The primary function of CV, not unlike many other transportation systems, is the communications component. For the CV system to work effectively, data communications are required from vehicle to vehicle; and vehicle to roadside.

In the previous issue, we introduced the concepts, goals and objectives of the Connected Vehicle (CV) program. In this article, we take a look at how we got here, and how the USDOT is planning implementation of this program.

To recap, Connected Vehicle refers to the ability of vehicles to communicate wirelessly with other vehicles; with roadway infrastructure, such as traffic signals, to support a range of safety, mobility and environmental applications. Vehicles include autos, light and heavy trucks, emergency vehicles and transit vehicles.

The application also extends to aftermarket devices that could be added to vehicles. This would facilitate a more rapid penetration into the marketplace. In addition, pedestrians, motorcycles, and cyclists, may also be users, which could make these vulnerable users more visible to surrounding traffic.

A Brief History

From the Connected Vehicle Trade Association (CVTA), the following background of the CV program was outlined:

- Automotive Multimedia Interface Collaboration (AMI-C) was formed by 12 automakers in 2001 and developed 3,500 pages of specifications for in-vehicle communications. At the completion of this work, the automakers wanted to work on a common ex-vehicle communication system.
- The VII (Vehicle Infrastructure Integration) Consortium was formed in 2004 and signed a Cooperative Agreement with the USDOT for $50+ million to develop and test a generic DSRC communications solution.
- The automakers asked that a non-profit trade association be formed to bring together all the various industry sectors needed to build out a complete system. CVTA was incorporated in early 2005 with 12 founding companies from different industries.
- In 2006-2008, CVTA and the Center for Automotive Research developed the Connected Vehicle Proving Center, now a part of U of M, at Dearborn, MI.
- In 2009, with the conclusion of the majority of the pre-competitive research by the VIIC, and realizing the need to include cellular and WiFi communication protocols, the US DOT initiative was renamed IntelliDrive®. In 2011 the US DOT renamed IntelliDrive to the Connected Vehicle Initiatives.
- National Highway Traffic Safety Administration (NHTSA) will begin a deployment decision process in 2013 that could lead to a rulemaking that would require all vehicles to communicate via DSRC specific Vehicle to Vehicle safety messages. Commercial Vehicles will likely be mandated to communicate safety information in 2014-15 timeframe.

The communications methodology must be reliable, secure and cost-effective.

Communications Protocols under consideration include:

- Cellular – Diagnostics and Communications
- Wi-Fi – Information and Entertainment
- DSRC – Safety Communications
- Near Field – Bluetooth, Zigbee, etc.

To meet a wide-range of user needs, the devices are anticipated to be:

- Embedded – built into the car
- Aftermarket – added after sale
- Nomadic – carried in by driver/passerby

Security and Privacy

It goes without saying that security and privacy are key concerns for all involved with this program. The public documents address privacy this way:

- “DOT is committed to fostering a connected vehicle environment that ensures stakeholder and operational needs are met while at the same time protecting consumers appropriately from unwarranted privacy risks.
  - The connected vehicle environment will incorporate appropriate privacy controls; transparency; individual participation and redress; purpose specification; limitations on use of information; data minimization and retention; data quality and integrity; security; and accountability and auditing. For example:
    - The environment must provide consumers with appropriate advance notice of and, for opt-in systems, opportunity to provide consent for information collection, use, access, maintenance, security and disposal.
    - The environment will limit the collection and retention of personally identifiable information to the minimum necessary to support stakeholder and operational needs.
  - As the federal role and other critical aspects of connected vehicle regulation and/or implementation are further defined, DOT will document publicly the privacy risks and controls applicable to the system and users.
- The system must be secure to an appropriate level. The system will:
  - Ensure secure and trusted information exchange among users
  - Provide protection from hacking and malicious behavior
  - Maintain data integrity.”

When discussing ‘Implementation and Oversight’, USDOT goes on to say:

- “An organization will be required to manage and operate the system responsible for ensuring security and other functions associated with the proper operation of the connected vehicle system.

Continued on page 26
The following statistics are vital to appreciating the depth and breadth of the implementation issues. For CV to be effective, a significant market penetration is required. From “Deployment Readiness ITS Joint Program Office U.S. Department of Transportation, Research and Innovative Technology Administration AASHTO Connected Vehicle Infrastructure Deployment Analysis – Final Report” comes the following review.

