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Conversations with industry about IoT in…

the WIZARDRY *in* INTELLIGENT TRANSPORT SYSTEMS (ITS)

– and how to combine 5G, AI, IoT, and Edge

by Juan Pedro Tomas
Editor, Enterprise IoT Insights

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Intelligent transportation systems (ITS) are advanced applications developed with the main aim of providing innovative services relating to different modes of traffic management and transport. These applications are deployed with the ultimate goal of allowing users to be better informed and make safer and smarter use of transport networks.

According to the U.S. Department of Transportation, ITS "apply a variety of technologies to monitor, evaluate and manage transportation systems to enhance efficiency and safety."

Some of the most frequent and basic ITS already implemented globally include calling for emergency services when an accident occurs, the use of cameras to enforce traffic laws or the installation of signs that mark speed limit changes in highways. However, these systems are expected to be more complex in the future, while new use cases will emerge in the ITS field as new technologies such as IoT, 5G, artificial intelligence (AI) and edge computing become more widely available.

Analysis from KPMG and global market intelligence firm IDC estimates that by 2023, with an uptick in the adoption of 5G and edge computing, the smart transportation market is forecast to drive $24 billion in annual revenue into the entire ecosystem, which includes connectivity, hardware, software and services, compared to annual revenues of $12 billion in 2019.

KPMG highlighted that the large volume of sensors and devices along roadways and in parking systems requires 5G's massive density as the improved latency, higher network capacity and elimination of poor coverage means faster and more accurate insights, which also translates into better performance, smoother transit and traffic flow, and fewer accidents.

The proliferation of IoT devices and 5G technology at a global level are key for the development of the ITS space. IoT is essential for the provision of sensors and controllers that can be embedded into nearly any physical machine to be controlled and managed remotely, while 5G technology provides the high speed communications needed for managing and controlling transportation systems in real time with very low latency.

Apart from 5G and IoT, the widespread use of other innovative technologies such as AI and edge computing will open up new possibilities in the ITS field, with more futuristic use cases around the corner.

However, despite the continued evolution of new technologies paving the way for a more massive adoption of ITS use cases, both government agencies and tech providers need to work in close cooperation to enable these deployments, as well as define proper business models for ITS.

ITS deployments still in its infancy, Black & Veatch says

The company believes that apart from fiber optic, new technologies such as 5G and IoT will be key enablers of ITS

To analyze the current state of Intelligent Transportation Systems, we will begin with Black & Veatch, an engineering, procurement, consulting and construction company that focuses on the design and deployment of high-speed fiber networks. The firm is starting to see some trac-tion in the ITS field, although, according to its view, the overall ITS development is still in an early phase.

According to Paul Pishal, sales director in the Telecom Division of Black & Veatch, for example, the full set of ITS capabilities is yet to be realized. The executive noted that some challenges for ITS projects include the complexity of the business model, as well as the complexity of the solutions itself, as more technologies are being constantly introduced. However, Pishal said that the pace of adoption of ITS is accelerating at a fast pace.

Pishal said wireless technologies play a key role in the ITS space despite the fact that fiber o ptic i nfrastructure c ould b e considered as the backbone of ITS projects.

"Wireless plays a large component to this as well," said Pishal "The fiber provides bandwidth, but the amount of data available for the implementation of intelligent transportation systems is going to be exponentially larger over the years, especially when you're capturing a large component of data from vehicles. And the ability to process all that information and take appropriate actions to bring safety and efficiencies to transportation is all part of this distributed infrastructure of fiber, wireless and processing that needs to occur in order for the pieces to tie together."

Pishal also highlighted that technologies such as IoT and 5G will also be key enablers of ITS. "IoT will be an important aspect of getting information through the deployment of sensors. All these sensors are part of the IoT infrastructure. When it comes to 5G, this technology will allow for the real improvement of ITS due to the bandwidth and the low latency capabilities of 5G. The real fidelity or improvement of the travel experience in autonomous vehicles really comes about with 5G," the executive said.

