

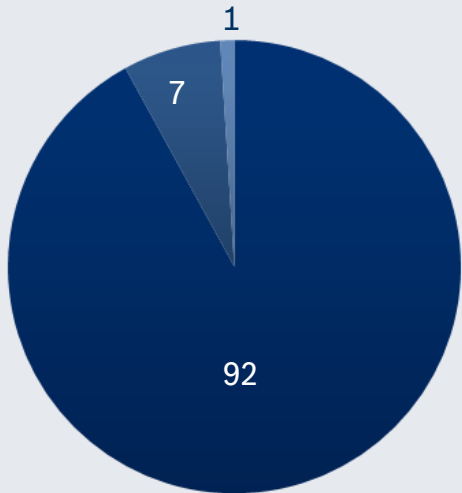
Building Smart Cities and Communities with Bosch



Building Smarter Cities and Communities

Bosch Global Footprint - Four business sectors

Shareholders



1 Robert Bosch GmbH
 7 Bosch family
 92 Robert Bosch Stiftung

4

Business sectors and divisions

- Mobility Solutions
- Industrial Technology
- Consumer Goods
- Energy and Building Technology

Mobility Solutions



World's largest supplier of cutting-edge automotive technology

Industrial Technology



Leading in drive and control technology, packaging, and process technology

Consumer Goods



World's largest power tool manufacturer
 Leading the field in household appliances

Energy and Building Technology



Leading manufacturer of thermo, and building security technology; World's largest supplier of heat pumps



approx. **410,000** associates

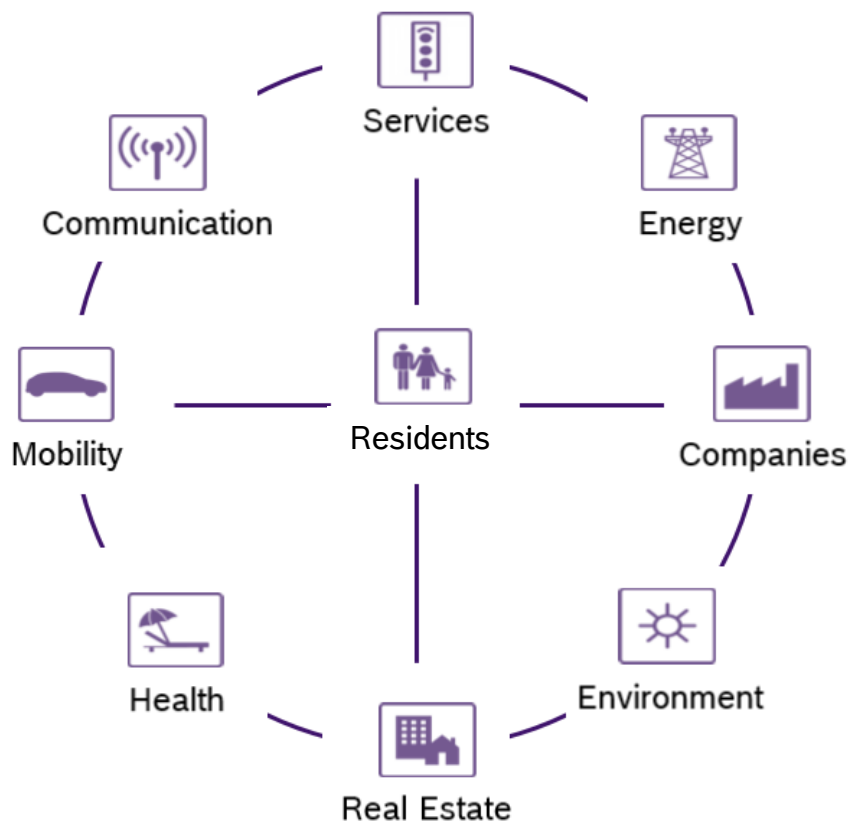
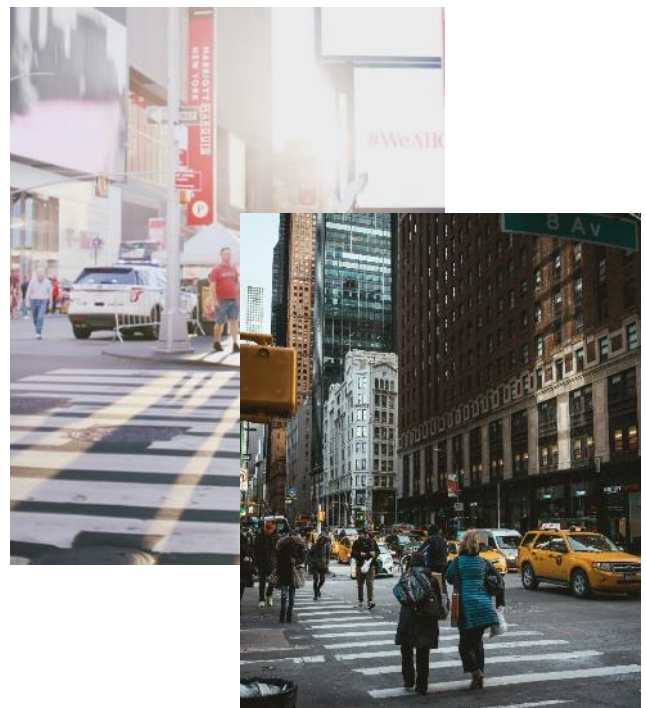
89.2 billion dollars in sales in 2018

