Enabling Accelerated Installation of Aftermarket On-Board Equipment for Connected Vehicles

TASK 2: VENDOR/MARKET READINESS REPORT

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Table of Contents

List of Tables

List of Figures

Executive Summary

This Vendor/Market Readiness report is the second milestone in the University of Virginia's Enabling Accelerated Installation of Aftermarket On-Board Equipment (OBE) for Connected Vehicles Project, conducted under the umbrella of Cooperative Transportation System Pooled Fund Study. The report summarizes industry's views of the current market readiness through interviews conducted with OEM, Tier 1, and Tier 2 experts. In addition, the availability of OBE hardware manufacturers to provide aftermarket dynamic configurable multi-band OBE product has been documented. Finally, the report captures consumer insight through focus groups on product attributes, unmet consumer needs, aftermarket OBE pricing, time to market for OBE applications, and where to distribute aftermarket OBE products.

1 Introduction

1.1 Project Goals

The goal of this project is to evaluate the potential approaches for accelerating the introduction of aftermarket OBE units to the vehicle fleet. Without a rapid deployment, the safety, mobility, and convenience benefits of the USDOT Connected Vehicle Research Program will not be realized. It is widely recognized that deployment on new vehicles alone will not provide the penetration required for maximum benefit. Therefore, aftermarket deployment is critical. The combination of aftermarket and new vehicle sales equipped with 5.9 GHz DSRC or other communication technologies will more effectively produce benefits to the consumers. Furthermore, from the consumer perspective, only a system that provides immediate benefits will offer value. Without value, the envisioned USDOT Connected Vehicles Program systems and applications will not be accepted by consumers on its own merits.

In this vendor/market readiness report, the thoughts of the industry are communicated, along with the current availability of devices and the ability for industry to manufacture OBE equipment. In addition, consumer opinions with regards to product features and price points are documented.

1.2 Report Layout

In Chapter 2 the opinion of industry is broken into three sections: OEMs, Tier 1 suppliers, and Tier 2 suppliers. Each of the sections will provide insight on the challenges, opportunities, technologies, features, and product readiness of aftermarket OBE as expressed by industry experts. A summary of the key findings from all three groups will conclude the chapter.

Chapter 3 provides an analysis of onboard equipment beginning with background information with regards to the aftermarket industry, followed by an overview of components related to aftermarket products. Next, the availability of key technologies required for aftermarket products will be discussed. An assessment of potential aftermarket OBE products will be reviewed. Finally, a summary of the readiness of aftermarket OBE hardware will complete the chapter.

Chapter 4 will provide perspectives from surveyed consumers based on focus group studies with regards to product attributes, unmet customer needs, OBE hardware pricing, thoughts on when product features would come to market, and where consumers would prefer to purchase, as well as service OBE hardware.

Chapter 5 provides conclusions based upon the interviews conducted, the OBE hardware analysis, focus group events, and expert judgment.

2 Interviews

The research team identified a broad list of industrial experts to interview and solicit inputs from several different sectors of the automobile and technology industries. Among those that provided documented feedback, the group of experts included five OEMs, eight Tier 1 Suppliers, and ten Tier 2 Suppliers. This chapter will share their opinions on challenges, opportunities, technology, features, and product availability for the aftermarket onboard equipment market. Section 2.1 will focus on insight from automotive manufacturers. In section 2.2 Tier 1 suppliers' feedback will be discussed. Section 2.3 will provide reactions from Tier 2 suppliers. Section 2.4 will summarize key insights from all three groups.

2.1 OEMs (Automotive Manufacturers)

Automotive manufacturers have committed considerable resources in research and development related to vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) technologies to date. They are steadfast in developing next generation vehicle technologies to improve safety and security while enhancing efficiency, convenience, and comfort. All of the OEMs interviewed embrace the development and deployment of intelligent transportation systems and were keen to share their thoughts on challenges, opportunities, technology, features, and product availability. In the next few paragraphs we will discuss each area in greater detail.