Pishal also said that the U.S. is making great strides to become the leader in the ITS space despite the challenges in ITS implementation due to the number of states and parties involved in these initiatives.

"We have 50 different states, the federal government and a diverse population. I think it's potentially easier to do it in smaller countries. And we're seeing good progress in countries such as the Netherlands and Singapore, where you have very condensed areas and you can deploy quicker as you have just one government that adopts the regulatory changes necessary to move forward. However, the U.S. is very progressive and a lot of innovation is coming out of the U.S." he continued.

Commenting on the most common ITS use cases, Pishal mentioned traffic management capabilities, the monitoring of

"There's plenty of dollars on the sideline looking for creative ways to invest in intelligent transportation systems. But it's a complex set of components that need to come together, how it's funded, how it's deployed, how it's operated and maintained and evolved. This is probably the biggest challenge facing the industry today."

Paul Pishal, Sales Director in the Telecom Division of Black & Veatch

PA Turnpike

Pennsylvania Turnpike

traffic flows to regulate traffic and accident notification, adding, "The creativity of use cases is endless. It's safety, its efficiency. Those are the key drivers."

The transportation authorities are key players in this field to ensure that intelligent transportation gets deployed effectively. And then, these agencies maintain and optimize the ITS. Pishal also said that financing is one of the main challenges of ITS:"Effective business models need to be developed as intelligent transportation systems are further deployed and handled, and how these are deployed and how they're paid for."

"There's plenty of dollars on the sideline looking for creative ways to invest in intelligent transportation systems," he added. "But it's a complex set of components that need to come together, how it's funded, how it's deployed, how it's operated and maintained and evolved. This is probably the biggest challenge facing the industry today."

Pishal highlighted that Black & Veatch is currently involved in an ITS project being developed by the Pennsylvania Turnpike Commission (PTC), which had selected the firm to install a new fiber optic network along more than 200 miles of the Pennsylvania Turnpike (PA Turnpike).

PA Turnpike

When completed, the network will boost connectivity between the PTC's administrative buildings and support All-Electronic Tolling (AET) and Intelligent Transportation Systems for safety and mobility. The network will also prepare the PA Turnpike to support emerging technologies for smart roadways and Connected and Autonomous Vehicles (CAVs).

The executive explained that fiber will be installed using a process known as microtrenching, which overcomes the challenges of the PA Turnpike's often rocky topography by installing the line within the roadway's shoulder.

The upgraded network will meet the PTC's connectivity needs for its office structures, maintenance sheds, service plazas, traffic cameras and all roadside IoT/ITS.

Pishal said that this project is expected to be fully completed in late 2021 or early 2022.

"We expect this movement of smart transportation to be a significant change to the U.S. economy, providing better safety and improvement in efficiencies moving forward," he added.

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The current state of ITS, the technologies involved and the main challenges ahead

Enterprise IoT Insights talked with key industry leaders, analysts and officials at government transportation agencies to know how the ITS concept has been evolving in recent years, what technologies will be behind the more successful ITS use cases and what the main challenges remain for further development of ITS. It's time for the real players moving the ITS market to talk. (A key to the speakers can be found in the box).

What is the current state of Intelligent Transport Systems and how do you think that this concept has been evolving over the recent years?

Myhrberg/Ericsson: "ITS has become an umbrella term for how ICT can improve the transport sector and embraces many application areas ranging from road pricing to V2X and self-driving vehicles."

Mollenhauer/VTTI: "The current state is that many Department of Transportation (DOTs) and municipalities are looking at ways to have smarter intelligent transportation systems. This typically means more connectivity and more sensors being deployed to get more intelligence from what they can gather from the field. I would say that as an industry we are not necessarily moving forward as quickly as we could on the connected side of things."

Maggiore/Cisco: "Intelligent Transportation Systems are delivering applications that benefit both system operators and the travelling public. The benefits of ITS for things like congestion reduction, environmental quality and traveler experience far outweigh the cost. As the costs of things like edge computing continue to decrease, we see low-latency applications transforming safety, particularly for things like pedestrian protection."

