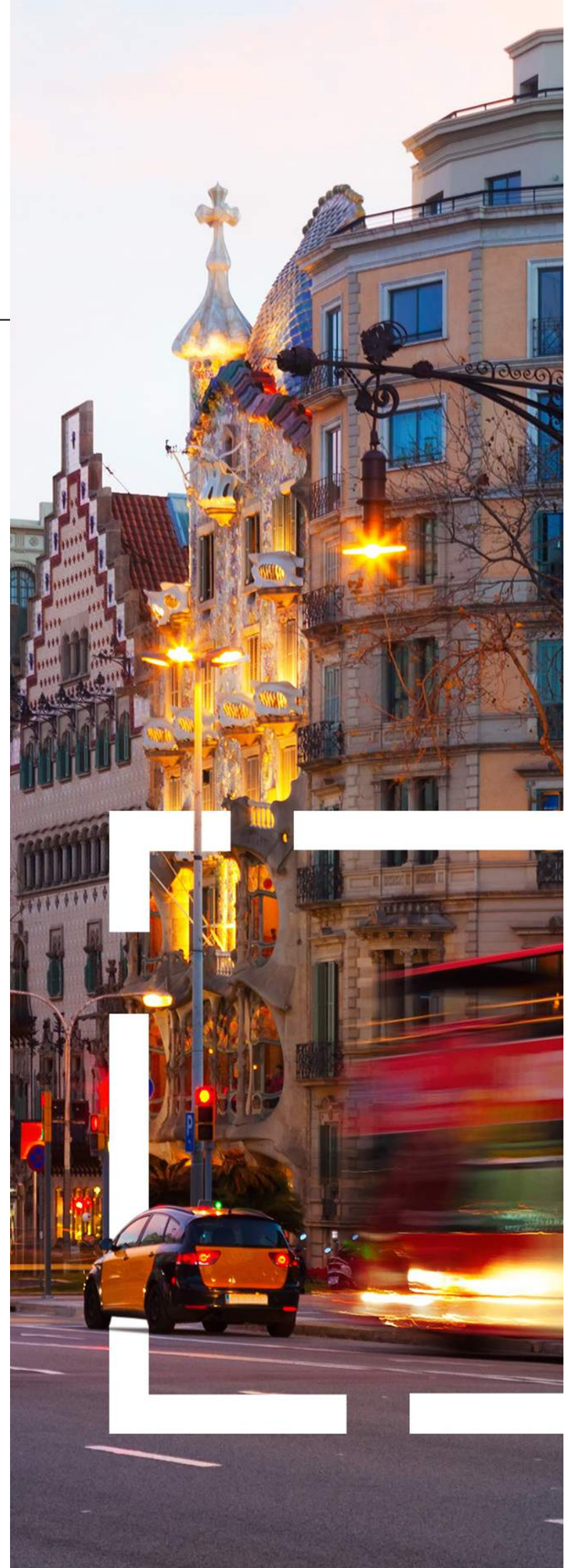
Supply Chain

Sensor technology can give immense leverage to organizations involved in manufacturing and supply chain logistics, where location – and the efficient movement of goods between locations – is everything.

Complex product intelligence scenarios can be broken down into component elements without losing track of the big picture; then tracked, visualized, understood and acted upon in ways that weren't possible before the IoT. This allows an organization to uncover new efficiencies, and monitor assets and items across the entire spectrum of their trek. Location tracking is especially useful in dealing with today's global distribution networks.

One of the biggest trucking companies in the US has discovered the value of IoT and location. With more than 9,000 trucks and 25,000 trailers operating from more than 300 locations, the company tracks fleet movements in real time. It visualizes this information on maps, using it to optimize driver behavior and truck routes. The company also uses historical data to predict future scenarios, and works collaboratively with drivers to create optimal routing and delivery solutions based on predictive analysis.

Tracking and optimizing fleet behavior has created significant monetary and organizational efficiencies, and the company continues to harness data in new ways to amplify the power of its predictive and prescriptive analytics across its fleet.



Smart City: Barcelona

Cities offer endless opportunities for data collection via sensors on public assets; cities become smart when they integrate the IoT with other sources of data and use analysis to improve the lives of residents.

