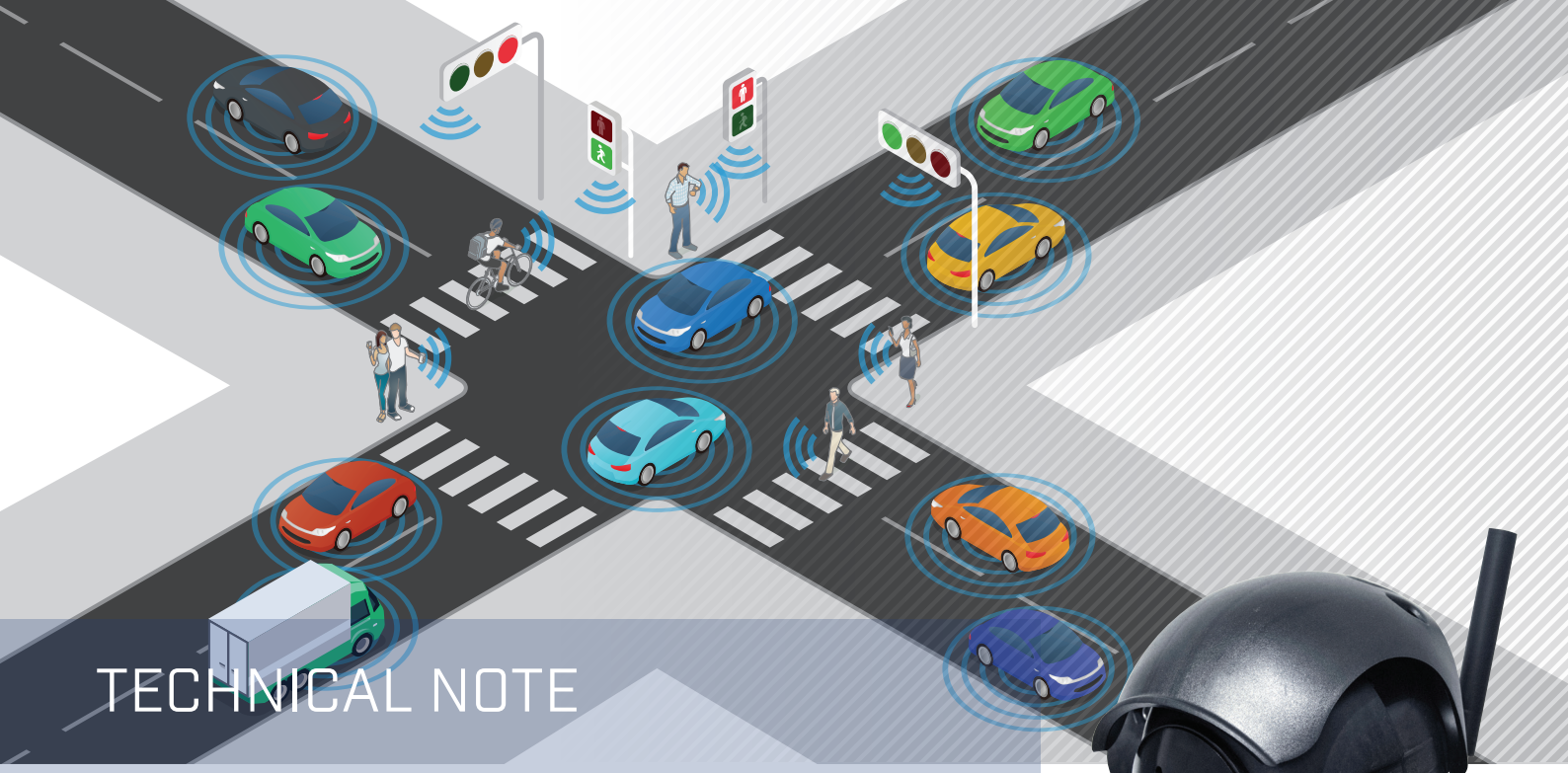


TECHNICAL NOTE

Camera-enabled V2X for public transportation and emergency vehicles

FLIR ThermiCam V2X, an intelligent, V2X-enabled thermal camera.