Misener/Qualcomm: "Along the way, ITS has spawned a host of "electronics-meets-the-highway" innovations that have become mainstream tools for things like traffic management, changeable message signs and coordinated traffic signals. But with the advent of and the push for Connected and Automated Vehicles (CAV), it has come full circle. In short, CAV is the instantiation of the Intelligent vehicle highway systems (IVHS) vision. What has changed is that technologies — and from my perspective primarily communications technologies — have finally met the vision."

Muraine/Alcatel-Lucent Enterprise: "Considering the multiple subsections of Intelligent Transport Systems, each evolving at their own rate, it is difficult to say how ITS is evolving as a whole. It is also worth mentioning that many ITS projects have been paused due to Covid-19 and many active startups have folded or changed direction.

Look who's talking (in order of appearance)

Stefan Myhrberg, Head of Road ITS, Intelligent Transport Systems at Ericsson

Mike Mollenhauer, Division Director of Technology Implementation at the Virginia Tech Transportation Institute (VTTI)

Michelle Maggiore, Country Digitalization Manager, Cisco

Jim Misener, senior director of product management and C-V2X lead, Qualcomm

Roch Muraine, Worldwide Sales Director for Transportation, Alcatel-Lucent Enterprise

Justin Belk, Statewide Integrated Corridor Operations Engineer at Washington State Department of Transportation (WSDOT)

Matt Arcaro, Research Manager, Next Generation Auto, Transportation, and IoT at IDC

Joel White, ITS Solution and Strategy Product Owner for Bosch Security and Safety Systems in North America

Alecia Collins, Deputy Communications Director, Florida Department of Transportation (FDOT)

Dominique Bonte, VP at ABI Research

Steve Mazur, Director, Government, Digi International

Peter Meckel, Program Manager C-ITS, ASFINAG, an Austrian publicly owned corporation which plans, finances, builds, maintains and collects tolls for the Austrian highways

As a result, the innovations of the future we discussed a few years ago, such as self-driving cars for example, remain in the future rather than in the present day."

Belk/WSDOT: "For the Washington State Department of Transportation, ITS started decades ago as a way to utilize technology by primarily enhancing traveler information and improving flow to address congestion in regions like the Seattle metropolitan area, where adding additional lanes is not feasible or cost effective. Over time, strategies have matured and technology has increased to enable solutions reaching across the geographic diversity of our state. We now view ITS as one tool among many as we use Transportation Systems Management and Operations (TSMO) strategies to enhance safety and mobility for all modes of transportation, in a variety of settings."

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Justin Belk, Statewide Integrated Corridor Operations Engineer at Washington State Department of Transportation (WSDOT)

White/Bosch: "As wireless communications technologies continue to improve, the presence of economical wireless deployments will grow. The speed and bandwidth of the latest technology are already sufficient to transport high resolution video data, so we expect growth in infrastructure intelligence and infrastructure to vehicle communications with advanced cloud-based solutions playing a growing role in real-time event and data aggregation use cases."

Misener/Qualcomm: "Certainly, wireless communications — both long and short range — is part and parcel of ITS. I would argue that wireless communications are responsible for the great leap forward as it allowed road users such as cars and soon enough pedestrians and bicyclists to connect to the road infrastructure through technologies such as Cellular-V2X (C-V2X)."

Muraine/Alcatel-Lucent: "There has been a shift in focus to make investments in safety and cybersecurity more of a priority in ITS. Technology that protects the user is arguably now considered part of the backbone of the industry."

Arcaro/IDC: "Cellular is an increasingly important part of the infrastructure backbone for ITS. Its advantage, in terms of availability, has made it an important complement to hard-wired physical communication infrastructure. Cameras and other multi-purpose sensors are viewed as the next iteration of ITS sensor technologies by DoTs and road operators. The sensors and its supporting compute and storage infrastructure allow them to take a broader, platform and use case view to solving ITS challenge, rather than the traditional fixed, purpose-built sensor approach."

"We can mention 5G and V2X / C-V2X. Increasingly, edge computing is becoming a key enabler of real-time ITS applications such as traffic management, tolling, and parking. In particular, In the future, 5G-enabled edge cloud infrastructure will become a key component of ITS solution enabling low latency sensor data sharing supporting a new range of use cases."