Challenges will exist with any new product or system introduced into the market, and V2V/V2I systems are no exception. OEMs conveyed four main areas of concern with regards to the acceleration of aftermarket OBE into the market. The first challenge is the deployment of the infrastructure to support OBE hardware. The second concern is the stability and reliability of communication coverage over the majority of United States roads. The third concern revolves around security and the ability for V2V/V2I systems to authenticate users instantaneously 100% of the time. The final challenge is related to a viable business model where OEMs can offer a product that delivers required features and functions to the consumer profitably. It is expected that collaboration and compromise among key stakeholders will identify viable solutions that can be implemented.

With regards to opportunities that the OEMs identified, there are three key areas to assist in the acceleration of OBE deployment. The main consensus to accelerate deployment is a government mandate that will establish basic principles required for V2V and V2I systems and allow industry to work together on developing the appropriate products for the market. Another opportunity is the development of industry standards to help with reliability or interoperability issues. Well defined standards assist in the product development phase and reduce the time to deliver a product to market. The third area with potential is incentives from the insurance industry for the purchase and installation of OBE hardware. The customer receives the short

term benefit by subsidizing the cost of the OBE hardware and everyone benefits from the long term gains associated with the reduction in accidents, elimination of fatalities, less congestion, and a low carbon society.

In regards to wireless communication technology associated with V2V and V2I products the OEMs are aligned with the type of communication technologies that are suitable for given applications. For safety applications, 5.9 GHz DSRC is currently the appropriate technology. For efficiency and comfort applications, 3G/4G/LTE are the technology of preference. Wi-Fi could be used for some comfort applications with the understanding that connection to Wi-Fi is limited to certain scenarios and not viable during typical driving modes. Both two-way satellite and Bluetooth wireless communication are not practical technologies for the primary communication of V2V and V2I systems.

During the discussion of aftermarket OBE features the OEMs provided insight on a tiered approach to deploying features and functions. Initial systems should focus on safety applications that are passive and provide the driver relevant information or warnings of upcoming events. Efficiency and comfort applications can be introduced at the same time based on consumer interest and acceptance. The subsequent generation of products should continue to advance the safety features from passive to a more active role to warn drivers of upcoming events. Furthermore, as the industry takes action on consumer feedback from products and applications in the field, the number of efficiency and comfort applications available to the consumer will increase greatly.

In looking at the ability to manufacture and deliver aftermarket OBE to the market the majority of OEMs envision a three to four year product delivery plan. This assumption takes for granted that the major challenges discussed earlier in this report have been addressed and all stakeholders are in agreement on practical solutions. In general, the OEMs believe the supply base has feasible product delivery plans to support the OBE market and there is no design or manufacturing limitations at this time.

2.2 Tier 1 Suppliers

Similar to OEMs, the Tier 1 Suppliers are investing significant time and resources in developing technologies related to V2V and V2I systems. They have aligned goals with the OEMs to deliver advanced safety and security systems. In addition to safety and security, they plan to improve or add efficiency and comfort features as well. Through the interviews the Tier 1 Suppliers provided input on challenges, opportunities, technology, product features, and product availability. Even though most of the feedback from the interviews aligned with the OEMs opinion, there are some additional insights we will discuss in the following paragraphs.

The four main concerns of the Tier 1 suppliers matched with that of the OEMs - infrastructure deployment, communication coverage, security, and business case. In addition, there were two more concerns frequently discussed with the group. The first item is bandwidth limitations of the wireless communication system in cases where too many users in a particular

area overload the network. In current cellular networks this scenario can happen and some percentage of the users lose cellular service. Loss of service may be tolerable for cellular consumers since their usage is typically not safety critical, but for V2V and V2I systems a loss of communication would be unacceptable. The second concern mentioned is driver distraction for the consumer with new V2V and V2I systems. It is imperative that government and industry collaborate on the user experience related to V2V and V2I systems in order to minimize the possibility of driver distraction when consumers interact with these safety systems. Fortunately, projects like the Safety Pilot/Model Deployment program will provide a collaborative environment for all stakeholders to observe, document, and address the major challenges identified.