Building Smarter Cities and Communities

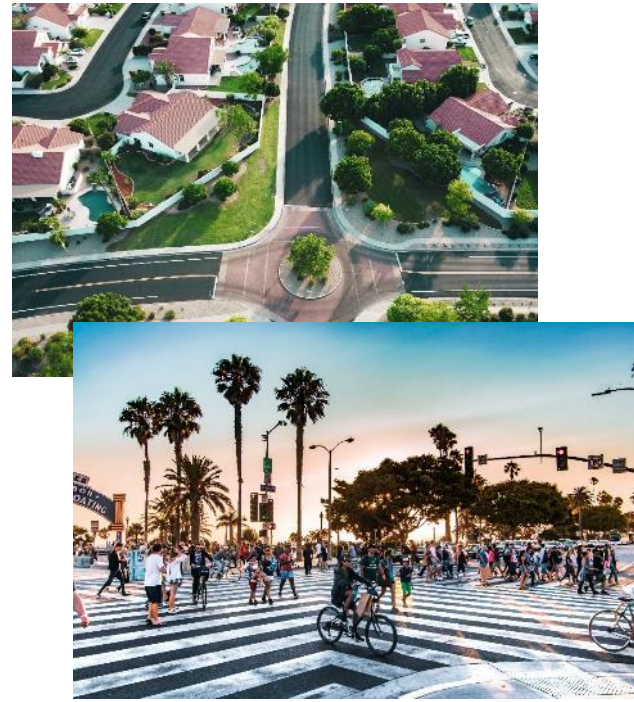
Smart City and Smart Community

Our **vision** for a smart city is to create an **interconnected ecosystem** that works to optimize **performance**, increase **efficiency**, and to enhance **quality of life** for all.