In recent years, Barcelona launched a campaign to transform the city into a connected, smart community. The local government installed an IoT-based "system-of-systems" throughout the city. For example, residents use an app called ApparkB to find open parking spots. Sensors in the asphalt signal whether a spot is open, and the app guides drivers to available locations. The app also allows drivers to pay for parking online. In addition to enhanced convenience for individual drivers, the program reduces overall municipal traffic congestion as well as emissions. Within a year of its launch, Barcelona was issuing 4,000 parking permits a day through ApparkB.

Another program monitors waste, via municipal trash cans fitted with sensors. The IoT connected trash cans monitor waste levels, optimize collection routes and text residents when their waste output is high. Barcelona has initiated many other IoT programs, including smart street lighting, bike shares and a digital bus experience.

Since implementing its IoT program, Barcelona has saved $58 million on water and $37 million annually on lighting, increased its parking revenue by $50 million per year and created 47,000 new jobs.[3] ▶

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3 Adler, Laura. *How Smart City Barcelona Brought the Internet of Things to Life.* Smart City Data Solutions, Harvard University. February 2016.

Transforming Sales and Supply Chain

Singha Corporation (Boon Rawd Trading International)

A major producer of beer, bottled water, snacks, and rice, Boon Rawd is most well known for its pale lager, Singha.

One of the largest companies in Thailand, Boon Rawd handles shipping to 300 distributors, 20,000 wholesalers, and 200,000 retailers.

Thanks to its success, the company not long ago found itself managing distribution and sales over a vast territory, in which representatives traveled personally to sell the product on-site. Some sales were pre-arranged but many were ad hoc.

With over 2,500 trucks dispersed to locations across Asia, sales representatives were dispatched with blank order forms and their own knowledge of customer relationships in their assigned regions, but little else. There was no system in place to ensure cost-effective travel. That translates into wasted time, and costly wear and tear and depreciation on the firm's fleet and supplies. Sales representatives also self-reported their numbers, without receipts or documentation, and would sometimes even need to make extra trips just to have a receipt signed.

Committed to innovation and digital transformation, leaders at Boon Rawd discovered: For companies that must move large amounts of merchandise across long distances, it is crucial to have a spatial awareness of operations. It is also essential to maximize the benefit of spatial awareness and spatial analytics, and leverage them to boost efficiency in operations and ultimately increase sales. For Boon Rawd, this meant real-time location intelligence needed to be incorporated into every aspect of the supply chain — in particular, sales. If a business knows where, when, and why sales decisions are being made, it can use that intelligence to improve future strategies.

The rapid growth of Boon Rawd and the growing popularity of its products meant that inefficiencies in the organization would have to be addressed. So, Boon Rawd implemented location-powered technology to upgrade its entire management system, including its customer database, sales territory planning, effective route analysis systems, and a vehicle tracking system to instantly check delivery status. It also embraced the use of digital maps via smartphones for customer location mapping. ▶

Back in the office, managers are now able to monitor each and every sale. Using their location data, they can map sales data and the regions they oversee, and generate visualizations that clearly communicate to all stakeholders which areas are performing and which are not. One immediate benefit of this common view is that it allows resources to be allocated to those sales territories where they will produce the greatest profit. Prior to this high-precision geographic approach, there was a risk in selling to the wrong customer, selling twice to the same customer, or even missing them altogether.

Today, six years into its pursuit of digital transformation by using location intelligence, Boon Rawd utilizes a wide array of Internet of Things (IoT) sensors and devices to plan, route, and execute all of its sales.

With the demands of managing 2,500 trucks of different sizes, and meeting tight, specific delivery windows, a system that automates massive networks and decision-making has proven very valuable.