The insight from Tier 1 Suppliers with regards to opportunities echoed the opinion of the OEMs. A government mandate, industry standards, and insurance industry incentives are great initiatives to accelerate an aftermarket deployment. The key to success is for each initiative to deliver resolution to some degree during the aftermarket deployment phase. Another opportunity discussed by the Tier 1 Suppliers involves the experience of the consumer. Products that satisfy customer expectations such as ease of use, performance, and perceived value will be successful in the market. It would be easy to say that industry is the only stakeholder responsible for addressing the experience of the consumer, and in most markets this is true, but for the V2V and V2I market where safety is so critical all stakeholders have a responsibility to contribute to an acceptable consumer experience.

In evaluating wireless communication technology the majority of the Tier 1 Suppliers are in agreement that 5.9 GHz DSRC is the primary communication technology for safety applications. There is also consensus with efficiency and comfort applications using 3G/4G/LTE communication. A few responses indicated the potential of future LTE networks to support some of the safety applications planned for DSRC, but not completely replace DSRC as the primary communication technology. Additional research would be required to understand the complete role of the LTE network and what applications LTE is suitable for. Tier 1 Suppliers agree with OEMs that Wi-Fi would be appropriate for comfort features, but view it as impractical for V2V systems during typical driving modes. Two-way satellite and Bluetooth wireless communications are also viewed by the group as unlikely technologies for primary communication in V2V and V2I systems.

With regards to aftermarket OBE features, the Tier 1 Suppliers envision safety, efficiency, and comfort applications all being available to the consumer. They all agree that safety features should be standard, with efficiency and comfort features being optional. The thought behind standard and optional features is based on the assumption that the majority of consumers will be more interested in efficiency and comfort than safety. This should drive demand in purchasing optional features, which in turn should provide an additional source of revenue beyond the purchase of the base hardware.

Tier 1 Suppliers have accounted for the ability to manufacture and deliver aftermarket OBE in their product delivery plan. The majority of the Tier 1 Suppliers refrained from sharing their production timing for V2V and V2I systems mainly due to proprietary information. Some were willing to provide their opinions, which correlated with the observation from OEMs for a three to four year product delivery plan. Tier 1 Suppliers are confident that the supply base can achieve their product delivery plan.

2.3 Tier 2 Suppliers

In support of the OEMs and Tier 1 Suppliers, the Tier 2 Suppliers are devoting considerable time and resources to developing new components or enhancing existing components to advance the development of V2V and V2I systems. They are in a unique position to leverage technologies and products designed for adjacent industries to accelerate the product development process for the automotive industry. During the interview process the Tier 2 Suppliers provided similar feedback on challenges, opportunities, technology, OBE features, and product availability. The insight received is comparable to the other two group interviews with a few new points to be examined.

Beginning with challenges, the Tier 2 Suppliers were completely aligned with the Tier 1 Suppliers concerns of infrastructure deployment, communication coverage, security, business case, bandwidth limitations, and driver distraction. Of the six areas mentioned, the Tier 2 Suppliers view infrastructure deployment, communication coverage, and the lack of business case as top concerns for V2V and V2I systems. This group identified liability as an additional concern. Due to the nature of the safety systems being discussed, a few of the Tier 2 Suppliers viewed liability as an area where government and industry need to work in partnership. They believe collaboration between industry and government is vital when developing potential solutions for all of the challenges.

The opportunities shared by the Tier 2 Suppliers were again completely in line with the views of Tier 1 Suppliers. This alignment once again demonstrates how well the industry works together to achieve common goals and initiatives. They are certain that the best opportunities to accelerate deployment lie in the area of a government mandate, release of industry standards, participation by the insurance industry, and a successful consumer experience. The Tier 2 Suppliers believe additional initiatives will surface as plans are developed and executed for the main opportunities identified.

In reviewing wireless communication technology with this group there is no difference in opinions of the OEMs or Tier 1 Suppliers. The use of 5.9 GHz DSRC for safety applications and 3G/4G/LTE for efficiency and comfort applications show the most promise for accelerated deployment. Several of the suppliers added that as the capability of the LTE network evolves over time safety features could leverage these advancements. Tier 2 Suppliers provided the same insights as the other two groups with regards to Wi-Fi, two-way satellite, and Bluetooth.

The Tier 2 Suppliers believe aftermarket OBE safety features should be the primary focus

with regards to delivering applications to the market. The reason for this is that the efficiency and comfort applications have been part of the mobile device market since the introduction of the smartphone and implementation of these type of features into OBE hardware will require much less time than safety features. Due to the different development times, they are convinced that efficiency and comfort features are ready and will continue to evolve for deployment, while safety features are being implemented and offered.