Smart City



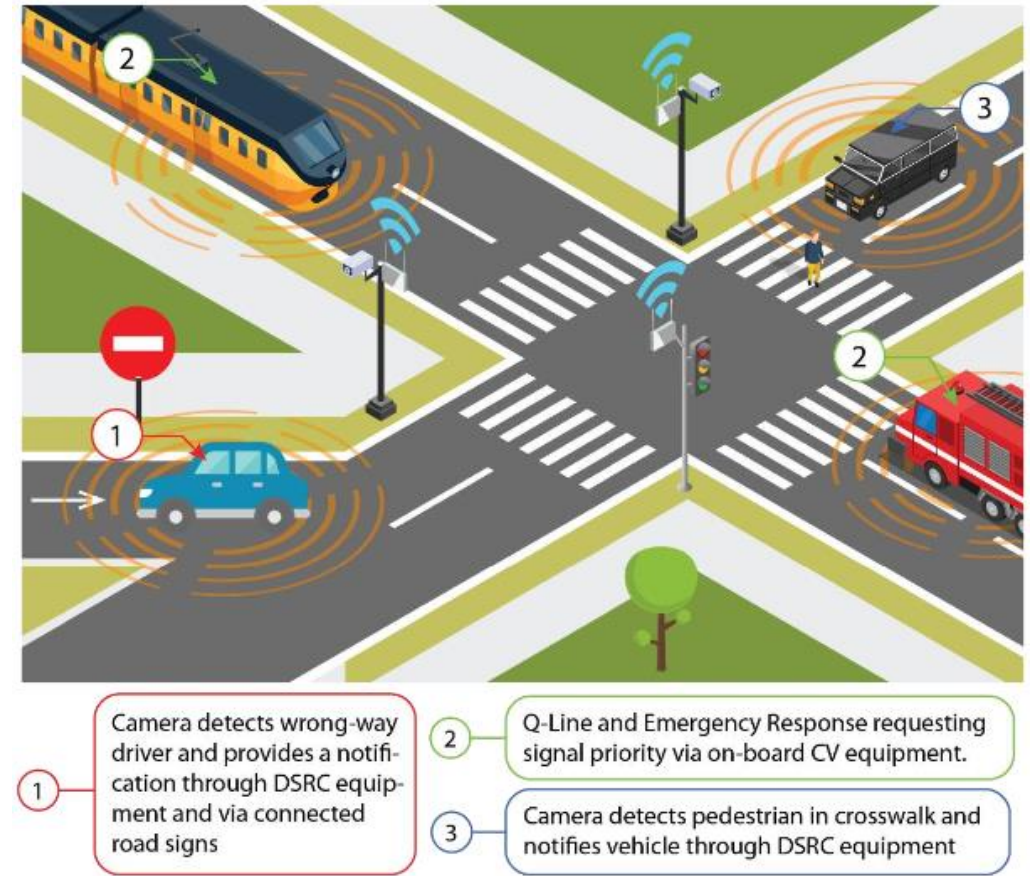
Smart Community



Intelligent Traffic Systems

ITS example – US DOT ATCMTD submission

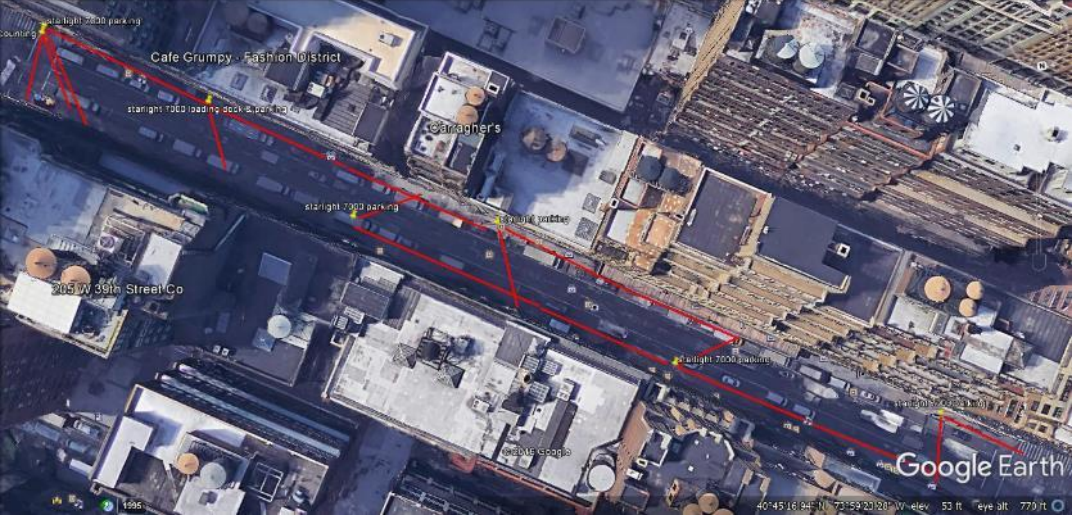
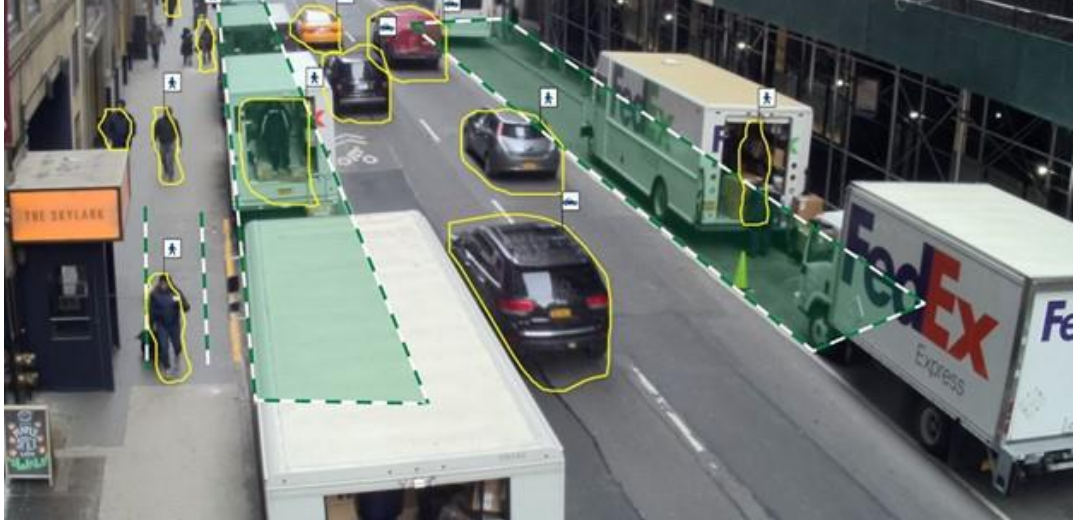
- ▶ Pedestrian detection, prioritization, and alerts
 - Improved pedestrian and vehicle safety
- ▶ Traffic intersection preemption and signal priority for authorized vehicles
 - Reduced response times for emergency vehicles
 - Improved on-time arrivals for public transportation
- ▶ Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications
- ▶ Transportation system optimization through data analytics and edge computing
- ▶ Wrong way driver detection and alerts
- ▶ Incident and near miss detection



Intelligent Traffic Systems

Curbside Management Pilot

- ▶ Car & Truck counting with Dashboard
- ▶ Truck parking analytics, frequency & duration
- ▶ Delivery zone violations and availability
- ▶ Double parking detection
- ▶ Bus stop & ride-share violation detection



Transportation
Research Center
East Liberty

Marysville

Dublin

Columbus



US-33 Smart Mobility Corridor

the **MIDWEST'S** *proving ground*
for smart mobility technology

Bosch is partnering with DriveOhio to test intelligent video sensing solutions along the US-33 Smart Corridor and in Marysville that have the ability to increase safety.

Fast Facts

- Project led by ODOT and DriveOhio
- 35-Mile Smart Mobility Corridor
- Prepares Ohio roadway infrastructure for the future of connected and automated vehicles
- Bosch is collaborating with partners to deploy smart mobility solutions
- Bosch's intelligent video sensor helps improve safety

Cross Traffic Warning	Warn drivers at intersections where cross-traffic is hard to see.
Curve Speed Warning	Alert drivers approaching exit ramp at too high speed.
Pedestrian Safety	Inform connected vehicle drivers of pedestrian presence near or in the roadway.
Exit Ramp Queue Warning	Inform drivers of approaching exit ramps of queues or stopped cars.
Red Light Violation Warning	In combination of Cross-Traffic Warning, inform connected vehicle of probable violation.
Work Zone Warning	Identify late merge of distracted driver, audio and visual alerts to inform driver and workers.
Wrong Way Driver	Detect and notify drivers of hazard, track wrong driver with pan-tilt-zoom camera.