V2X offers enormous potential for cities in the years to come and will have a significant influence on traffic management operations. Although today's city authorities are still hesitant to fully adopt V2X technology, a number of early adopter applications—such as traffic signal priority for public transportation vehicles—do offer short-term benefits. Camera-enabled V2X could enhance the effectiveness of these applications even more.

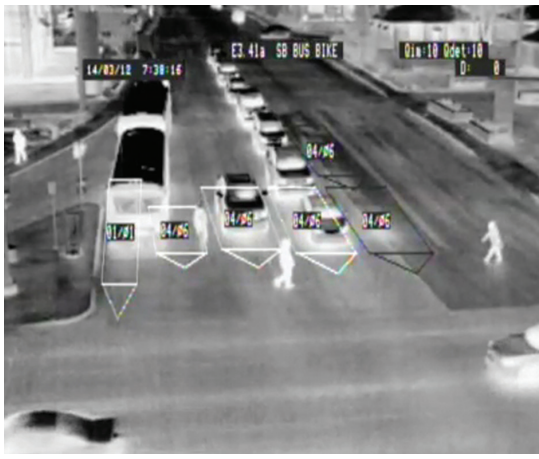
In the smart city community, V2X is gaining more importance and is believed to bring great benefits in terms of traffic safety and efficiency. The practical applications of V2X are numerous. By providing real-time traffic information, V2X allows vehicles to receive pre-emptive warnings about hazardous situations, such as hard-breaking vehicles ahead. Vehicles can even receive messages about the status of traffic signals ahead of them, allowing them to adapt their speed accordingly and drive more economically. V2X also plays an important part in paving the way to connected and automated driving.

WHAT IS V2X?

V2X is a crash avoidance technology that relies on communication of information between nearby vehicles and infrastructure to warn drivers about potentially dangerous situations that could lead to crashes. For example, V2X helps warn drivers that a vehicle ahead is braking and they need to slow down, or let a driver know that it is not safe to proceed through an intersection because another car, unseen by the driver, is quickly approaching.

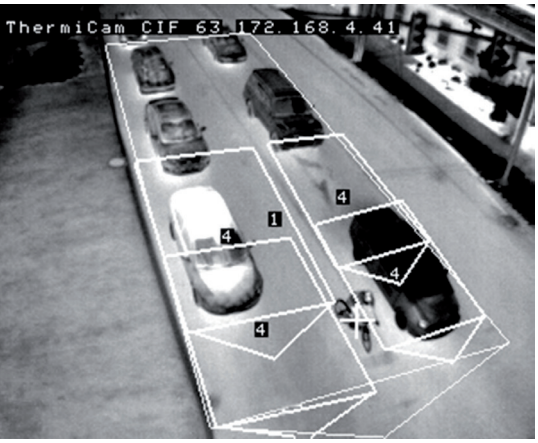
V2X includes communication between vehicles and infrastructure (V2I, or "vehicle to infrastructure") and communication among vehicles (V2V, or "vehicle to vehicle"). Sharing mobility information between vehicles and road infrastructures requires continuous communication for up to date information about vehicle states and their environment. On-board units and roadside units (vehicle and infrastructure) constantly send and receive messages. V2X devices in cars are often referred to as an On-Board Unit (OBU), whereas a V2X device installed on the road infrastructure is called a Road-Side Unit (RSU).

During the last decade, standard administrations, automobile manufacturers, and researchers have been working together to define new standards for vehicular applications, and to develop wireless technology and



FLIR's ThermiCam V2X equipped with MARBEN V2X software will send and receive basic safety messages to and from nearby vehicles.

communication systems for vehicles. One of these technologies is Dedicated Short-Range Communications (DSRC), which is a two-way, wireless communication permitting secure and fast messaging needed for safety applications. DSRC enables vehicles and infrastructure to exchange information — such as location, speed, direction and braking status — in a range of approximately 300 meters, depending on the surrounding environment.



The ThermiCam V2X will alert surrounding vehicles of the presence of bicyclists along roadways and near intersections.