With regards to the ability to manufacture and deliver aftermarket OBE the Tier 2 Suppliers are the most confident in having components ready for OEMs and Tier 1 Suppliers. The majority of suppliers believe one to two year product delivery plans are attainable for the components they plan to develop for the market. This confidence is derived from their ability to leverage technology and components developed for other industries, which reduces development and deployment times.

2.4 Summary of Interviews

In looking at all three groups as a whole there is admirable alignment among each of them with regards to the five topics we discussed. In terms of industry's view of accelerating deployment of aftermarket OBE hardware there is consensus on challenges, opportunities, technology, OBE features, and product availability. Having consensus is the first step to building a solid development plan. It is important for government and all other stakeholders to come to the same level of consensus with industry in order to achieve the goal of accelerating the deployment of OBE into the market and realizing the benefits of Connected Vehicles. From the view point of industry they are committed and appear to be willing to work with all stakeholders to achieve the goal.

3 OBE Hardware Analysis

3.1 Background

To discuss the OBE hardware availability, we suggest starting with a broader perspective. Aftermarket can come in many forms and levels of capabilities, which will be tailored to the preference of customers and visions of marketers that are built on viable business cases. For example,

- Value-added subscription services to provide real-time traffic information are being offered via portable navigation devices (PND).
- Applications can be purchased and downloaded onto cellular phones to execute various convenience and entertainment services.
- Nokia's Terminal Mode[i] approach is to enable users to run smart phone applications with built-in vehicle interface and to facilitate creations of new services and applications with the same platform on the phones or in the cars.
- USDOT's Safety Pilot Program is in the process of developing and implementing selective types of aftermarket devices that can perform safety functions, such as curve speed warning (CSW) and emergency electronic braking light (EEBL), based on vehicle-to-infrastructure and vehicle-to-vehicle communication via Dedicated Short-Range Communications (DSRC).

3.2 Aftermarket Components

To help assess the availability of on-board aftermarket devices, it is helpful to dissect into the envisioned functionality and components of an aftermarket device. Essentially, an aftermarket on-board equipment (OBE) or device (OBD) includes the following components:

- Wireless Communication links
  This is central to the operational concepts of connected vehicles, in which wireless communication links enable the exchange of data and empower the applications for safety, mobility, environment, comfort, convenience, etc.
- Interface
  The most common manner of interfacing with the drivers/users are provided via visual and auditory messages, but haptic or other means to offer sensory inputs to users may also be considered.
- Application/Processing
  Depending on the system architecture, a varying degree of processing power is needed and it resides within the OBE/OBD.
- Data Storage
  Depending on the system architecture, a varying degree of data storage capability will reside within the OBE.

3.3 Availability of Key Technology Components

A general review is provided below to assess the availability of technical components that are required to construct aftermarket devices:

- Communication links

  The wireless communication links that have been discussed or deployed for Connected Vehicles usage includes Bluetooth, Wi-Fi, DSRC, Cellular, Radio, and Satellite, and Infrared.. Almost all of these technological elements are very mature and in mass production, except for DSRC. With ongoing evaluation and validation activities conducted by industry and government DSRC technology will be fine tuned and ready for initial deployment. Government regulation may help to speed up its process for maturity and mass production.

- Sensor

  A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. For example, a Forward Collision Warning system will typically use a forward-looking sensor mounted at the front of the host vehicle that detects targets (other vehicles or objects) ahead of the host vehicle and in its field of view. There has been tremendous progress in this area, and the market is generally ready to offer sensors to be coupled with aftermarket devices if needed.

- Global Navigation Satellite System

  Providing highly accurate positioning information by means of Global Navigation Satellite System (e.g. GPS) is important for ITS applications, especially crucial for time-critical active safety applications. Achieving lane-level precision may be necessary for lane change warning or intersection collision warning.