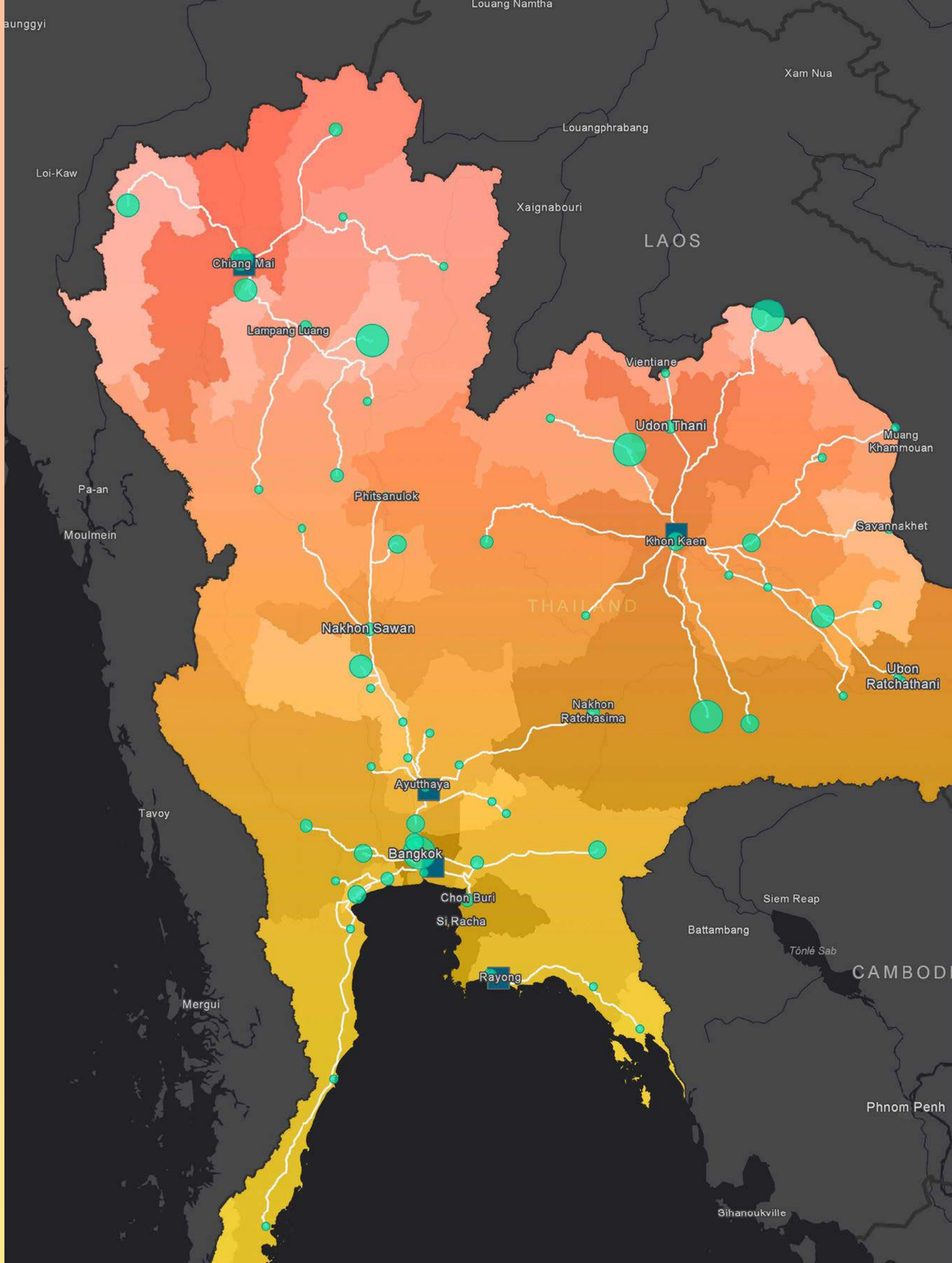
The company's trucks are equipped with location-aware sensors that track their position at all times. Headquarters can then monitor the precise location of each truck in real-time from an operational dashboard fed by a powerful geographic information system (GIS). If one truck strays off-route or is seen driving recklessly, operations staff is immediately aware. This capability also enables operations managers to re-make delivery routes for last-minute orders. With dashboards that give a live feed of every truck's location, management can now see which truck with which merchandise is closest to the area where a customer has placed an order.

In addition to the benefits to operations, customer satisfaction has increased, in part because Boon Rawd is now more agile and able to respond to more ad hoc sales requests and increase its overall sales capacity.

Finally, a mobile app that field sales representatives are using to process orders allows billing transactions to be linked back to corporate headquarters immediately instead of waiting for a truck to return with an invoice.