V2X APPLICATIONS

Vehicle-2-vehicle (V2V) communication enables several different safety applications:

- **Intersection Movement Assist (IMA)** warns the driver when it is unsafe to enter an intersection because of high potential for a collision with one or more vehicles.
- **Left Turn Assist (LTA)** warns the driver there is high probability they will collide with an oncoming vehicle when making a left turn. This is critical when the driver's line-of-sight is blocked by a vehicle.
- **Emergency Electronic Brake Light (EEBL)** warns the driver to be prepared to take action when a vehicle ahead is braking. V2V allows the driver to see through other vehicles or poor weather conditions to know that traffic ahead is coming to an abrupt stop.
- **Forward Collision Warning (FCW)** alerts the driver of the risk of an impending rear-end collision with another vehicle in traffic, in the same lane, and the direction of travel.
- **Blind Spot Warning (BSW)** and **Lane Change Warning (LCW)** notifies the driver when a vehicle in an adjacent lane is positioned in the driver's "blind spot" zone.
- **Do Not Pass Warning (DNPW)** tells the driver that it is not safe to pass a slower-moving vehicle because vehicles are approaching from the opposite direction in the passing lane.

The US Department of Transportation analyzed two potential applications, intersection movement assist (IMA) and left turn assist (LTA). The analysis indicated that there could be an average 50-percent reduction in crashes, injuries, and fatalities through these two applications alone.

Vehicle-to-Infrastructure (V2I) applications will not only be able to improve traffic safety, but also improve traffic efficiency and reduce congestion:

- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Reduced Speed Zone Warning
- Spot Weather Information Warning
- Stop Sign Violation Warning
- Railroad Crossing Violation Warning
- Oversize Vehicle Warning
- Electronic Toll Collection
- Pedestrian in Signalized Crosswalk Warning (PSWC)
- Public transport priority
- Traffic signal preemption for emergency vehicles

V2X AND AUTOMATED VEHICLES

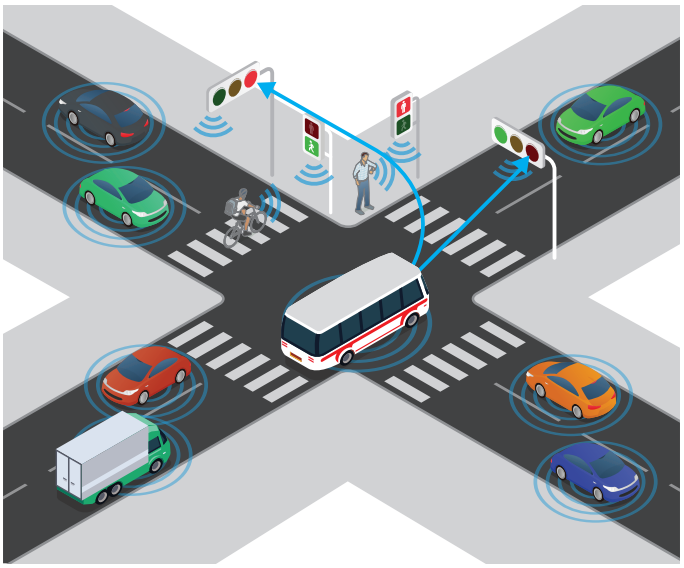
V2X and automated vehicle technologies are highly complementary to each other. When deployed together they will have significant safety benefits. V2X expands sensing performance beyond what is achievable by "line-of-sight" sensors. With V2X, a vehicle gains capability, such as "seeing" around corners, buildings or trucks, and many vehicles ahead or behind.