- Interface

  In recent years, automakers have implemented and offered a number of in-vehicle features, including comfort and convenience applications such as Telematics Services offered by OnStar[ii], Ford Sync[iii] and similar systems. In addition, safety systems are increasingly available to provide lane-departure warning and prevention, pedestrian alerts, blind spot warning, frontal collision warning and braking assist. It suffices to say that the state-of-the-art in-vehicle interface, as provided by OEMs today, will have the capabilities to handle the required driver interaction in aftermarket devices if they can be adopted appropriately for the functionality served by aftermarket devices. The caveat is that aftermarket devices may not be fully integrated, with vehicle-based Control Area Network (CAN) data bus for example, and may only provide limited forms of interactions. While NHTSA have taken steps to offer guidelines in interface design after considering various issues including driver distraction, the effectiveness

of a safe and effective driver interface via portable and aftermarket devices remains an open question and is to be evaluated on a case-by-case basis.

- Processing/Data Storage
  Given the advancements in computing, there is little doubt that the electronics industry is well positioned to provide the needed functionalities and capabilities to be implemented on aftermarket devices.
- Application
  The acceptability and usefulness of applications have to be evaluated on a case-by-case basis, given the potential diversity of aftermarket devices. With an increasing number of in-vehicle Telematics systems being offered by OEMs and industrial participants and the dynamic adaptive capabilities of the computing and software industries, any deficiency in this landscape will be quickly overcome. The robustness and feasibility of safety-oriented applications, such as DSRC-based V2V and V2I functions, are still in the process of being verified in field tests conducted by the automakers and government agencies around the globe. The current USDOT Safety Pilot Model Deployment[iv], for example, is a major effort in this aspect.

3.4 Current Status and Evolutionary Choices of Aftermarket OBE

In this section, we contemplate and assess the potential adoption of various devices as aftermarket OBE, from their current forms. First, the necessary additions to several portable or brought-in devices that are required for these devices to become an effective OBE capable of realizing full safety, mobility, and environment benefits are considered. For example, in the current USDOT Safety Pilot activities, a couple of vendors have proposed to integrate safety functions into cell phones. In another example, Japan Smartway[v] project is adopting an approach that builds upon Electronic Toll Collection (ETC) and VICS[vi] to offer an OBE that expands to safety and other applications.

The table below provides an overview of some currently available devices and their potential to become the envisioned aftermarket devices.

Table 3.1 Overview of available devices

Types of Devices	Current Functionality and Capabilities	Additional Features Needed
Portable Navigation Devices	• Map/GPS/Navigation • Optional Traffic Information (via FM-RDS)	• Computing power to host additional applications • Additional interface with drivers if needed; It needs to be cognizant of driver distraction issues

		• Additional communication links (such as DSRC, 3G/4G, Wi-Fi) • Interface with vehicle CAN bus and other sensors if needed
Advanced Cell Phones	• Map/GPS/Navigation • All kinds of comfort, convenience, entertainment functions • 3G/4G connection	• Additional communication links (such as DSRC) • Additional interface with drivers if needed; It needs to be cognizant of driver distraction issues • Interface with vehicle platforms if needed (such as Nokia's Terminal Mode) • Interface with vehicle CAN bus and other sensors if needed
Evolving or Non Traditional Connected Devices (e.g. Tablets)	• Map/GPS/Navigation • All kinds of comfort, convenience, entertainment functions • 3G/4G connection • Most have convenient interfaces already	• Additional communication links (such as DSRC); It needs to be cognizant of driver distraction issues • Interface with vehicle platforms if needed (such as Nokia's Terminal Mode) • Interface with vehicle CAN bus and other sensors if needed
OBU from DSRC Vendors	• Data protocols conforming to SAE J2735 and IEEE 802.11p, 1609 standards	• Additional communication links (besides DSRC) • Computing power (if needed) to host additional applications • Interface with drivers • Interface with vehicle CAN bus and other sensors if needed

Based on the industry feedback, the two most viable communication technologies relevant to the aftermarket safety devices are DSRC and cellular 3G/4G. Based on their performance characteristics, these two technologies might be used individually or in conjunction to deliver safety and mobility functionalities. Devices that currently have cellular connectivity could be converted into OBE with required modification to the interface and addition of relevant application software. But the problem with current cellular connection is coverage, assured quality of services and latency. The latency will improve with the

deployment of 4G systems but other factors make it practical only for applications like soft safety, probes, remote diagnostic etc. DSRC is much better suited for hard safety applications, which demands a latency of less than one tenth of a second. As an example, there is already an implementation of DSRC integration with a cell phone by OKI[vii], Japan. These DSRC devices, which can be integrated with cell phones, could act as excellent portable OBEs.