Autonomous Mobility Services

US DOT grant award – Truck Platooning

- ▶ Ohio Department of Transportation (ODOT) and DriveOhio to Test and Deploy Automatic Driving System Technology in Ohio
- ▶ Bosch is a sub-awardee on this project as a technology provider for level 1 & 2 autonomous functionality to enable truck platooning.
- ▶ Benefits of truck Platooning
 - Improved road safety
 - Decreased fuel consumption
 - Improved freight logistics efficiency resulting in positive economic impact



Bosch eBike Systems

eBike Pedal-assist System



- ▶ **Pedal-assist:** Electric motor engages only when pedaling, allowing precise assisted speeds of up to 20 or 28 mph, no throttle needed and either hand is free
- ▶ **Power and range:** the 350-watt motor is powered by a 500 Wh lithium-ion battery for up to 100 miles per charge
- ▶ Fast, full charging in 4.5 hours using a standard 110V wall outlet
- ▶ Available on over 30 different bicycle brands in North America



Bosch eBike Systems

Bosch 'n Blue Program



Columbus, OH



Laguna Beach, CA



Tucson, AZ



Detroit, MI & Wayne State University

- ▶ Over a dozen police departments across the country have taken advantage of what eBikes provide
 - ▶ Increased range, higher speeds, incredible flexibility,
- ▶ Over 60 test riders (police officers)

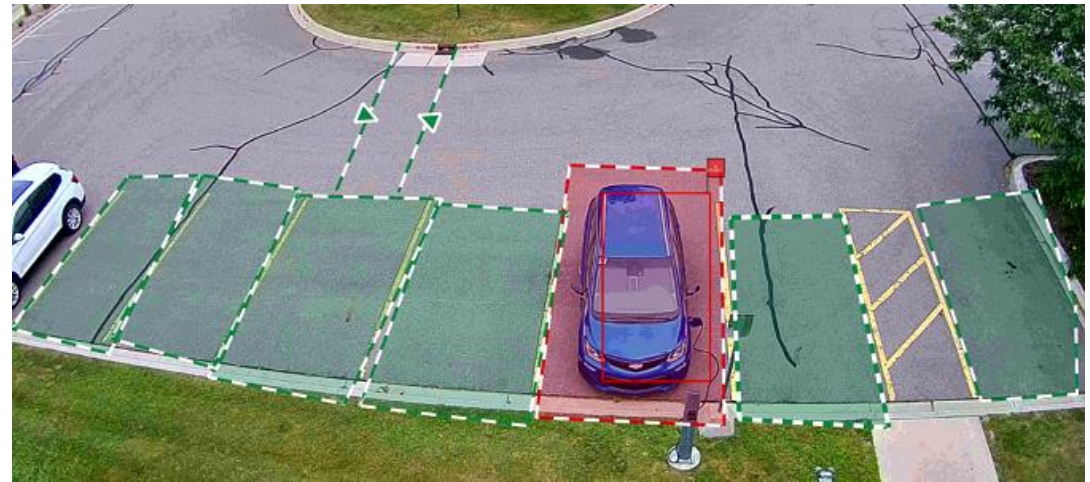
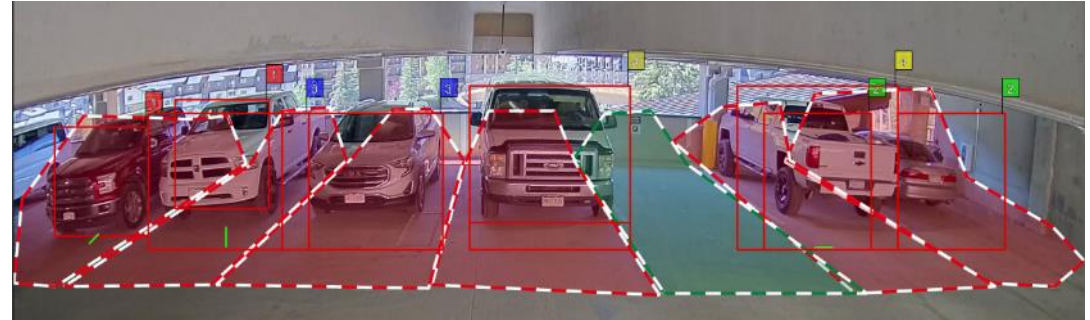