Dominique Bonte, VP at ABI Research

Collins/FDOT: "Apart from fiber optic infrastructure and sensors, the department also uses wireless communications throughout the state. Wireless solutions are applied at the project level whether to solve last-mile connectivity, avoid environmental impacts, or simply provide quick solutions. FDOT owns and operates a statewide digital microwave radio network that is currently being upgraded to accommodate the growing demand of data transmission around the state. Although the bandwidth is not comparable to fiber optic, the reliability

is very high which is important during emergencies. To achieve an acceleration in the ITS technologies the department implemented cameras, vehicle detection devices, and motorist information dissemination devices such as dynamic message signs (DMS) and roadside units (RSUs) for connected vehicle applications."

Bonte/ABI Research: "We can mention 5G and V2X / C-V2X. Increasingly, edge computing is becoming a key enabler of real-time ITS applications such as traffic management, tolling, and parking. In particular, In the future, 5G-enabled edge cloud infrastructure will become a key component of ITS solution enabling low latency sensor data sharing supporting a new range of use cases such as cooperative adaptive traffic lights, automated traffic management and remote operation of autonomous vehicles and systems."

Do you see a higher level of development of ITS initiatives in certain markets such as in the U.S. or Europe or do you see a homogeneous level of implementation across all developed regions?

Maggiore/Cisco: "Regardless of the technologies, the goals are similar everywhere: Safety, congestion reduction and environmental improvements are common use cases for ITS. The level of investment varies by country, but as the world recovers from the pandemic, the hope is that there is more investment both in the U.S. and abroad."

Misener/Qualcomm: "ITS addresses a complex global problem statement: Enhancing safety and mobility while fostering environmental stewardships. However, there are distinct differences in regional and in some cases national investments. Those include prioritization and investment in the aforementioned multiple-dimensioned problem statement, centralized versus decentralized planning and inherent differences in land use, which results in different trip generation and mode choice. Consequently, the pace and type of ITS deployment will be at the very least regionally distinct."

Bonte/ABI Research: "Countries most active in deploying innovative ITS solutions include China and the U.S. They both are leading in C-V2X deployments and regulation. Both also have set aside huge budgets for extending or upgrading smart road infrastructure. However, ultimately, next generation ITS will spread to all countries and regions in tandem with 5G deployments."

Could you describe the main technologies currently enabling ITS initiatives and which of these technologies could be combined to achieve an acceleration in these kinds of projects?

Mollenhauer/VTTI: "I think that AI, including machine learning and machine vision processing, is huge. For example, we see that with detecting pedestrians, vehicles and bicyclists at intersections and trying to act on these detections to make things happen, whether that be a change in the phasing of the lights or to make the intersection more efficient and safer. We are also seeing things like radar and lidar being deployed at a greater scale than they were before to overcome some of the downsides of camera-based processing. By putting the two together, you get the best of both worlds. With this, we are seeing a lot more applications where radar and lidar are deployed along with a camera at an intersection and fused together to provide higher quality data and to overcome challenges like low lighting, where it may be harder for a camera to detect objects."

White/Bosch: "Our perspective on this is that highly accurate sensors with on-board deep learning AI processing are the foundation for all real-time detection and data aggregation/analysis use cases."

Belk/WSDOT: "Emerging wireless communication and other broadband technologies can enable more data-sharing. This includes higher-definition and more real-time information to improve transportation operations. Crowdsourcing and other big data analytics have the potential to supplement or replace some existing in-house data sources and procedures. The real potential for improvement would be combining these outside aggregated datasets with agency systems to achieve some level of sensor fusion and enhanced situational awareness."

What is the role of IoT in the ITS field and how do you think that 5G technology is already contributing or will contribute in ITS deployments?