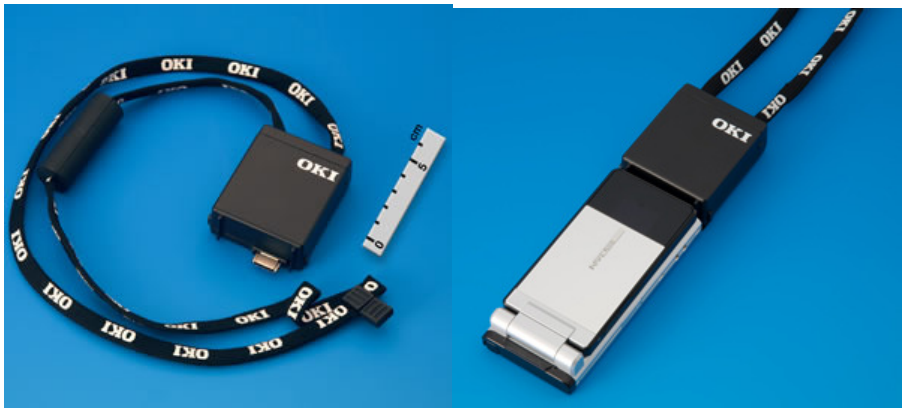

Figure 3.1 DSRC attachment for mobile phone by OKI, Japan

3.5 Summary of OBE Hardware Readiness

In summary, when considering the market readiness of hardware components needed for aftermarket devices, we can be fairly certain that the associated industries are already equipped or in a position to gear up for the demands. Certain sectors of the market are already progressing rapidly to utilize wireless communication to offer consumers convenience and mobility applications. Many industrial players are still waiting for the eventual validation of DSRC technologies or the like to assure that potential safety benefits can be realized and more importantly government agencies are ready to proceed with a mandate on safety regulations.

4 Consumer Research

In order to gain consumer expectations with regards to aftermarket OBE hardware two focus group interview (FGI) events were conducted to discuss product attributes, unmet customer needs, OBE hardware pricing, thoughts on when product features would come to market, and where consumers would prefer to purchase as well as service OBE hardware.

4.1 Focus Group Background

The focus group events were split into two sessions. One session focused on commercial vehicle drivers and the other session focused on ordinary passenger drivers. Drivers from both sessions were required to have some experience with in-vehicle electronics or brought-in consumer electronics that help in their daily commute. All of the participants had more than ten years of driving experience. Participant feedback from each session implies that communication technologies can assist or improve the consumer's driving experience.

4.2 Product Attributes

A recent white paper from U.S.DOT [viii] describes the premise of the original approach to the Vehicle Infrastructure Integration (VII) initiative that provides the basis for the earliest discussion of deployment strategy. The white paper explains that Vehicle to Vehicle (V2V) communications could provide the greatest safety gains. It would take time to equip all cars, trucks, and buses to achieve these benefits and could potentially result in approximately $44 billion in safety benefits. Below are sixteen applications that would be available on V2V and V2I systems:

1. Emergency Braking Warning
2. Traffic Signal Violation Warning
3. Stop Sign Violation Warning
4. Curve Speed Warning
5. In Vehicle Signage: Local Notifications
6. In Vehicle Signage : Regional Road Redirection
7. Traffic Information: Real Time Traveler Information
8. Electronic Payments: Toll Roads
9. Electronic Payments: Gasoline Purchase
10. Electronic Payments: Parking Fee
11. Roadway Condition: Weather
12. Roadway Condition: Road Maintenance
13. Traffic Management: Corridor Management
14. Traffic Management: Ramp Metering
15. Traffic Management: Signal Timing Optimization
16. Traffic management: Big Events

Each of the focus group participates were provided the list of sixteen applications. They were asked to select and prioritize the applications based on their perceived importance and interest levels. Participates were also asked to select the top ten applications they would like to have in an aftermarket OBE product. Tables 4.1 and 4.2 provide a summary of responses from each focus group.