Royal Oak, MI

Smart Parking Solution

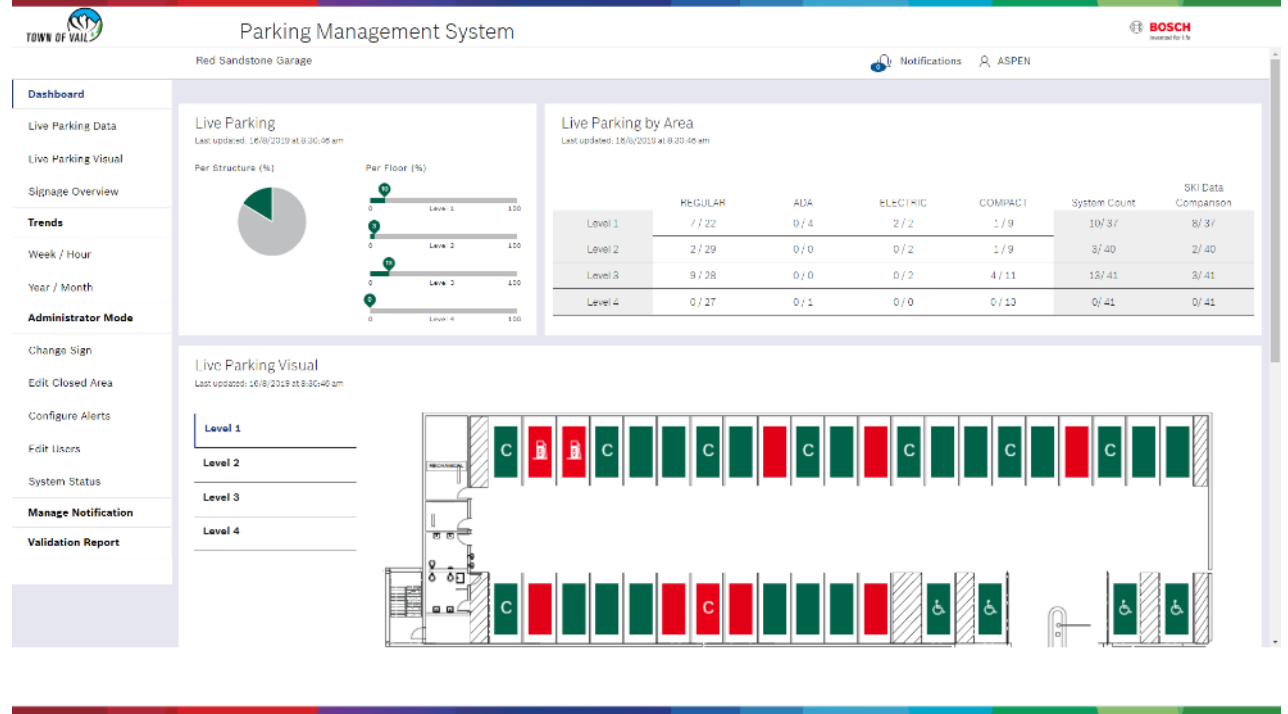
Key Functionality

- ▶ Parking availability via ground sensors or cameras' on-board intelligent video analytics
- ▶ Cameras provide security video and/or vehicle count metadata of parking lanes, decks or lot.
- ▶ License plate recognition-based access control
- ▶ Parking availability data can be provided to signage or customer specific apps
- ▶ Dashboard for visualizing data analytics and parking space management
- ▶ Parking Management Software



Smart Parking Solution Benefits

- ▶ Reduced vehicle traffic and emissions from drivers circling the block looking for a parking spot
- ▶ Improved driver experience leading to greater return customers and improved parking spot utilization rates
- ▶ Detection and notification of vehicle overstays
- ▶ Meta-data stream (object identification /classification) preserves privacy while also reducing back-end communication bandwidth requirements (on-camera edge intelligent video analytics processing compared to full video stream)



THANK YOU!



<http://cds.bosch.us/smart-city>



Testimony of Scott Averitt

Technical Expert and Manager of Public/Private
Partnerships

Robert Bosch LLC



Field Hearing: Smart Mobility: It's a Community Issue

House Committee on Science, Space and Technology
United States House of Representatives

October 25, 2019

Robert Bosch LLC
Testimony before the House Committee on Science, Space and Technology
October 25, 2019

Good Morning Chairwoman Stevens, Ranking Member Baird, members of the Committee... Thank you for the opportunity to testify before you today. My name is Scott Averitt and I work for Bosch in North America as a technical expert and manager of public/private partnerships.

Bosch is a global company with roughly 410,000 employees spread across more than 60 countries around the world. Bosch first established a presence in the U.S. in 1906 and currently employs nearly 35,000 associates in more than 100 locations in North America. Bosch has technologies across our four different business sectors that are applicable toward smart mobility and smart communities.

Our vision for a smart city is to create an interconnected ecosystem that works to optimize performance, increase efficiency, and enhance quality of life for all. In order for smart community solutions to be successful, they must be born out of people's experiences and needs. Bosch draws upon a user experience driven process to develop our products and services.

One of the fundamental truths that defines a thriving community is the accessibility to safe and efficient mobility. For example, our recent grant submission to the US DOT in partnership with the Michigan DOT aims to achieve this. Through the deployment of Bosch's video as a sensor solution, our cameras will increase pedestrian and vehicle safety through detection, prioritization, and alerts of pedestrians and cyclists. Additional technologies from our partners will help to reduce traffic incidents and congestion through the use of vehicle to vehicle and vehicle to infrastructure communications. The benefits include reduced emergency vehicle response times and public transportation on-time performance. Additionally, Bosch cameras will be used to identify wrong way drivers. The system will use communications and signage to send out alerts to the driver and nearby travelers to mitigate risk and save lives.

The intelligent video analytics embedded in our cameras can also help cities with tasks such as curbside management, delivery zone violations and availability, parking analytics, and double-parking detection.

Bosch has partnered with the Ohio DOT regarding deployment and testing of technologies along the US-33 Smart Mobility Corridor. Video analytics are being used to generate warnings for cross traffic, curve speed, exit ramp queue, red light violation, work zones along with detection and notifications for pedestrians and wrong way drivers. These technologies are applicable and scalable from big cities to smaller size cities and rural areas.

As part of a recent US DOT grant awarded to the Ohio DOT Bosch will be the technology provider on a project that will test and deploy driver assistance systems in the form of Truck Platooning. The technologies to be deployed are expected to help cities, suburban areas, and rural communities through improved road safety, decreased fuel consumption, and improved freight logistics efficiency. Freight shipping is essential to the success of many industries, therefore, it is critical that we continue to innovate and transform this industry in a sustainable way.

Personal mobility solutions should be scalable and accessible to all. Bosch's eBike system aims to extend cycling accessibility to a wider range of commuters. Bosch's pedal-assist electric motor drive engages only when pedaling. This enables precise assisted speeds of up to 28 mph with hands free, no throttle operation. eBikes essentially flatten hills, shorten distances, and provide a viable option to ride for those who otherwise could not.

The Bosch 'N Blue program has been successfully implemented across the country. This program provides specially outfitted eBikes to police departments as a trial period to augment their mobility fleets. Police departments have praised advantages of increased range, higher speeds, and incredible flexibility. eBikes are a great way for officers to engage with the community while still quickly and safely getting to where they are needed.