**Autos**

- The U.S. auto industry produces approximately 15 million light passenger vehicles and heavy vehicles each year. The overall population of such vehicles is relatively stable at about 200 million units, which means that about 15 million vehicles are also retired each year. Vehicles last in the fleet an average of 12 years, although this average includes vehicles that are destroyed the day they are purchased, and other vehicles that are more than 50 years old.
- The relatively long average lifespan results in some interesting market dynamics for passenger vehicles, and consequently complex dynamics for the deployment of Connected Vehicle equipment. Specifically, any fixed equipment (including, for example, Connected Vehicle OBEs) sold on a passenger vehicle will be in use for an average of 12 years. The passenger vehicle market is also marked by rather long development cycles. A new vehicle platform takes about four years to develop. Typically the components used in the vehicle are frozen about one year into the development cycle. Given the comparatively fast lifecycle for consumer electronics equipment (about 18 months) this means that consumer electronics related equipment embedded in a vehicle (phone, radio, media interface, navigation, etc.) will be about 15 years (10 generations) old by the time the average vehicle is retired. In other words, the radios and other equipment are already a few years old before they have even reached the showroom floor.
- A good example of this issue was the OnStar system, which initially used an analog cellular telephone. The first vehicles with this system were sold around 1997. In early 2003 the FCC announced a five-year sunset, after which the cellular providers would no longer be required to support the analog mobile phone system. Despite a request for delay, the so-called analog sunset became effective in February 2008. Shortly thereafter most carriers ceased providing analog mobile phone service. At that point at least five years of GM production vehicles and about three years of Lexus vehicles were on the road using this system. The OnStar systems in those vehicles became obsolete on Feb 18, 2008.
- Similar issues have occurred with iPod plugs, USB plugs, memory cards, navigation databases, hands-free systems, and other technological conveniences manufactured into passenger vehicles.
- In general, the passenger vehicle industry is also exceedingly cost conscious. Each vehicle platform is based on a production cost budget, and any extra cost either increases the price or reduces the profitability of the vehicle. As a result, vehicle manufacturers weigh the cost of every part against the need for that part, or the estimated value to be perceived by a prospective buyer. Vehicle executives are highly wary of adding cost without proof that the added value provided by that cost will pay off. The result of this situation is that it is challenging to add new equipment to a vehicle. Typically the demand for the equipment must be obvious in the marketplace before such equipment will be embedded in the design. Many examples of this exist in the history of the motor vehicle. The first car radios appeared in about 1928, eight years after they were available for home use. In 1962 Philips invented the compact audio cassette medium for audio storage, introducing it in Europe in August 1963, and then in the United States in November 1964. However, it was not until about 1974 that cassette players were available for cars, and sometime after that before the cassette player was standard equipment.
- As a result, deploying Connected Vehicle equipment in vehicles requires that the system provides clear value to the vehicle user (such that a vehicle manufacturer can be sure that the added feature will provide value to the customer commensurate with the cost of the equipment). This value must be realizable by customers in a time frame that is relevant to their ownership of the vehicles (that is, they must realize its value while they own the car, and preferably when they are considering their vehicle purchase). These considerations are generally in conflict with the dynamics of the market. The time required to achieve sufficient penetration in the fleet, such that some benefits (value) are obvious to the owner, is longer than that which would motivate the installation (and cost) of the equipment.

**Medium and Heavy Vehicles**

- There are approximately nine million medium and heavy **Continued on page 28**
The Connected Vehicle Part II - Implementation . . .

Continued from page 26

vehicles on the road today (FHWA 2006), and each year about 260,000 new heavy vehicles are manufactured (the production rates for 2009 were substantially below normal levels due to economic factors). In general, the population of medium and heavy vehicles is expected to rise at a rate of about 2% per year. More than 700,000 of the heavy vehicles are private buses and motor coaches.

- Truck life spans are typically quoted in miles as opposed to years (about 1.2 million miles), although using estimates of annual vehicle miles traveled for heavy trucks (an average of 130 thousand miles per year) indicates an average life span of about ten years.

- Heavy trucks generally use multiplex networks for gauges and other electronics, and generally they are configured to support a variety of aftermarket installed electronic equipment. The typical large truck also includes physical provisions for such equipment. As a result, it is much easier to add equipment to a truck, either as original equipment or as aftermarket equipment than it is to add such equipment to a passenger vehicle.