Collectively, these location-powered technologies have also improved the overall efficiency in the company's logistics – specifically, by reducing truck accident rates by 1.4% and reducing fuel costs by 10%.

Ultimately, knowing where, when, and why things are happening in real-time has helped Boon Rawd modernize its operations and realize the benefits of analytics-driven decision-making. ■

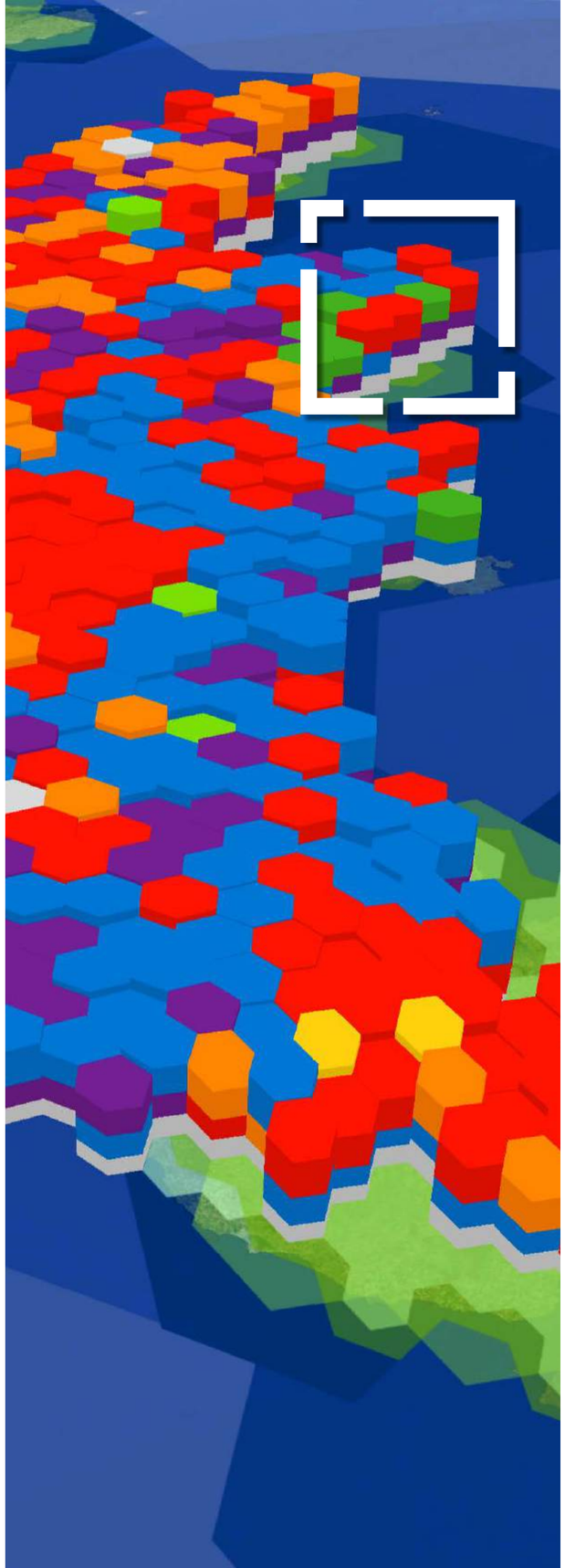


The Utility of Real-Time Data with the IoT

There is clearly a very powerful set of tools and capabilities that helps companies and organizations and cities of every sort deal with the IoT data. It's the fusion of information together in different technologies in different domains that is making it so very powerful. Dashboards with real-time data can be applied in other powerful ways:

- Companies use real-time social media feeds such as Twitter to gauge feedback and monitor social sentiment about particular issues
- Retailers can leverage data on where customers are spending time in their stores
- Oil and gas companies monitor equipment in the field, tanker cars, and field crews
- Law enforcement agencies monitor crime as it happens, as well as incoming 911 calls

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 organizations and businesses 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 IoT Work for You

As sensor-laden products, systems – and by virtue of mobile communications devices, people – become sources of nearly unlimited information with the Internet of Things, data becomes a more crucial asset for every company every day. But remember, data per se is not in and of itself valuable. A recent article in the *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."[4] 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 IoT-generated date types available, promises 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 company 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 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 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. ■

4 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, Los Angeles, and Wellington, NZ

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, Los Angeles, and Wellington, NZ, are three cities using real-time awareness fed by networks of live Internet of Things (IoT) 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.