Vehicle parking continues to be a challenge for drivers and communities alike. Bosch's smart parking solution detects parking availability for garages, lots, and on street. The camera solution performs dual functionality by providing security video and parking spot detection. Parking management software and dashboards makes it easy to share parking availability via signage or customer specific apps.

More efficient parking systems help to reduce vehicle traffic from drivers circling the block looking for a spot. It improves the driver experience leading to greater return customers and improved parking spot utilization rates. Our cameras use on-board intelligent video analytics to generate a separate data stream that provides information about object identification, classification, and path of motion. This method preserves privacy while also reducing back-end communication bandwidth requirements.

Thank you once again for your time today and I would be happy to answer any questions you may have.

Support Information

Overview of Bosch's Smart Community Initiatives in the U.S.

Bosch's Overall Approach: Provide services, solutions and technical expertise from across Bosch's business sectors to achieve a holistic and connected community, which is highly efficient, sustainable, and provides residents with a high quality of life. The Bosch Smart Community vision includes the following areas:

- **Energy:** Building energy storage, energy-efficient heating, hot water & cooling systems (residential, commercial, industrial, campus wide), geothermal HVAC systems, energy-efficient appliances, distributed energy generation through Solid Oxide Fuel Cells (SOFC).
- **Buildings:** Building Management Platform, video surveillance, fire alarm systems, Energy Management Platform, elevator monitoring, occupancy detection, heat mapping.
- **Security:** Intelligent video analytics, video systems, access control, public address system, intrusion alarm systems, gun-shot detection, perimeter security, critical infrastructure security.
- **Mobility:** Intelligent Transportation Systems (smart parking, wrong-way driver detection, pedestrian detection, curbside management, V2X, cybersecurity), autonomous & connected vehicle systems, EV-mobility, eBikes, eScooters.
- **Smart Community:** Micro-Climate Monitoring, Community App & Community Portal.

Current and pending project examples:

- 1) **DOT Grant awarded to Ohio Department of Transportation (ODOT) and DriveOhio to test and deploy Automatic Driving System technology in Ohio.**
 - Bosch is a sub-awardee on this project as a technology provider for level 1 & 2 autonomous functionality to enable truck platooning.
 - Benefits of Truck Platooning
 - Improved road safety
 - Decreased fuel consumption
 - Improved freight logistics efficiency resulting in positive economic impact



2) **MDOT project submission to US DOT ATCMDT grant opportunity for the “Intelligent Woodward Corridor Project”**. M-1 Woodward Avenue from Campus Martius Park to I-696.

- Bosch is a partner on this submission to provide our “Video as a Sensor” product solution.
- Key Technologies: 1) Pedestrian detection, prioritization, and alerts; 2) Traffic intersection preemption and signal priority for authorized vehicles; 3) Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications; 4) Transportation system optimization through data analytics and edge computing; 5) Wrong way driver detection and alerts.
- Benefits
 - Improved pedestrian and vehicle safety including detection and warning regarding wrong way driver incidents.
 - Reduced response times for emergency vehicles.
 - Improved on-time arrivals for public transportation including the Qline and public busses.
 - Reduced congestion for public transportation, freight deliveries, and commuters.
 - Better management of pedestrian and vehicle traffic surrounding events along the corridor



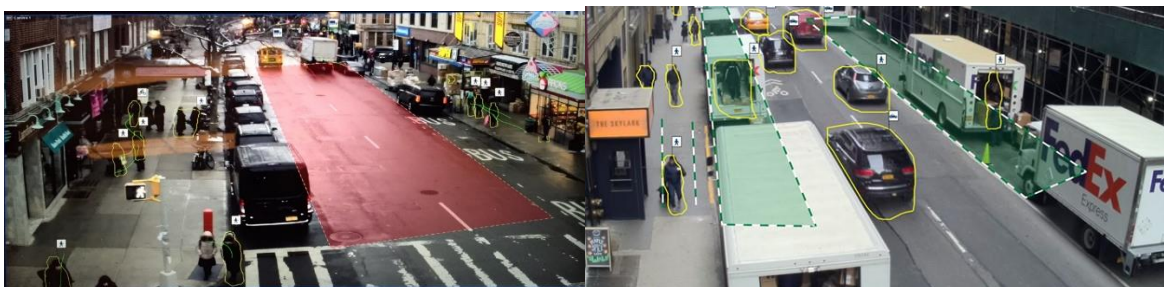
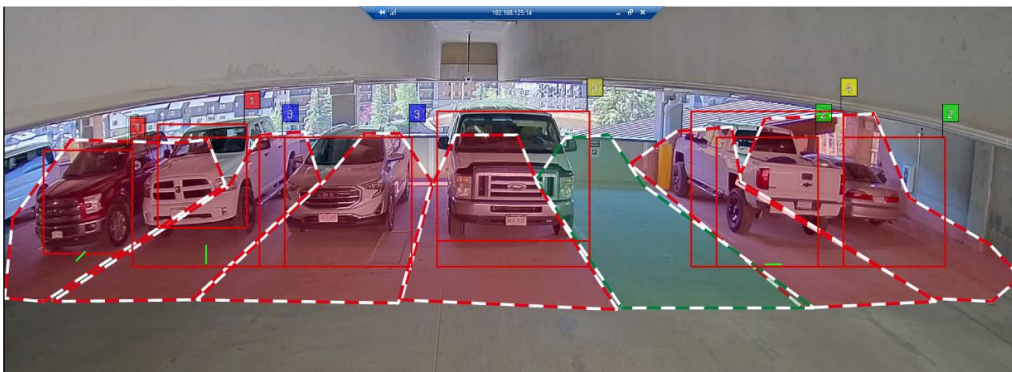
- 1 Camera detects wrong-way driver and provides a notification through DSRC equipment and via connected road signs
- 2 Q-Line and Emergency Response requesting signal priority via on-board CV equipment.
- 3 Camera detects pedestrian in crosswalk and notifies vehicle through DSRC equipment

3) Bosch project proposal to NSF's Smart & Connected Communities funding opportunity for "Lake Nona Connect: Developing Innovative Solutions to Build a Healthy Integrated Community".