FLIR ThermiCam V2X

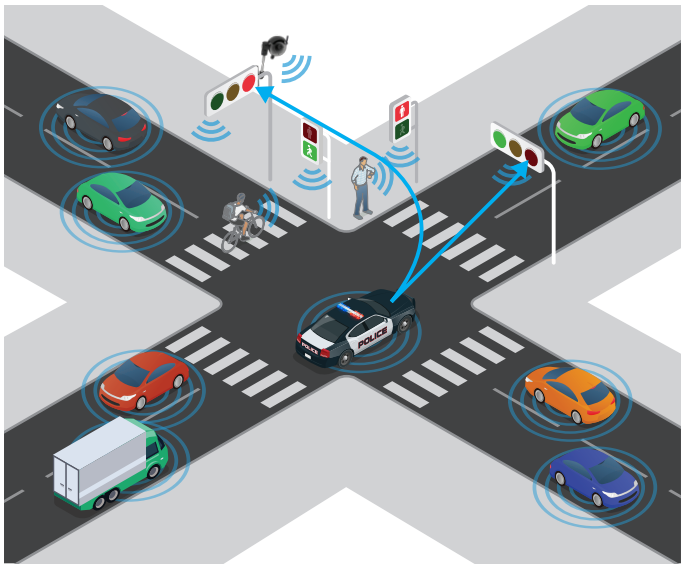
Intelligent Thermal Camera with V2X

Combining intelligent cameras with V2X can be done in two different approaches. One approach is to connect an intelligent camera via TCP/IP to a commercially available off-the-shelf V2X modem. Another approach is letting the embedded intelligent camera platform host a V2X chipset and radio transmitter. The ThermiCam V2X thermal traffic sensor is an example of this second approach.

ThermiCam V2X includes a thermal sensor and detector for vehicle and bike detection that uses thermal energy emitted from vehicles and bicyclists. In addition, it contains an integrated V2X modem that can capture the video detection information and process this together with the received V2X messages from vehicles.



V2X for public transportation vehicles.



V2X for emergency vehicles.

V2X has a larger effective sensing range than conventional sensors, providing additional lead time for decision algorithms, which is essential for higher levels of automation. V2X packs a rich set of "vehicle performance and status" information directly from the source, which enables automation algorithms to "know" what surrounding vehicles are doing and not to guess or estimate what they may be doing.

V2X WITH INTELLIGENT CAMERAS

Traffic management systems have always made use of cameras to monitor traffic and detect traffic users in real time. Be it for automatic incident detection, traffic signal control or traffic data collection, smart cameras have significantly contributed to the safety and efficiency of our roads.

By combining the real-time detection capabilities of these cameras with real-time vehicle-to-infrastructure communication, even more capabilities can be unlocked. Here are a few examples:

- **Automatic incident detection:** Traffic incidents, such as stopped vehicles, wrong way drivers, speed drops or fallen objects can be detected by intelligent cameras. This detection information can be sent to vehicles through the V2X system. This offers traffic operators the ability to warn oncoming traffic on potential threats nearby.
- **Traffic signal control:** Highly automated traffic control, such as real-time adaptive signal systems, requires extensive detection systems, particularly on arterial roads. Road operators generally deploy cameras to detect traffic participants in real-time to be able to change traffic signals 'on demand'. With V2X at an intersection, a lot more information from traffic users becomes known that can be communicated with V2X technology. For example, the presence of pedestrians and cyclists on an intersection can be detected and communicated to vehicle-mounted V2X units in order to prevent possible collisions with vulnerable road users.

PRIORITY FOR PUBLIC TRANSPORT AND EMERGENCY VEHICLES

Another application for connected traffic signal control is priority for public transport and emergency vehicles, enabling the rapid movement of those vehicles on urban arterial roads. It allows traffic control strategies to decrease the Emergency Vehicle Response Time (EVRT) and to minimize public transport vehicle delay.

In urban areas, one of the main factors affecting the response time of emergency vehicles is the delay caused by traffic congestion and traffic signal controls at intersections. The basic idea with traffic signal priority is to change the traffic signal status to green adaptively (and red to others) when an emergency vehicle is approaching so that the traffic can make way.

V2X can also improve the Estimated Time of Arrival (ETA) of public transportation vehicles in cities. In addition, traffic signals can be adapted to the presence of public buses and the number of times they need to stop at a traffic junction can be reduced.

