Enabling Accelerated Installation of Aftermarket On-Board

Equipment for Connected Vehicles

TASK 4: STRATEGIC REPORT SUMMARIZING RECOMMENDED ACTIONS

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Executive Summary

This Strategic Report Summarizing Recommended Actions is the fourth and final 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 will capture a summary of previous findings as well as any recent developments with regards to rapid introduction of aftermarket OBE devices to the vehicle fleet. An integration assessment for aftermarket OBE devices will be discussed. In addition, an analysis of outside market forces that may affect driver adoption of connected vehicle technologies will be shared. Finally, recommendations will be provided for strategic approaches to foster the rapid introduction of aftermarket OBE devices and garner consumer interests to purchase these devices.

With regards to the integration of OBE devices into the vehicle it is important to understand the interface to the vehicle as well as the communication technologies. The key aspects regarding the interface of the device are the power supply connection, integration of the vehicle communication network, and the human-machine-interaction. As for the integration of different wireless communication technologies it will depend on the applications and features specified for the OBE device. Wireless technologies such as cellular, DSRC, Wi-Fi, and Bluetooth in combination, or in some cases alone, are capable of supporting a wide variety of OBE devices. For reference both the USDOT Safety Pilot Model Deployment and Japan Smartway program are important projects in the advancement of OBE products for consumers. Furthermore, industry devices from Kapsch, Savari, Denso, ITRI, and NEXCOM are examples of dynamically configurable multi-band wireless hardware that could be developed as OBE devices with the appropriate software development customized for specific applications.

When looking at outside market forces that may influence consumers adoption of OBE devices there is great potential to integrate V2V and V2I features in current Aftermarket products like telematics modules, smartphone applications, and PND's. With regards to technological influence products that can combine safety features with convenience and comfort features can provide a viable value proposition to consumers. The political opportunity to influence consumers will reside with a government mandate. The insurance industry can be a key catalyst with regards to adoption with incentives associated with OBE products.

There are challenges and opportunities that have a significant impact on the deployment of aftermarket OBE devices. The main challenges are viable business cases, infrastructure deployment, security, scalability, driver distraction, and product liability. The main

opportunities are a government mandate, standards, and insurance incentives. Each of the identified challenges can be resolved by the leadership of the primary party and with commitment and collaboration by all stakeholders involved.

1 Introduction

1.1 Project Goals

The goal of this project is to evaluate the potential approaches for accelerating the introduction of aftermarket OBE devices to the vehicle fleet. Without a rapid deployment, the safety, mobility, and efficiency 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 expedient enough for maximum benefit. Therefore, aftermarket deployment is critical. The combination of aftermarket OBE devices and new vehicles 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.

1.2 Report Layout

In Chapter 2 the integration assessment of OBE devices is discussed in three areas: important aspects of OBE interfaces to the vehicle, dynamic configurability of multi-band wireless communication, and current OBE devices in the market.

Chapter 3 provides an analysis of market forces that may affect consumer adoption of aftermarket OBE devices. The chapter begins with the identification of outside market forces that could influence consumer purchasing behavior. Next, a model analysis is presented to identify pro’s and con’s associated with Social, Technology, Environment, and Policy (STEP) factors with regards to the OBE market. Finally, a mixed analysis is utilized to provide insights in product, price, promotion, and place (4P) in relation to consumer, competitor, company, and community (4C) for the aftermarket OBE market.

Chapter 4 will offer recommendations on strategic approaches to foster the rapid introduction of aftermarket OBE devices. In addition, recommendations to garner consumer interest to purchase aftermarket OBE devices will be discussed.

Chapter 5 provides summary remarks based upon the previous reports and this current report as a conclusion to this project.

2 Integration Assessment for OBE devices

This section provides an overview of requirements and issues related to the interface, attributes, and communication technology of aftermarket OBE devices, to establish the foundation for discussions in later sections.

2.1 Important aspects of OBE interface to the vehicle

In this section, we offer a description of important aspects with regards to interface to the vehicle, and discuss how the power supply, vehicle communication network, and HMI are connected to the vehicle.

- Power supply

The vehicle should provide 12V (for light passenger vehicle) or 24V (for heavy truck vehicle) DC power input to the OBE device. In general, the OBE device's power consumption is typically specified at a relatively low level.[1] In addition, the OBE is equipped with a standard type of power connectors.[2]

- Vehicle communication network

Most modern vehicles are equipped with an in-vehicle communication network. A vehicle network is a specialized internal communications network that interconnects components inside a vehicle (e.g. automobile, bus, and train). Special requirements for vehicle control such as assurance of message delivery, assured non-conflicting messages, assured time of delivery as well as low cost, EMF noise resilience, redundant routing, and other characteristics mandate the use of less common networking protocols. Protocols include Controller Area Network (CAN), Local Interconnect Network (LIN), and others. The CAN bus can be used in vehicles to connect engine control unit and transmission, or (on a different bus) to connect the door locks, climate control, seat control, etc. Although there are no hard requirements in general for interfacing to in-vehicle communication network, it is extremely advantageous to have the network interface to leverage the data elements within the vehicle communication network into OBE functionalities. For safety applications, such as emergency electronic braking light

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[1] For example, based on USDOT procurement specifications of HIA [1] the power consumption should be less than 16 W, and according to the Maximum Operating Current requirement, the HIA device should operate at a maximum of 1 amp in the Halt, Run, and Start modes.