- Partnership with the University of Central Florida (behavioral science center) and Tavistock Development Company.
- Lake Nona is a master plan community near Orlando Florida.
- The goal of Lake Nona Connect (LNC) is to deploy technological innovations that are driven by community need and input to 1) understand the movement of people, goods, and services, and 2) benefit the wellbeing and quality of life (QOL) of its residents.
- The first objective is to identify the preferred methods of inclusive transportation, pain points, behavioral patterns, including pedestrian mobility. This will help to determine the effects on accessible transportation infrastructure and how to improve mobility throughout the community and surrounding areas.
- The second objective is to improve the health and welfare of people within the community. This may include health and wellness, healthcare, human services, resiliency, safety, social services, and telecommunications.

4) Smart Parking / Curbside Management

- Parking availability via ground sensors or cameras with on-camera intelligent video analytics.
- Cameras serve dual purpose for security video and vehicle count of parking lanes, decks, on street, or lot.
- Parking availability data can be provided to signage, backend services, and/or customer specific apps.
- Curbside Management including delivery zone violations, ride-share pickup & drop-off, bus stop violation detection, double park violation detection, and more.
- Dashboard for visualizing data analytics and parking space management.
- License Plate Recognition (LPR) for access control and billing.
- Benefits
 - Reduced vehicle traffic from drivers circling the block looking for a parking spot.
 - Improved driver experience leading to greater return customers and improved parking spot utilization rates.
 - Detection and notification of vehicle overstays.
 - Meta-data stream (object identification/classification) preserves privacy while also reducing back-end communication bandwidth requirements (on-camera edge intelligent video analytics processing compared to full video stream).



5) US-33 Ohio Smart Mobility Corridor

- Project led by Ohio DOT and DriveOhio to create a 35-mile Smart Mobility Corridor along US-33.
- Bosch is deploying pilots to demonstrate intelligent video sensing solutions along the Smart Corridor and in Marysville that have the ability to increase safety.
- Prepares Ohio roadway infrastructure for the future of connected and automated vehicles

Cross Traffic Warning	Warn drivers at intersections where cross-traffic is hard to see.
Curve Speed Warning	Alert drivers approaching exit ramp at too high speed.
Pedestrian Safety	Inform connected vehicle drivers of pedestrian presence near or in the roadway.
Exit Ramp Queue Warning	Inform drivers of approaching exit ramps of queues or stopped cars.
Red Light Violation Warning	In combination of Cross-Traffic Warning, inform connected vehicle of probable violation.
Work Zone Warning	Identify late merge of distracted driver, audio and visual alerts to inform driver and workers.
Wrong Way Driver	Detect and notify drivers of hazard, track wrong driver with pan-tilt-zoom camera.

6) Bosch eBike Systems

- **Pedal-assist:** Electric motor engages only when pedaling, allowing precise assisted speeds of up to 20 or 28 mph, no throttle needed and either hand is free
- **Power and Range:** the 350-watt motor is powered by a 500 Wh lithium-ion battery for up to 100 miles per charge
- Fast, full charging in 4.5 hours using a standard 110V wall outlet
- Available on over 30 different bicycle brands in North America