Arcaro/IDC: IoT continues to be an underutilized tool in today's ITS deployments. A lot of this underuse comes from the challenges to integrate these sensors and their systems with legacy hardware and technology solutions. 5G opens up greater possibilities for bringing real-time data, insights, and decision making to an ITS system anywhere within the network's footprint. This flexibility will be key when designing or deploying a solution at scale, when the physical connectivity infrastructure cannot scale or support the deployment approach."

Mollenhauer/VTTI: "More things are now being connected and can report their position and status automatically, and I think that is one of the things that IoT supports well. IoT allows for more things within the ITS ecosystem to be connected and

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therefore more useful. 5G will support faster and higher bandwidth data transfer for data generated by cameras, lidar and radar. For basic connectivity for simple status or location information, I think today's communications technologies can support typical data transmission needs."

Maggiore/Cisco: "ITS is essentially the original IoT, since traffic data from sensors has been collected and recorded for quite some time. With edge computing, traditional sensors can provide information in real time, and with more reliable network connections, these sensors allow for automation. As more devices/assets become connected, there are more data points, and more inputs and outputs. This will allow ITS to be delivered with more granularity, to react quicker. When it comes to pedestrian safety, milliseconds count. 5G will help give fiber-like speeds over the air, but 5G by itself does not deliver everything — rather 5G can be a key connectivity technology, and connected vehicles in this area will make the biggest impact."

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Michelle Maggiore, Country Digitalization Manager, Cisco

White/Bosch: "In a general sense, everything we deploy in ITS, involves an IoT device using its embedded intelligence to enable an intelligent devices web for intelligent infrastructure. Communication and power technologies are critical to deployment of viable solutions at scale. Every device requires power and connectivity and these two infrastructure items alone are often the most time consuming and costly in ITS projects."

Muraine/Alcatel-Lucent: "IoT is clearly a huge player in the ITS field as we have discussed in relation to smart roads and Mobility-as-a Service. With regards to 5G, contrary to many beliefs, it will not take over all areas of connectivity and replace all existing solutions. There is such a huge gap between 4G — which was established as a telephone network and 5G — which was built to handle multimedia IP communication, that they are not comparable. Although 5G is contributing to ITS deployment, we are arguably only scratching the surface of what is possible and no doubt the future holds not only 5G, but 6G and more future developments."

Collins/FDOT: "The role of IoT within the ITS field contributing to 5G technology is mostly related to Connected and Automated Vehicle (CAV) applications. 5G will likely play a bigger role in rural areas than urban as FDOT already has infrastructure in urban areas and along the interstate system. Also, as latency improves with 5G, FDOT can eventually rely on it to transfer data in real-time to support operational decision making."

Mazur/Digi International: "5G is being deployed now and it has tremendous capabilities. It's not just an upgrade of LTE. It's the enabling technology for a quick wireless communication link, which is critical for some of these newer ITS applications like connected vehicles. But another one is computing, both cloud and edge. And then, another one I think is image processing. But the computing and processing ability of that image is done locally right there at the intersection. And they use AI-based classification technology there to determine what the image is. And then lastly, another

"With 5G millimeter wave coverage, connected vehicle applications will know exactly where a car is, even when it's flying down a road at 60 miles an hour.."

Steve Mazur, Director, Government, Digi International

greatest technology enhancing ITS, is positioning systems. With 5G millimeter wave coverage, connected vehicle applications will know exactly where a car is, even when it's flying down a road at 60 miles an hour. These things will enable a much greater development of connected vehicle applications. Unfortunately, we have to wait, that's taking time. But we'll get there."

Myhrberg/Ericsson: "Artificial intelligence will be key to achieve efficient development and operation of many ITS services, and competition will make this happen. Edge computing is an important tool to optimize workload on computing and communication resources, which will be important to make many ITS applications efficient."

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Arcaro/IDC: "Artificial intelligence is an increasingly important tool to help road operators and DoTs obtain value from increasing streams and sources of data. These AI models help to look for patterns and anomalies to help understand what is going on, predict what is going to happen, or indicate when something isn't right. Edge computing is an emerging technology that will help in being able to localize, contextualize and cascade data from the hyper local all the way to the highest level. In this way, edge computing can be an important tool to help road operators and DoTs better manage and take action on their data."