[2] For example, in related USDOT procurement, it is required that OBE should provide one of three types of power input connector/interface listed below. DC-JACK connector (Worldwide industrial standard [2]) is a basic power input interface for the OBE device. Delphi connector is mandatory power input for USDOT projects (such as USDOT VAD and ASD projects [3][4]). Cigarette connector is an optional interface for the OBE device.

(EEBL) functions, the OBE should receive the braking signal through the CAN bus interface.

- HMI (auditory, visual, haptics)

To support drivers in a critical situation, the design of HMI (Human-Machine-Interaction) is of major importance. The applications embedded on the OBE can engage the drivers in different manners, and there are several possible alternative HMI modes (auditory, visual, or haptics) for such interactions. For example, an aftermarket safety device often has a speaker and a display for use as a human machine interface to convey safety alerts to drivers. Haptic interfaces for in-vehicle safety as well as comfort functions are now commercially available. In-vehicle functions are increasingly available and controlled via maneuverable buttons for activation and deactivation.

2.2 Dynamic configurability of multi-band wireless communication and desired applications

In this section, we summarize the performance features of wireless communication in relationship to the desired OBE applications.

- Integration of different wireless communications on an OBE device

The appropriate integration of wireless communications on an OBE device to meet user needs and wants is dependent on how the functionality of the system can best be accomplished. The popular types of wireless communications appropriate for an OBE device and their suitability for applications are summarized as follows.

- Cellular application assessment

  Data communications over cellular networks tend to be lower priority than voice communications, so data packets can be expected to encounter buffer-based latency if the networks are busy with voice traffic. The latency (typically at least several seconds) limitations will likely preclude the use of cellular communications for the majority of time-critical vehicle safety applications. Cellular communication is well equipped for convenience functions and many non-time critical safety features. Internet connectivity via cellular 3G services can also support entertainment application.

- DSRC application assessment

  The 5.9GHz DSRC latency, typically at tens of milliseconds, is three orders of magnitude lower than other existing wireless technologies. It is uniquely positioned to meet the essential communication requirements for most of the vehicle safety applications that have been proposed for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) applications. The 5.9 GHz DSRC also supports a wide range of efficiency and mobility applications such as electronic toll collection and eco-driving. DSRC 5.9 GHz is best suited for most time-critical safety features, which require short latency and high-bandwidth data transmission.

- Wi-Fi application assessment
  Wi-Fi networking equipment is widely available, inexpensive and popularly used in home, commercial, and industrial environments. The Wi-Fi protocols themselves are described by the IEEE 802.11 standards. Bandwidth has increased substantially from the original protocol implementations, and the most recent standards provide capacities comparable to wired connections. Wi-Fi is appropriate for convenience features that do not necessitate constant connection. For example, users can access Wi-Fi connection in home garages or at public access points, where they are able to download and/or upload useful information (e.g. up-to-date maps).
- Bluetooth application assessment
  Bluetooth is a low-power, low-cost, short-range (10m) wireless communication system. It is suitable for in-vehicle data transmission among sub-systems. For example, hands-free calling with mobile phones is typically accomplished via Bluetooth communication. It can support commercial applications like electronic payments at fast food drive-thru restaurants. In addition, Bluetooth can provide the gateway communication between a smartphone application and an OBE that in turn is connected to the DSRC network.

- Dynamic configurability of an OBE device

As discussed in Task 3 Guidance Document report, the OBE is preferred to be dynamically configurable between multi-band wireless communication channels, depending on its application requirements. The timing of switching the communication interface depends on several factors – transmission range, data rate, packet reliability, and network connectivity. Exemplar scenarios of an OBE device with dynamic configurability are explained as follows.

- From the point of view of transmission range, the system can be set up with a default communication interface such as DSRC for safety features. If the distance between the sender and receiver exceeds the DSRC transmission range (around 500m~1000m), the channel can then be switched to cellular to allow data transmission smoothly.
- From the point of view of data rate, if download for multi-media data (more than few Mega bit per second data rate is required) is activated, the OBE can be configured to cellular interface.
- From the point of view of packet reliability, the packets can be transmitted by using DSRC interface and cellular interface concurrently. The drawback with this scenario is the redundant packet overhead within the network.
- For inter-vehicle communications, the system can be set up with a default communication interface such as DSRC for safety features. When access to Internet backbone is needed, the OBE can switch to cellular or Wi-Fi dynamically.