- **Bosch 'n Blue Program** - Over 10 police departments



Columbus, OH



Laguna Beach, CA



Tucson, AZ



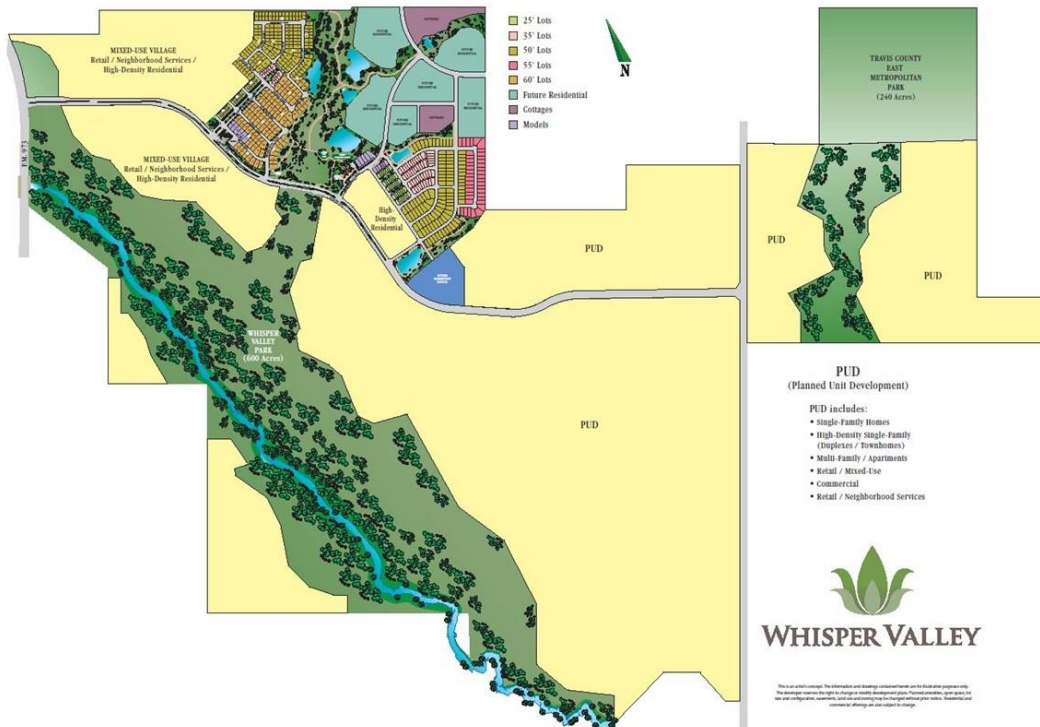
Royal Oak, MI



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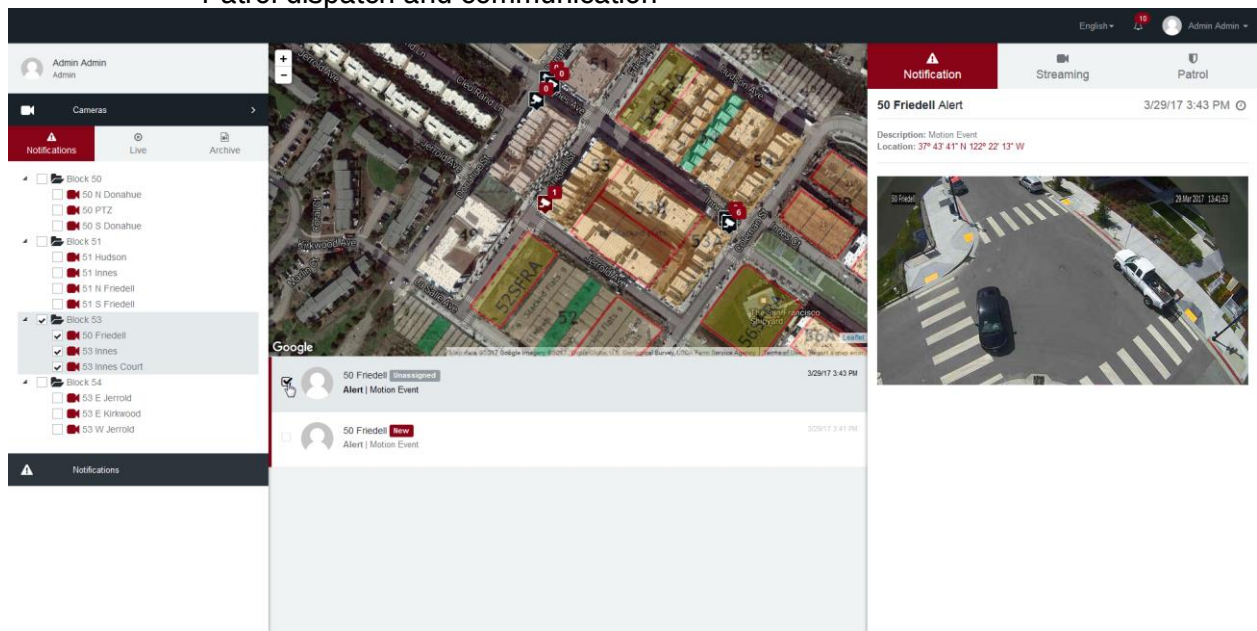
7) Whisper Valley master plan community – Austin, TX

- Partnership with Taurus Development and EcoSmart Solutions
- 2,0663-acre mixed-use planned community
- 7,500 single and multi-family homes
- Over 2.0 million square feet of retail & office space
- Focus on community scale energy efficiency
 - 100% geothermal, utilizing Bosch heat pumps and community shared geothermal loop
 - Energy efficient Bosch appliances
 - Google Fiber throughout community
 - Available solar PV to target Net-Zero capability
 - Dedicated land for on-site Farm to Table operations
 - On-site sustainable living education and community center



8) Five Point master plan community – San Francisco, CA

- Partnership with Five Point developer
- 12,000 new residences
- 5 million square feet of commercial space
- 350 acres of parks and green spaces
- Security Community Portal (SCP)
 - Engagement with residents, tenants, and employees in security
 - Live streaming of camera feeds
 - Tenant incident reporting and notifications
 - Incident assignment, notifications, and tracking
 - Patrol dispatch and communication



- Resident safety and security – "Walk Me Home" functionality.
 - User submits "Walk Me Home" request to observer (friends, family, or security provider)
 - Observer granted temporary access to movement path of requester
 - Observer alerted on:
 - a) Fall detection
 - b) Panic button press
 - c) Unexpected stop
 - d) Unexpected path change
 - e) Position update omission





BOSCH

October 21, 2019

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Short Biography for Scott Averitt

Scott Averitt works in the corporate government affairs group for Bosch where he serves as Technical Expert and Manager focusing on advanced R&D projects, public/private partnerships, and government funded projects. He collaborates across all four of Bosch's business sectors including Mobility Solutions, Industrial Technology, Consumer Goods, and Energy and Building Technology. Scott also works in partnership with many universities, national labs, and industry members. His activities include investigation of new technologies, products, markets, system solutions, business partner development and alliances, system level concept creation, and public funding proposal generation and project support.

He holds a degree in Electrical Engineering from Lawrence Technological University in Southfield MI and he has 20+ years of experience designing and developing electronics, software, and systems across residential, commercial, industrial, and automotive applications. Scott has held many roles within Bosch over the past 16 years of employment for the company. His previous positions include Design Engineer, Senior Project Engineer, Technical Expert, and Technical Project Lead/Manager.