In Table 4.1, the commercial vehicle drivers highly preferred to have collision warning systems to keep them safe while driving and provide timely assistance with functions such as emergency braking, road maintenance, traffic signal violation, curve speed and redirection warning. The drivers believe traffic management functions such as corridor management, signal timing optimization, and ramp metering should be the responsibility of public sectors. Their expectation is that it is preferable for the public sector to offer high quality, real time, traveler information, which can be accessed from connected vehicles.

Table 4.1 Importance and Interest from Commercial Vehicle Drivers

Applications	Commercial Drivers
Emergency Braking Warning	1
Roadway Condition: Road Maintenance	2
Traffic Signal Violation Warning	3
Roadway Condition: Weather	4
Curve Speed Warning	5
In Vehicle Signage : Regional Road Redirection	6
Traffic Management: Corridor Management	7
Traffic Management: Signal Timing Optimization	8
Traffic Management: Ramp Metering	9
Electronic Payments: Toll Roads	10
Traffic Information: Real Time Traveler Information	11
Electronic Payments: Parking Fee	12
Stop Sign Violation Warning	13
Traffic management: Big Events	14
In Vehicle Signage: Local Notifications	15
Electronic Payments: Gasoline Purchase	16

In Table 4.2, the passenger vehicle drivers prefer the real-time traffic information items for their route selection dynamically. Roadway condition weather, road maintenance, real-time traveler information, big events, and signal timing optimization are top features selected by passenger vehicle drivers.

Table 4.2 Importance and Interest from Ordinary Vehicle Drivers

Items	Ordinary Drivers
Roadway Condition: Weather	1
Roadway Condition: Road Maintenance	2
Emergency Braking Warning	3
Traffic Information: Real Time Traveler Information	4
Curve Speed Warning	5
Traffic management: Big Events	6
Traffic Management: Signal Timing Optimization	7
Traffic Management: Corridor Management	8
Stop Sign Violation Warning	9
In Vehicle Signage : Regional Road Redirection	10
Electronic Payments: Toll Roads	11
Traffic Signal Violation Warning	12
In Vehicle Signage: Local Notifications	13
Traffic Management: Ramp Metering	14
Electronic Payments: Gasoline Purchase	15
Electronic Payments: Parking Fee	16

4.3 Consumer Unmet Needs

The focus group participants were asked to identify any product features or attributes beyond the sixteen applications with regards to V2V and V2I safety features for aftermarket OBE products. The participants provided several features including potential V2V/V2I applications and non-V2V/V2I applications. The reason for documenting the non-V2V/V2I applications is to point out that consumers are interested in safety applications even if the applications are associated with Advanced Driver Assistance Systems (ADAS) products and are not necessarily offered through the V2V/V2I framework. According to the list of consumers' unmet needs, the safety-related features are their top priority. Below is a list of the most popular responses:

Potential V2V/V2I applications:

- Obstacles identification: An onboard safety system that detects objects such as vehicles or pedestrians around the vehicle, and properly warns the driver.
- Dynamic navigation system: A system that provides navigation suggestions based on real-time traffic information.

Non- V2V/V2I applications (ADAS features):

- 360 degree around view: A camera monitoring system that renders a bird's-eye view of the exterior of the vehicle on a driver's display.
- Back end camera system: A system that provides views of vehicle rear-end to alert drivers of obstacles.

- Driver drowsiness detection: An onboard system that monitors the driver status and detects driver's drowsiness.
- Forward collision warning detection system: A system equipped with radar or lidar to detect and track targets in front of the vehicle and provides hazard warnings.
- Blindspot detection system: A system equipped with short-range sensors to detect other vehicles located in the driver's blind spot that alerts the driver of their presence.

4.4 Feedback on OBE Pricing

According to focus group respondents there is a wide variation in what features or attributes would be the three most popular applications. They did seem to be aligned with an average price for an aftermarket OBE product of $200. There were a couple of respondents that believed the OBE product price should be below $100. With regards to the maximum price the response from the participants was $500 for an aftermarket OBE product.