- While comprising less than four percent of the overall vehicle population, the heavy vehicle industry is highly aware of the benefits and costs of technology, consequently they are much more proactive in making changes. The industry tends to support retrofit configuration much more easily than the passenger vehicle market, so it is a strong candidate for supporting early adoption of Connected Vehicle systems. Commercial vehicle operators have also demonstrated a willingness to participate in government-sponsored technology initiatives where it will enhance their efficiency or productivity. Today, for example, about 400,000 trucks use PrePass and NORPASS tags for electronic pre-clearance at weight stations and ports-of-entry.

- It should be noted that the Federal Motor Carrier Safety Administration (FMCSA) has recently published a proposed rulemaking requiring Electronic On-Board Recorders (EOBRs) for the purposes of recording drivers’ hours. EOBRs have the potential to not only record drivers’ hours, but to act as a potential enabling platform for other Connected Vehicle applications, such as safety checks, parking capacity prediction, and other important communications needs.

Transit Vehicles

- According to 2006 data, there about 70,000 transit buses in the United States. There are also over 400,000 school buses. Transit buses account for about 2.2 billion vehicle miles per year, and according to the Federal Transit Administration (FTA) have a useful life of about 12 years. Transit vehicles are typically highly-customized with a variety of electronic equipment selected by transit operators to improve the monitoring of bus operations or better reporting of passenger usage data. All bus transit vehicles will fall under the same Connected Vehicle standards.

- Transit vehicles represent a good target for early adoption of Connected Vehicle systems, as long as they can be shown to provide value to the operator. The cost of the equipment is relatively modest in comparison with other electronic systems typically deployed, so deployment of such equipment will generally depend on proving some level of operational benefits.

Emergency Vehicles

- There are about 75,000 fire trucks, 40,000 ambulances and about 90,000 police vehicles in the United States. There is limited information available about exactly how many emergency vehicles are produced each year. In general heavy fire equipment has a long lifespan, in some cases about 20-25 years. Fire equipment is typically built to order, and older equipment is often sold from wealthier municipalities to less wealthy municipalities as it ages. Ambulance equipment tends to follow a slightly faster obsolescence cycle as newer medical care and trauma equipment is developed. The average age of a police cruiser appears to be about four years after which specialized equipment is removed, and the police cars are sold publicly. This implies that about 25,000 new police vehicles are manufactured each year. Police vehicles are typically special models of conventional production passenger vehicles. In all instances, emergency vehicles are equipped with specialized communications and other electronic equipment.

Connected Vehicle Market Growth Projections

- Projections of future market growth for Connected Vehicle systems are a core component of this deployment assessment. These projections depend heavily, however, on the presumed underlying market mechanics. Unlike, for example, safety-related anti-lock braking system (ABS) and traction control systems, V2V safety systems are fundamentally cooperative systems that require almost ubiquitous coverage for effectiveness. In contrast, airbags followed an initial organic curve that was then accelerated via mandate. The intent of this discussion is to describe the possible Connected Vehicle deployment scenarios (e.g. market-driven, new vehicle mandate, retrofit mandate) based on previous market experiences, in light of the deployment motivations and underlying market conditions.

- The long life and large base of light vehicles in the U.S. means that change in the fleet occurs slowly. At the production rate of 15 million units per year, the fleet is theoretically replaced every 13 years. However, since some vehicles are retired early, and some vehicles last longer than the average, new features are not reflected in the overall population as quickly as might be expected. New features are also not adopted immediately across the entire annual build, so the rate of adoption of a feature in the vehicle population can lag substantially behind the introduction of such a new feature.”

To meet CV program objectives, there is a big hill to climb to introduce CV into the marketplace. With support from the auto industry, and the enormous safety element, CV offers a good chance of winning the day.

Summary

To date this program has garnered much attention at the senior DOT levels. At the same time, it has gone mostly unnoticed at the ‘street’ level. You need to be informed about this program. Make no mistake; it will have a profound effect on agencies and private companies when it receives approval, proceeds to implementation and becomes operational.

Watch http://www.youtube.com/watch?feature=player_embedded&v=RqC0a9bYQCE for a great overview of the program and the associated test beds. It is very informative.

Something to think about!