A bus or a priority vehicle can be recognized at an intersection when the vehicle is carrying a V2X OBU which is transmitting so-called Common Awareness Messages (CAMs). At intersections, a V2X RSU can receive and process the CAM originating from those vehicles and trigger an output towards the traffic signal controller indicating a priority vehicle is approaching. In combination with data from intelligent cameras such as queue lengths, zone occupancy, traffic volume etc., more parameters are available to make even smarter decisions to minimize the response time of emergency vehicles.

ADOPTION OF V2X

Although V2X is gaining momentum worldwide among traffic authorities, the deployment of this technology is slow. The benefits of V2X may be obvious, but tight city budgets and cumbersome procurement guidelines for public agencies often get in the way of good intentions.

A city-wide deployment of the required IoT (Internet of Things) infrastructure for V2X can be an investment that many cities are not ready to make. Moreover, many V2X applications, such as delay time or traffic volume measurement are only interesting when a certain portion of the vehicle fleet is equipped with V2X technology. Some V2I applications require at least medium level of vehicle DRSC adoption (40-60%) before benefits of V2I for road operators can be recognized.

LOW-RISK INVESTMENT

However, that does not mean that cities aren't willing to experiment and explore the many possibilities that V2X has to offer. Field operational tests that are being deployed globally prove that there is an increased interest from traffic authorities for V2X. At the same time, these authorities are looking for technologies that can provide short-term benefits and that offer low risk.

One way of doing that is by starting to deploy V2X technology for projects that do not require a vast amount of V2X-equipped vehicles to provide immediate benefits. Applications with a limited vehicle fleet, such as public transportation vehicles or priority emergency vehicles can prove the benefits of V2X in cities very fast and do not require the deployment of OBUs in a large number of vehicles.

V2I also requires the installation of RSUs. Connecting an off-the-shelf RSU to a traffic signal controller is done via TCP/IP communication, which requires Ethernet cabling from the traffic signal controller all the way to the RSU. Another way to save on the number of RSUs is by choosing a traffic detection sensor with integrated RSU, like the FLIR ThermiCam V2X.

With a FLIR ThermiCam V2X for example, agencies can install a high-performance vehicle, bicycle and pedestrian detection sensor that has V2X RSU hardware embedded.

Installing a FLIR ThermiCam V2X sensor does not require Ethernet cables, because the existing cables can be re-used thanks to Broadband over Powerline communication (BPL) technology incorporated in the sensor. BPL will superimpose the TCP/IP network communication on to the power cable, similar as the home-plug system architecture. Inside the traffic controller cabinet, a communication interface will demodulate the BPL signal and provide a TCP/IP connection to the traffic controller.

Since the installation position of an above ground traffic detector or sensor is also an ideal antenna position, a V2X enabled intelligent camera can benefit from the BPL system architecture and allows a more economical installation of V2X communication on to the existing infrastructure, using existing cables.

EASY UPGRADE

The BPL interface does not only provide TCP/IP communication to the controller but also provides output and input contacts that are configurable. This means that legacy traffic controller hardware, which has an amortization of typically 20 years, does not need to be replaced or upgraded to newer versions with TCP/IP communication to be able to use V2X.

Controller upgrades are expensive. However, by assigning V2X functionalities to the output/input contacts of the BPL interface, any existing traffic controller architecture can make use of the V2X capabilities of the FLIR sensor.

CONCLUSION: V2X IS POSSIBLE TODAY

Starting with V2X in cities does not require an unsurmountable investment. Technology budgets are tight for cities and traffic control equipment usually has a lifetime of close to 20 years. That is why traffic authorities are on the lookout for attainable solutions that offer a lot more value for their money on the long term. A V2X enabled traffic sensor is such a solution. By using V2X-enabled camera detectors, cities can reduce the number of required RSUs, making the investment accountable and painless.

In the short term, there are immediate benefits with early adopter V2I applications, such as traffic signal priority for public transportation and emergency vehicles. Even with a very low adoption rate of vehicles with V2X hardware in the beginning, cities and DoTs can benefit from using V2X in their public transport busses to allow prioritization along certain routes, similar to emergency vehicles such as police, ambulance and fire trucks getting green lights when they arrive at an intersection during an emergency.

For more information about thermal imaging cameras or about this application, please visit:

www.flir.com/traffic