4.5 Timing to Market of Features

The participants were asked to provide their opinions on when applications would be available to consumers in the market. They believe that emergency braking warning, curve speed warning, traffic information, real time traveler information, and weather information could be available in the market in one or two years. The rest of the applications would come to market in three years or beyond. The responses have been documented in Table 1.4.

Table 4.3 Participants Opinion on Time to Market for OBE Applications

Application	Time to Market
Emergency Braking Warning	1-2 years
Curve Speed Warning	1-2 years
Traffic Information: Real Time Traveler Information	1-2 years
Roadway Condition: Weather	1-2 years
In Vehicle Signage : Regional Road Redirection	3-5 years
Roadway Condition: Road Maintenance	3-5 years
Traffic Management: Corridor Management	3-5 years
Traffic Signal Violation Warning	3-5 years
Stop Sign Violation Warning	3-5 years
In Vehicle Signage: Local Notifications	3-5 years
Traffic Management: Ramp Metering	3-5 years
Traffic Management: Signal Timing Optimization	3-5 years
Traffic management: Big Events	3-5 years
Electronic Payments: Toll Roads	5+ years
Electronic Payments: Gasoline Purchase	5+ years
Electronic Payments: Parking Fee	5+ years

4.6 Where to purchase Aftermarket OBE Hardware

In both focus group session participants were asked where they would prefer to purchase and return for service their aftermarket OBE hardware. The commercial vehicle customers listed auto repair shops as the most popular location for purchase and service. The next most popular location identified was major retail stores followed by automotive electronics specialty stores.

For passenger customers both major retail stores and OEM dealerships were equally favored for purchase and service of aftermarket OBE products. Participants commented that either selection would be suitable but they stressed that reputable and reliable service would be the deciding factor for where to purchase the product.

4.7 Summary of Consumer Research

According to the consumer surveys, commercial vehicle drivers tend to care about the safety-related functions, and passenger vehicle drivers prefer real-time traffic information functions to assist their route decision while driving. No specific price range was identified but $500 seems to be limit. The accident warning and driver information applications will be available sooner than traffic management ones. Commercial vehicle drivers would prefer to purchase their aftermarket OBE hardware in auto repair shops, while passenger vehicle drivers prefer retail store and OEM dealerships as their purchase locations.

5 Conclusions

A number of observations can be summarized from this Vendor/Market Readiness report. The main conclusions are:

1) Industry and consumers perceive that current or future aftermarket devices have the potential to deliver V2V and V2I applications.
2) The industry is well aligned to develop and deliver aftermarket dynamic configurable multi-band OBE products within a three to four year product delivery plan.
3) Industry experts have identified challenges and opportunities in accelerating the deployment of the aftermarket OBE market. In the following paragraphs each of the main conclusions will be discussed.

Manufacturers of current or future aftermarket products such as portable navigation devices, advanced cell phones, connected devices, and DSRC OBUs all have great potential to enhance their product capability by implementing V2V/V2I applications. The general view of the industry is that the technical and manufacturing capabilities are certainly present to accelerate the deployment of aftermarket OBE to the market. The remaining road blocks or challenges are more business or institutional related issues. Consumer research shows a high level of interest in safety features and willingness to accept aftermarket products with V2V/V2I features. The main concerns from consumers are cost and ease of use.

Insight from industry reveals OEMs and Suppliers are all aligned with a three to four year product delivery plan. The plan assumes collaboration between all major stakeholders to address key challenges prior to execution of the product delivery plan. Consumers would like to see some aftermarket OBE products in the market in one or two years with safety features like emergency braking warning, curve speed warning, real time traffic information, and roadway weather condition. They believe the time to market for all other applications would be three years or beyond. Feedback on pricing from consumers revealed an average price point of $200 with a maximum of $500 for an aftermarket OBE product. Consumers were comfortable with purchasing aftermarket OBE product at existing distribution channels of the aftermarket industry.

The main challenges identified by industry are infrastructure deployment, communication coverage, security, business case, bandwidth limitations, driver distraction, and product liability. Each of the challenges mentioned demands that all stakeholders work together collaboratively to identify solutions and take responsibility in implementing the necessary actions. A government mandate, industry standards, and insurance industry incentives are initiatives that are identified by industry, and they should be part of the solutions that accelerate the deployment of aftermarket OBE product.

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