In the Event of Emergency

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 an online-based platform, it was impossible to relay critical updates and orders among thousands of individual first responders, race participants, volunteers, and spectators.

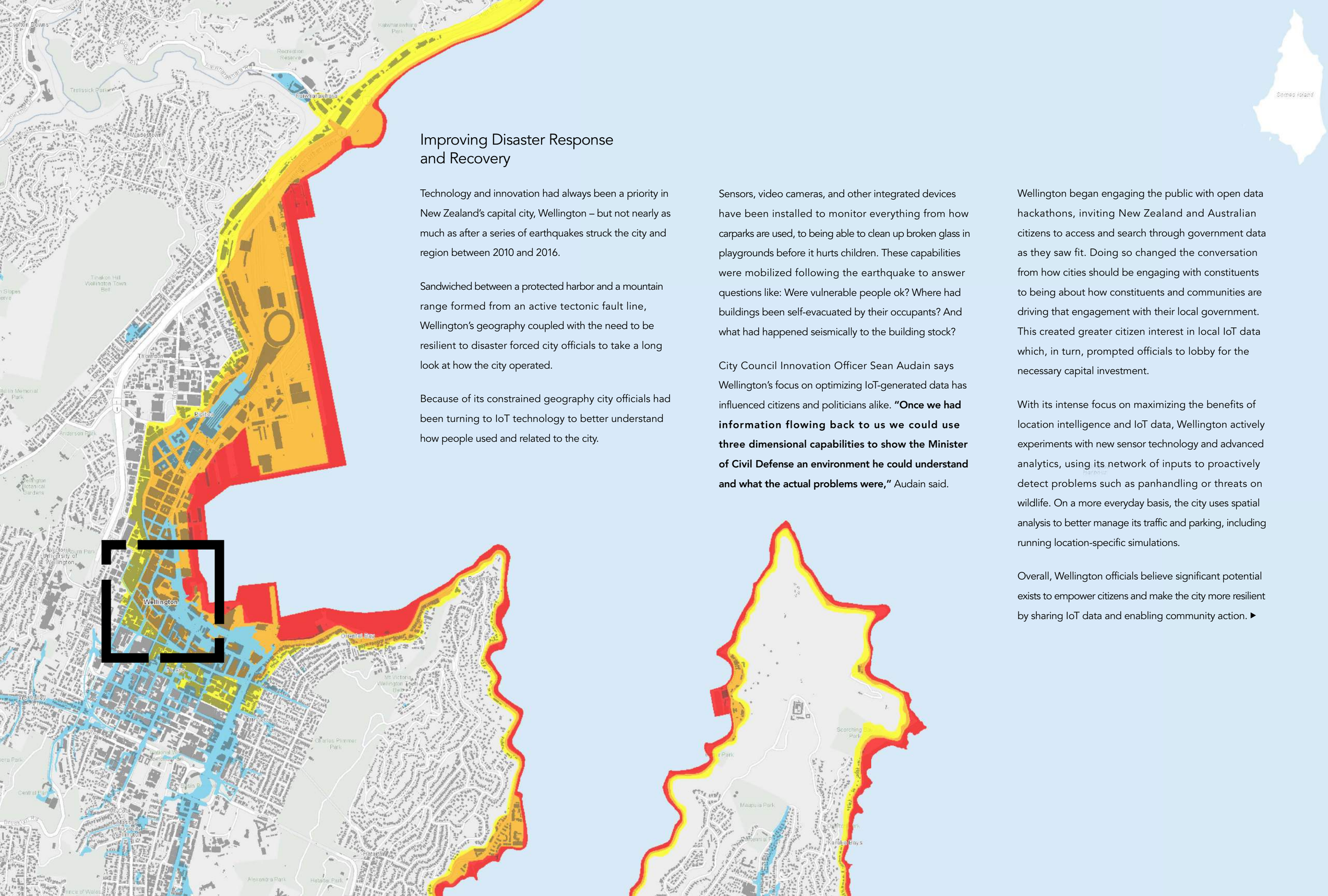
"The Boston Marathon bombing in 2013 showed us what data we needed to have online and not just on paper," said Desiree Kocis, Geographic Information System (GIS) Coordinator at Massachusetts Emergency Management Agency (MEMA).

