V2X COOPERATIVE SYSTEMS: WHAT IS IT ALL ABOUT?

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Abstract

Connected vehicles enable a wide variety of information services for drivers, road operators, car manufacturers and public authorities. New communication technologies allow for dynamic real-time information to increase driver safety and traffic efficiency, provide payment services, commercial infotainment and to enable the collection of valuable data for environmental purposes.

Key Words

Connected Vehicle

5.9 GHz DSRC

V2X
CHANGING WORLD

Technology is advancing at a rapid pace. This is seen in all industries and especially within the intelligent transportation systems industry. Technological advances in wireless communications are enabling connected vehicle services. The connected vehicle market is the service space where vehicles communicate with one another and the roadside through wireless means. It is the true implementation of the connected car. All forms of information exchange are envisioned for connected vehicles to improve safety, mobility and the environment. “V2X” is Kapsch’s vision of the connected vehicle market. V2X will continue to evolve and revolutionize the transportation industry in ways which have never been seen before. All manner of services are being provided and invented to provide more and more information to the traveler. Anything from route guidance, infotainment, mode alternatives, compliance and hazardous conditions can be relayed to the driver such that the driver can make intelligent, informed decisions about his/her route. This core data is also utilized by highway operators for managed lanes, incident detection and overall demand analysis.

Through V2X, a truly connected vehicle is being realized. Wireless technology used to transmit data into and out of the car is rapidly advancing and more options are available than at any other time before. 5.9 GHz DSRC, LTE/cellular, and even 915MHz all provide a mechanism for getting information to the driver and road operator. Each technology has its advantages and disadvantages. Selection of the most efficient and cost effective technology should be based upon the specific telematics solution being delivered to the end-user.

Figure 1: V2X Environment
WHAT IS V2X?

V2X is the combination of services utilizing bi-directional communications between vehicles and the roadside. Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication are the core communication paths utilized within the connected vehicle environment. Safety and mobility services fall into one of these categories.

V2X is based on 5.9 GHz DSRC radio communication, a two-way, short-range wireless communications technology designed especially for moving objects like vehicles. In general it allows vehicles to exchange data with other vehicles and roadside units, sensors and actors similar to Wi-Fi communication, but using efficient ad-hoc features.

5.9 GHz DSRC is based on interoperable open standards, which provides a mechanism for advanced electronic and mobile screening. Unlike cellular or satellite service, DSRC provides real-time data transfer from the vehicle to the roadside as well as increased cost savings for drivers of commercial and private vehicles because it avoids monthly service provider fees for access to the roadside. 5.9 GHz DSRC allows for nationwide interoperability for all states and all manufacturers, utilizes universal standards & prevents proprietary technology from diminishing the potential of the system such as has been seen with the existing ITS Program.

V2V focuses on those services which provide safety of life and property between vehicles. V2V extends the safety envelope around the vehicle. What this means is that unsafe conditions are realized further out from the vehicle. With V2X every car is able to sense its surroundings. It can use information about vehicles in its vicinity to calculate its current and future positions thereby creating situational awareness. This enables a number of safety services for avoiding crashes or predicting dangerous situations. Such conditions like emergency braking, left turn warning, or assisted cruise control can be identified to the driver before the driver is aware of the hazardous condition. Previous statistics have mentioned that nearly 80% of all accidents are due to human error. V2V services inform the driver of impending hazardous conditions in an attempt to avoid or circumnavigate these conditions.

V2I focuses on those services which utilize roadside infrastructure to provide not only safety services but also mobility improvement services. Similar to V2V for safety, V2I safety, provides early notification to the driver in order for the driver to react to hazardous conditions in a safe and timely manner. V2I safety services include red light warning, hazard roadway notification, and congestion warning. Commercial vehicle inspection services fall into this category as well. But V2I not only provides safety of life services but also mobility improvement services. V2I in particular can improve traffic efficiency and support eco-friendly driving. Depending on the traffic load, V2X roadside units can issue advisories to drivers recommending alternate routes or offering parking facilities near public transportation stations supporting multi-modal transportation. V2X equipped traffic lights can inform drivers about the time until the next traffic signal change or indicate the optimum speed to pass the intersection with green light. These services provide relevant information to the driver based on his or her route. Information such as
congestion, travel times, traveler information, weather, multi-modal information, and available parking. Essentially, any information a roadway operator would like to display to the driver regarding a corridor or destination.