Meckel/ASFINAG: "One of the use cases of C-ITS is "Collective Perception," the transmission of sensor based object detection shared between road users. In order to fuse multiple sensors and/or messages in real time, edge computing could be the solution. But these services are still in their infancy."

Mollenhauer/VTTI: "Edge computing supports the processing of sensor data using computationally heavy machine learning or machine vision applications at or near where the sensors are installed. This helps to eliminate or reduce the need to transfer large amounts of data to remote servers for processing. Edge computing can enable deployment of sophisticated algorithms to support ITS applications, without requiring high bandwidth backhaul."

Misener/Qualcomm: "Both AI and edge

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Peter Meckel, Program Manager C-ITS, ASFINAG

computing fit into this IoT paradigm and are quite relevant in the transformation of the original and still relevant ITS vision to reality. Think of a traffic signal and its controller. There are local, distributed actions such as actuating signals, soon enough done more accurately and safely with even more sensors. AI and edge computing transforms this further into an intelligent intersection. Join that to a progression of nearby intersections and coordinate them – and you have a problem that could be addressed quite well by both AI and edge computing."

Muraine/Alcatel-Lucent: "Edge computing and AI are hugely important in the

development of ITS. Through the power of edge computing and AI we have the ability to install supercomputers inside cameras which can process, analyze and understand information, and as a result highlight issues or areas of concern. Artificial intelligence and edge computing are hugely valuable aspects of ITS."

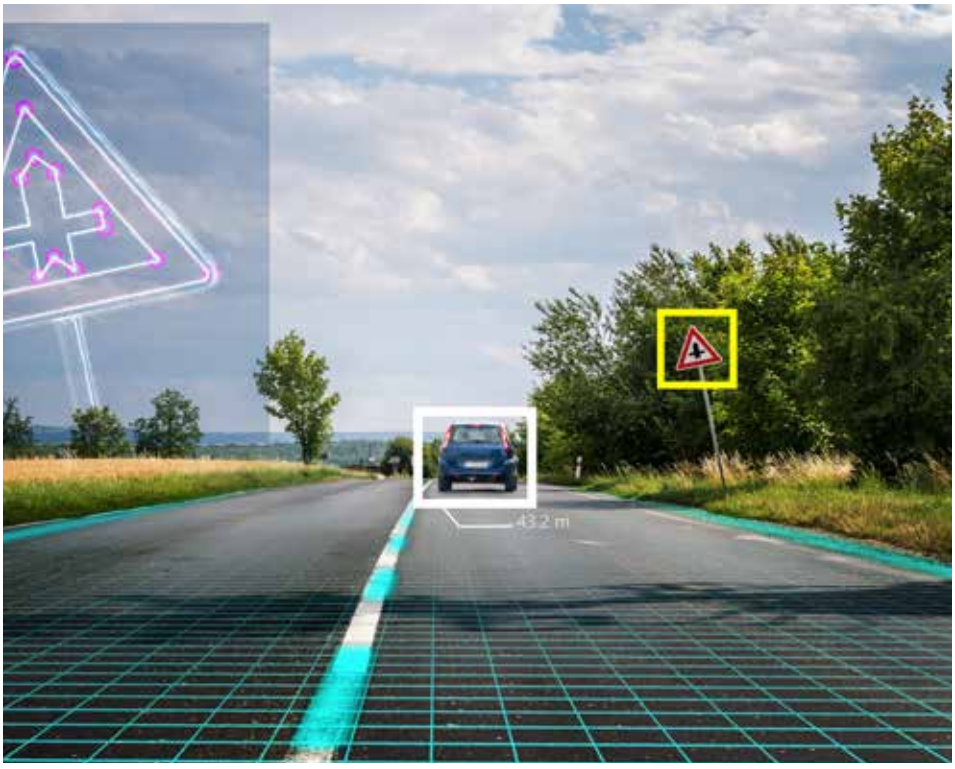
Belk/WSDOT: "Together, AI and edge computing significantly improve the efficiency of real-time data transfer by allowing information to be processed "on-site" at the edge of the roadway, greatly reducing the demand on the fiber and wireless communications infrastructure and enhancing operations, safety, mobility and traveler information with fewer physical assets."