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 how many active racers are in the field as well as how many people are in each section of the course, 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 serves as the foundation for information being shared quickly and easily among the public, event security, and emergency responders.

This benefit proves essential on race day where 60 different agencies, including state and local police as well as the Federal Emergency Management Agency (FEMA), use a 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. ▶



Improving Disaster Response and Recovery

Technology and innovation had always been a priority in New Zealand's capital city, Wellington – but not nearly as much as after a series of earthquakes struck the city and region between 2010 and 2016.

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

Because of its constrained geography city officials had been turning to IoT technology to better understand how people used and related to the city.

Sensors, video cameras, and other integrated devices have been installed to monitor everything from how carparks are used, to being able to clean up broken glass in playgrounds before it hurts children. These capabilities were mobilized following the earthquake to answer questions like: Were vulnerable people ok? Where had buildings been self-evacuated by their occupants? And what had happened seismically to the building stock?

City Council Innovation Officer Sean Audain says 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.

Wellington began engaging the public with open data hackathons, inviting New Zealand and Australian citizens to access and search through government data as they saw fit. Doing so changed the conversation from how cities should be engaging with constituents to being about how constituents and communities are driving that engagement with their local government. This created greater citizen interest in local IoT data which, in turn, prompted officials to lobby for the necessary capital investment.

With its intense focus on maximizing the benefits of location intelligence and IoT data, Wellington actively experiments with new sensor technology and advanced analytics, using its network of inputs to proactively detect problems such as panhandling or threats on wildlife. On a more everyday basis, the city uses spatial analysis to better manage its traffic and parking, including running location-specific simulations.

Overall, Wellington officials believe significant potential exists to empower citizens and make the city more resilient by sharing IoT data and enabling community action. ▸

> "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..."
>
> – Patrick Cross, Information Technology Manager for the Bureau of Street Lighting

Intelligent Integration

The city of Los Angeles is constantly evolving and growing. To meet this growth, greater numbers of departments across local government rely on smart technologies like IoT sensors. Generating 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) processes live IoT inputs from more than 700 trucks equipped with Automatic Vehicle Location (AVL) and electronic inspection reporting.

These components, in conjunction with millions of city trash cans embedded with RFID (radio-frequency identification) tags, help officials know whether trucks have completed their collection routes. Additionally, these sensors provide vehicle telematics, which range from the percentage of engine wear and tear to how many lifts each hydraulic arm has performed.

Since 2014, Los Angeles Department of Public Works Bureau of Street Lighting has been replacing light sensors on individual street lights with remote censoring nodes. These smart devices not only monitor whether the lamp has burned out, but if the electrical currents in the light register correctly or if any other broken components require maintenance as well.

Further, each censoring node is outfitted with cellular connectivity and a GPS radio; so, despite lacking hard-lined connectivity into the city's network, every smart light is virtually tethered without investing in additional infrastructure.

Patrick Cross, Information Technology Manager for the Bureau of Street Lighting, points out that smart applications of 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 city lights are functioning properly before anyone notices they might not be."

Network integration provides Public Works staff real-time awareness of the smart light's location and condition, as well as information pertinent to its upkeep and unique specifications. **Considerable time is saved 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.**

Making sure that street lights are functional is an essential city service, especially near businesses and residences where pedestrians may be at risk. Smart lights ensure illumination in intelligent cities like Los Angeles, highlighting new potential for the fusion of IoT and location technology. ■

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 US 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 roadside 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 advance 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 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 that 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. ▶