The US Department of Transportation’s Connected Vehicle program is specifically investigating the viability of V2V and V2I safety services. A large test bed in Ann Arbor, MI is currently underway with 3,000 plus light-duty and heavy-duty vehicles. Much of the data will be used to provide empirical evidence supporting the need of V2V and V2I safety services powered by 5.9 GHz DSRC communications. National Highway Transportation and Safety Administration plans on providing a recommendation for rulemaking for light duty vehicles in late 2013 and heavy-duty vehicles in 2014. This would trigger automakers to begin manufacturing new vehicles with 5.9 units although the actual roll out date for these vehicles is undetermined at this time. Europe is following a similar model but a bit more aggressively. 12 automakers have signed an agreement to begin including 5.9 GHz DSRC units as early as the 2015 model year. The focus is the same as the US which is initially utilizing the units for V2V and V2I safety.

Kapsch has been a major participant in the development of 5.9 GHz DSRC and the connected vehicle market in both the US and Europe. Kapsch solutions focus on standards compliant devices which meet the needs of the research and road operator requirements. An early adopter of V2X services will be commercial vehicles. Commercial vehicle compliance is a growing problem within the US as freight traffic increases and state resources decreases. Intelligent compliance and efficiency services are needed to ensure safe commercial vehicle operations.

**V2X FOR COMMERCIAL VEHICLES**

The Federal Motor Carrier Safety Association (FMCSA) and Federal Highway Administration (FHA) forecast increases in commercial vehicle traffic will strain capacity and adversely affect highway safety, mobility, and the environment over the next 25 years. While transportation infrastructure capacity is static, highway traffic continues to grow so the need to be more efficient using technology is critical to meet growing demand. The effects of growing demand and limited capacity are felt as congestion, upward pressure on CV transportation prices, and less reliable trip times as carriers struggle to meet delivery windows(1). In addition, the dependence on foreign oil use is disproportionate in the U.S. This dependence means higher costs and more market volatility.

Studies by the Environmental Protection Agency (EPA) suggest that increasing average arterial speeds from 10 to 20 mph, for example, reduces HC emissions by roughly 40 percent and NOx emissions by roughly 20 percent. The Energy Information Administration predicts that in the coming years transportation sector CO2 emissions will grow faster than residential, commercial, and industrial sector CO2 emissions.

How does V2X help with the commercial vehicle problem? By adding secure, V2I communications at fixed, mobile, and virtual weigh stations. 5.9 equipped stations are able to
collect real-time driver, vehicle, fleet, and cargo information at mainline speeds keeping the truck moving safely. Any discrepancies found, then the truck may be pulled into the weigh station for further inspection. V2X does not replace existing systems such as weigh-in-motion, automatic license plate readers, US DOT Number readers, or dimensioning services. V2X is meant to complement these services with data collection which cannot be achieved through technology which only identifies the outer portions of the truck. Cameras and lasers are unable to identify the driver of the vehicle, driver’s hours of service or the cargo manifest.

The benefits to commercial vehicles drivers are numerous:

- Vehicles equipped with a V2X enabled by 5.9 GHz device will be able to communicate further and faster for all information including inspection stations compared to ITS standards. (up to 1 km (.6214 miles) distance line of sight, 12-40 time faster data rate).
- A V2X in-vehicle device enables real time integration with the weigh station for verifying and authenticating the identity of the driver, vehicle condition data, hours of service, highway data collection (speed, volumes, class, weight) for planning, programming & asset management, 24/7 data collection, storage and retrieval, real time data transmission/network, and weather information for traffic management/road conditions.
- V2X commercial vehicle inspection will provide more efficient assessment operations. State resources will be maximized using the system. The system will identify key information for officers to intelligently and quickly identify trucks with faults. This allows trucks without discrepancies to by-pass or move through the station more quickly.
- Fleets can save upwards of a billion US dollars annually through the use of electronic fleet credentials which can be stored on the V2X transponder. Currently, fleets are required to maintain paper copies of insurance, registration, use taxes, and state operations authorizations within the truck cab. Regulations are currently being reviewed to allow electronic versions of these documents to be maintained in the cab.
- The device will enable transfer of vehicle diagnostic information both for the carrier and the operations center. V2X in-vehicle components connect to the vehicle’s CANbus to collect safety critical data elements available such as brake temperature, ABS status, vehicle fault codes, and light status. Available data elements are based on vehicle model. The CANbus also provides valuable input to the V2X module calculating hours of service, speed monitoring, and driver behaviors for fleet telematics. For example, this information can be continuously monitored whenever the commercial vehicle passes by the roadside infrastructure the weigh station corridor. Thus, vehicles can be frequently monitored without installing additional inspection sites or being diverted to inspection stations.
- Implementation of a V2X roadside at key locations such as weigh stations, electronic toll collection stations, have the potential to reduce fuel use and NOx emissions as a result of reduced queuing, open road tolling and increased, steady speeds. A single stop at a weigh station will cost a driver or fleet over $8 and 1 gallon of fuel.