Bonte/ABI Research: "The combination of AI and edge compute is the single biggest enabler of next generation ITS systems; it will enable real-time direct response automated services and solutions for streamlining and automating all aspects of traffic management by avoiding any form of human intervention."

What are the most developed use cases of ITS and what are the key learnings that the industry could take from them? What are the most complex use cases and what are the main challenges associated with them?

Meckel/ASFINAG: "C-ITS 'day one' use cases currently available include roadworks warning, hazardous location notifications and in-vehicle signage. Many more use cases are currently in development."

Mollenhauer: VTTI: "Thinking through more traditional ITS technologies, one of the most used would probably be variable dynamic message signs, which are deployed quite broadly in metro areas. By providing indicators of travel time, as well as when queues are developing and accidents are occurring, they support efficient incident management and information dissemination. Currently, more and more sensors are being deployed to help understand where queues are and to provide that information to drivers. A lot of activity is also seen around work zones. Work zone safety is a big deal for the DOTs, and we want to support that by saving lives and making those jobs better for workers."



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Maggiore/Cisco: "The most developed groups of use cases in traditional ITS include traveler information and traffic counting. Advanced ITS applications are adjusting traffic signal phase and timing based on sensor inputs and communication and coordination between intersections. Key learnings from the advanced intelligent intersection use case is that it is a relatively easy deployment if all the equipment is from the same vendor, but mixed vendors can be challenging due to proprietary protocols in legacy equipment."

Belk/WSDOT: "The most developed and complex cases of ITS used within WSDOT are our Active Traffic Management (ATM) system corridors. Our ATM systems measure actual speeds and other inputs and, using an algorithm developed and adapted over time, post variable speeds to smooth flow in that corridor. By gradually slowing down traffic, stop and go conditions are reduced. The system also provides dynamic lane control to direct drivers from blocked lanes. This use and display of information can decrease rear-end and secondary collisions, provide more consistent speeds for drivers, and

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improve our ability to quickly and efficiently provide lane closures."

Collins/FDOT: "Video monitoring and vehicle detection technologies are amongst the most developed uses of ITS. Traffic monitoring is still the most cost effective and efficient means of incident detection and response. The most complex ITS use cases are related to Connected and Automated Vehicle (CAV) deployments. The technology is not yet mature enough to function as a stand-alone/turnkey solution for communicating with connected vehicles and other C-V2X applications."

If we think long-term, what new use cases for ITS will be possible to achieve with current and future technologies?

Myhrberg/Ericsson: "The transport sector is being heavily transformed, as vehicles and transport services are getting connected, automated and shared. Also, new types of vehicles are coming. ITS can play a key role to integrate and manage transport on a system level, to avoid congestion and increase efficiency and safety."

Meckel/ASFINAG: "Use cases to support Automated Driving and enable Platooning will be the future in C-ITS."

Mollenhauer/VTTI: "The biggest impact would be in connecting vehicles to intersections for both safety and efficiency purposes. Connected intersections that can respond to traffic demands would allow control of the lights to make it more efficient, so that fewer people are stopping at any given time."

White/Bosch: "This is difficult to predict. Today, most use cases address safety and mobility. There are use cases that cannot be well supported by AI detection technology used today. One would expect that as with all detection use cases, this will improve as AI technology and real-time analysis improves. Near-miss detection/analysis is one example."

What is the role of government and transportation authorities in the execution of ITS initiatives and what are the main challenges in terms of the financing of these projects?

Mollenhauer/VTTI: "On the federal level, it is useful for the government to develop pilot programs and establish incentive programs to help bring everyone to a standardized solution so that ITS can be deployed broadly. The federal government can play a role by helping to standardize and prove a concept, while also funding that effort. They can also show how the benefits can be achieved through these pilot programs. When it comes to implementation, the DOTs have to see the benefits. Many DOTs, I believe, are interested in making those investments if the benefit can be shown. The main thing that has been holding it back is making sure everyone is on the same page on the connectivity side of things, when looking at a modern data flow and ITS systems. The DOTs will begin to make the investments once the value is there."