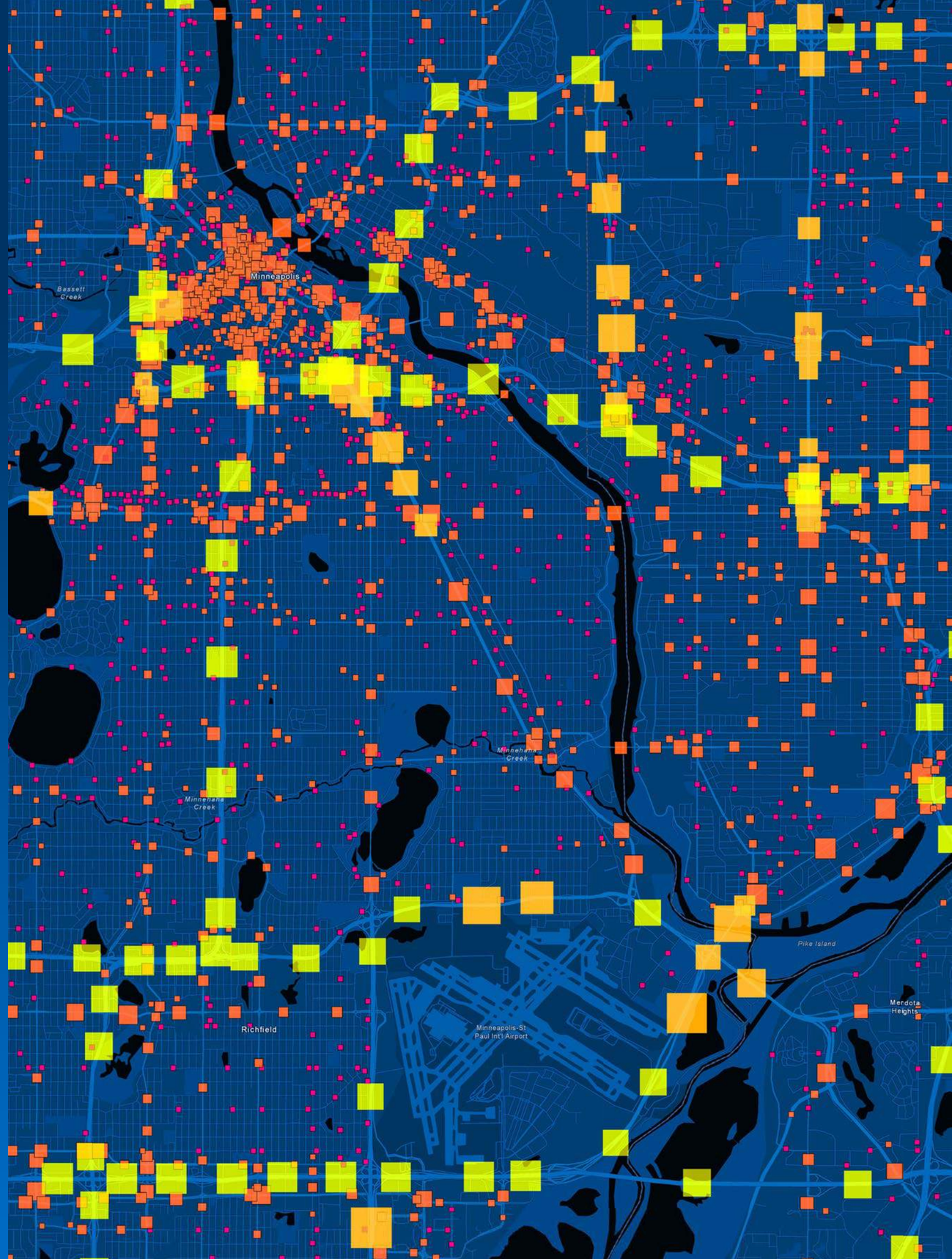
The spatial analysis capabilities in Esri's software is being used on the data collected by Mobileye's ADAS to expand its functionality and provide cutting edge location intelligence, refined visualization, and enhanced mapping capabilities. **By synthesizing this network of sensors into a common unified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