The process of commercial vehicle inspection utilizing V2X is a fairly simplistic approach. A V2X system consists of three main segments: in-vehicle, roadside, back office. The in-vehicle
segment encompasses the components and processes within the vehicle itself. Typically the components consist of a 5.9 GHz DSRC transponder, a tablet with a human machine interface (HMI), and a connection to the vehicle’s CANbus. Driver data such as personal identification, hours of service can be manually entered or entered through an automated process. The HMI tablet is merely a hands free display for communicating with the driver if necessary. The roadside segment links the roadway to the back office. The roadside components typically consist of 5.9 roadside transceivers, controllers and processes, and supporting cabinet hardware. The roadside configuration prior to a weigh station consists of two transceiver stations or gantries. These gantries are typically positioned 2/10 of a mile apart. The first gantry, known as the Advanced gantry, conducts the data collection. The second gantry, known as the In-Cab notification gantry, provides the weigh station screening or by-pass result to the driver. The back office segment provides the interface for enforcement officers to view screening results, query federal and state databases, and linkages to other V2X services such as traveler information.

At the Advanced gantry, the in-vehicle V2X 5.9 GHz DSRC transponder provides driver and vehicle information to the roadside segment. The roadside forwards this data on to the back office for query with the applicable federal and state databases. The roadside will also send the latest fleet credentials back down to the transponder, ensuring the most up to date credentials are loaded onto the transponder.
While the truck is traveling from the Advanced gantry to the ICN gantry, the back office is querying the federal and state level databases. These databases, such as the Commercial Vehicle Inspection and Enforcement Window (CVIEW), maintain the fleet level credentials of trucks. It is these databases that the inspection officers refer to for enforcement of commercial vehicles. Once a query is complete, an exception based result is returned to the inspection officers user screen. Business rules adjudicated at installation time determine the by-pass requirements for the weigh station. The by-pass result is queued for the truck when it reaches the ICN gantry.

At the ICN notification gantry, the by-pass result is transmitted to the in-vehicle transponder and the information is relayed to the driver. The driver will now have instructions on whether or not he/she is allowed to by-pass the station. The result may contain a WIM result if the station was equipped, the clearance message, and any other information relevant to the weigh station or the roadway operator. If the driver is allowed to by-pass, the weigh station screening is complete and the driver may continue down the roadway. If the by-pass result was negative, the driver would follow instructions to pull into the weigh station.

Commercial vehicle V2X is not only used for safety and compliance of commercial vehicles. It can also be used for driver and fleet services such as fleet telematics or traveler information. One key service that is utilized still provides a safety aspect. This is commercial vehicle truck parking availability. Kapsch TrafficCom North America in collaboration with HNTB and the Michigan DOT (MDOT) are delivering a Truck Parking Connected-Vehicle System at five sites along the I-94 corridor in Michigan. The Kapsch solution consists of a 5.9 GHz Dedicated Short Range Communications (DSRC) in-vehicle unit and roadside equipment with customized application software that together provide drivers with real-time truck parking availability information from MDOT facilities and private truck stops. This system is the first truck parking system to be deployed in North America utilizing 5.9 GHz -- the chosen technology for the US DOT Connected Vehicle Safety Pilot program. The system will be fully delivered in December 2013. The contract has a rather low volume but a high strategic significance.
The in-vehicle segment of the Kapsch solution will consist of a location-based application running on the TS3306 5.9 GHz DSRC On-Board Unit and a truck parking application user interface hosted on an off-the-shelf Android-based tablet. The roadside segment will feature the MTX-9450 5.9 GHz DSRC WAVE Transceiver, interfacing with MDOT’s Advanced Traffic Management System, which will furnish real-time truck parking availability data.

The benefits are multi-faceted. As drivers are planning a route it is critical that they know or identify where along their route there is available parking near the time their daily hours of service limit will expire. Knowing where available parking is will prevent drivers from extending their service day illegally and reducing the threat of a fatigued driver induced accident. Parking in approved parking lots prevents the incidences of private vehicle crashes into parked vehicles. Many times a commercial vehicle driver will simply pull over and park on the side of the road or on-ramp. Inattentive drivers have crashed into these parked vehicles causing numerous fatalities. Finally, it affords the driver a reduced crime area to park and rest. There have been instances, such as the incident killing Jason Rivenburg which created Jason’s Law, which have put drivers into precarious or fatal situations. Having a safe, secure area to rest and sleep is essential to the wellbeing of the commercial vehicle driving force.

**SUMMARY**

V2X services offer a multi-service platform for active safety systems for V2V and V2I. It further provides beneficial mobility, environmental, compliance and efficiency solutions for roadway users. V2X will enable a truly connected vehicle market which will usher in the next age of transportation. An age of active information exchange, increased vehicular safety, efficient mobility and environmental friendly vehicular travel.
REFERENCES