Maggiore/Cisco: "Federal governments can play a key role in setting standards and providing the frameworks for local government and relevant authorities to deploy the technology as safely as possible. It varies from

country to country of course, but generally speaking, ITS is an area for investment by governments around the globe. This often happens in cooperation with the private sector, via public/private partnerships."

Belk/WSDOT: "The role of government and transportation authorities is to ensure a consistent and fair playing field is maintained for ITS technologies and initiatives to operate effectively and benefit the public. Historically, traveler information services and the supporting ITS infrastructure have been owned, operated and maintained by public agencies. In the future we anticipate a more multijurisdictional, public-private partnership approach in some cases. Challenges in financing deployments include balancing the choice of investment in more traditional infrastructure versus working to squeeze out the maximum operational efficiencies using ITS strategies first."

Bonte/ABI Research: "The main role of government and transportation authorities is to define objectives, standards, policy frameworks and standards. A joint approach is needed across public and private sector in terms of ecosystem cooperation to define affordable, relevant solutions offering significant benefits with short ROIs, new business models based on OPEX versus CAPEX, hardware subsidization and data monetization all driving down the cost for governments to deploy ITS at scale."

Mazur/Digi International: "I think it's a great partnership. Where our industry provides the equipment, the technology and perhaps services, and the government is the end user. Think of traffic and transit systems, and they are the ones who are procuring these systems, deploying them for the benefit of the residents. Often there's talk of public private partnerships, and those do work. In some cases, like toll roads, there's plenty of examples of that in the United States. But it does become problematic. I just can't imagine, right now, how connected vehicle applications could be a public/private partnership program. It's too complex."

What are the main obstacles that are preventing a more rapid adoption of ITS? Are these obstacles more related to the tech side, or the challenge is more related to the financing of these initiatives?

Myhrberg/Ericsson: "To some extent, many obstacles are related to financing, where investments tend to focus on existing infrastructure and services, such as highways and airports, making it challenging to finance and implement new mobility services such as shared mobility."

Maggiore/Cisco: "Public and private sectors need to work together to drive adoption, pilot programs should demonstrate the use cases and further adoption will come. Funding is always an issue, so as a technology community, we need to continue to advocate for ITS and other operational technology infrastructure for our critical assets."

Muraine/Alcatel-Lucent: "Arguably tech and financial obstacles go hand in hand in this instance. Ultimately, there are a number of challenges delaying the adoption of ITS, from technological issues, to siloed organizations and of course finances, all of which has only been put under increased strain due to the implications of the pandemic. Although the future of ITS is still within sight, we are not as close as we might have hoped to be and there is still work to be done and many questions to answer."

Bonte/ABI Research: "The number one obstacle is the undoubtedly highly fragmented and ultra-conservative risk averse attitude of city governments and transportation agencies as it relates to adopting new technologies making it difficult to reach scale any time soon. Second barrier is financing though many of the new technologies will actually allow governments to save costs by increased automation and preventive maintenance. Additionally, governments will be able to monetize data generated by the connected infrastructure they own. Technology obstacles are often more related to regulation."

"Arguably tech and financial obstacles go hand in hand in this instance. Ultimately, there are a number of challenges delaying the adoption of ITS, from technological issues, to siloed organizations and of course finances, all of which has only been put under increased strain due to the implications of the pandemic. Although the future of ITS is still within sight, we are not as close as we might have hoped to be and there is still work to be done and many questions to answer.

Roch Muraine, Worldwide Sales Director for Transportation, Alcatel-Lucent Enterprise

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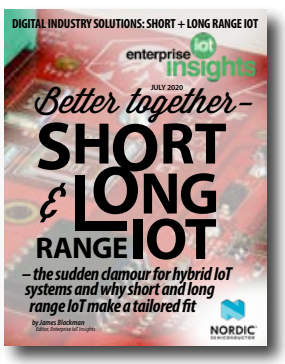

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