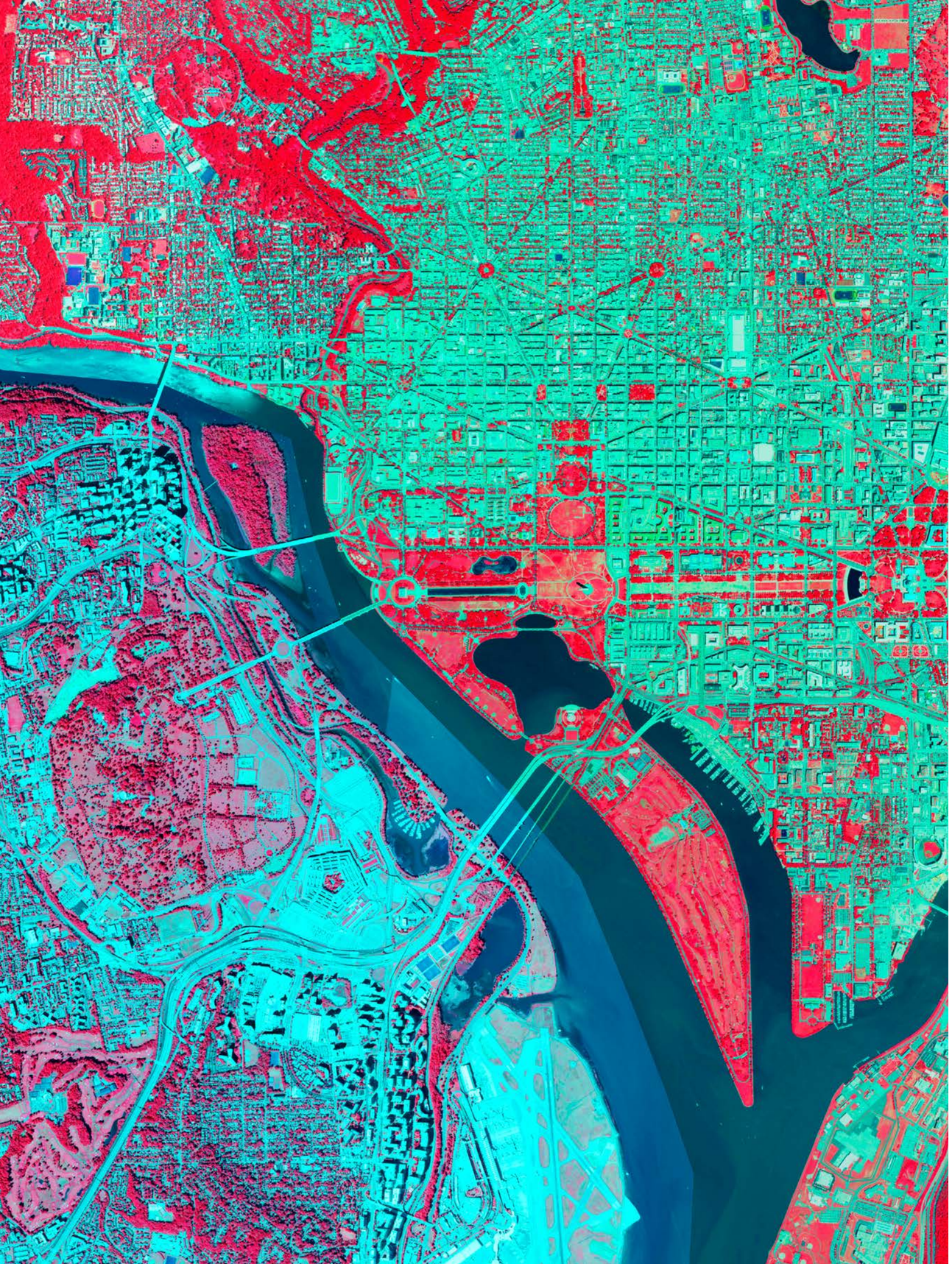
"Vehicles equipped with this technology can function together as a fleet of powerful sensors that are actively moving around the city continually collecting imagery and data," says Jim Young, Business Development Head at Esri. "The data collected provides the opportunity for the real-time monitoring 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 policymakers 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," says 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

Esri, the global market leader in geographic information system (GIS) software, offers the most powerful mapping and spatial analytics technology available. Since 1969, Esri has helped customers unlock the full potential of data to improve operational and business results. Today, Esri software is deployed in more than 350,000 organizations including the world's largest cities, most national governments, 75 percent of Fortune 500 companies, and more than 7,000 colleges and universities. Esri engineers the most advanced solutions for digital transformation, the Internet of Things (IoT), and location analytics to inform the most authoritative maps in the world.

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