As described in the above scenarios, several similar devices (e.g., Kapsch, Savari, Denso, ITRI and NEXCOM) discussed in Section 2.3 below support multi-band wireless communication hardware interfaces (e.g., DSRC/Cell/Wi-Fi/Bluetooth). The choice of the communication interface depends on the application requirements. In addition, the similar devices offered by industry also need software development efforts to meet the above dynamic switching scenarios. Therefore, the above scenarios are typically highly customized to conform to the application requirements.

- Implementation of V2V and V2I applications on an OBE device and selection of communication technologies

V2V communication is typically demanded for short range data exchange between vehicles. Exemplar applications of V2V include safety alert notifications and probe data sharing for mobility applications. V2I communication can utilize a variety of wireless technologies for a vehicle to communicate with the infrastructure and to enable seamless handover from one communication medium to another. The popular wireless communication technologies of an OBE device for V2V and V2I application assessment are explained as follows.

  - DSRC is uniquely suited to mobile vehicular applications needing high bandwidth and low latency in short range communications (on the order of a few hundred meters). Security is managed through a certificate management scheme that issues new certificates to each radio at regular intervals. Radios can be deployed in vehicles and in roadside equipment to enable V2V and V2I communications.
  - Cellular network services are not generally appropriate for real-time localized V2V or V2I data exchange. They are, however, very suitable for data transmission that can span over long distances and across a wide area network.
  - Wi-Fi is another wireless technology, suitable for selective V2I applications. It has been accepted in a wide variety of products ranging from mobile phones, laptop PCs, and tablets. It is a low-cost alternative for non-critical missions.
  - Bluetooth may serve as the communication link between the OBE and smartphone or PDA. This will allow the smartphone or PDA to act as the driver interface for V2V and V2I applications.

2.3 Current OBE devices

This section summarizes OBE capabilities from the USDOT Safety Pilot Model Deployment and Japan Smartway program, as well as other industry developed devices.

- USDOT Safety Pilot Model Deployment OBE

In USDOT Safety Pilot Model Deployment project, the in-vehicle devices to be tested include embedded or integrated systems, Aftermarket Safety Device (ASD), and a “simple” communications beacon (Vehicle Awareness Device, or VAD). All of these devices emit a basic safety message 10 times per second, which forms the basic data stream that other in-vehicle devices can use to determine when a potential conflict exists.

- VAD

  In an earlier definition, HIA (Here I Am) [1] devices periodically send vehicle and location message based on the Basic Safety Message (BSM) defined in SAE J2735. A newly named VAD [3] devices provide revised functional capabilities from the HIA device. VAD devices implement one 5.9 GHz DSRC radio as called out in IEEE 802.11p and IEEE 1609.

- ASD

  ASD can send and receive BSMs. The ASD has display, audio and selective built-in safety applications (such as FCW, EEBL, CICAS-V and CSW [4]). The ASD have two 5.9GHz DSRC radios as called out in IEEE 802.11p and IEEE 1609. In addition, the ASD equipment includes one or more optional non-DSRC radios of the following types (3G Cellular and WiMAX). Therefore, the ASD device could be configured to multi-band DSRC/Cell/WiMAX communication technology interface.

- Japan Smartway OBE

The Japan Smartway [5] program incorporates VICS (Vehicle Information and Communication System) [6] and ETC (Electronic Toll Collection) functions plus navigation into an integral OBE. OBE communicates with RSE via DSRC (5.8 GHz). In addition, Japan also uses infrared beacons and FM multiplex broadcasting in their VICS and Smartway systems. In their VICS system, the OBE can receive information about expressways and ordinary roads as far as 30 km ahead, and 1 km behind from the car. FM multiplex broadcasting can provide information about the user location, neighboring area and regional borders. The Smartway OBE is configured to utilize multi-band DSRC/Wi-Fi/FM/Infrared communication technologies.

- Similar Devices offered by Industry

There are several similar devices throughout the industry developed by Kapsch, Savari, Denso, ITRI and NEXCOM.

- Kapsch Devices

  The Multiband Configurable Networking Unit (MCNU) R1551 [7] is a wireless communication solution for transportation infrastructure. The MCNU is deployment ready and supports Vehicle Infrastructure Integration (VII) and industry common protocols for vehicle communications operating in the 5.9 GHz DSRC band. The MCNU dual radio platform also provides simultaneous communications in licensed (4.9 GHz) and unlicensed (2.4 GHz and 5 GHz) frequency bands offering wireless broadband access to VII. In addition, the MCNU has two high-speed Ethernet ports to enable flexible routing between multiple wired and wireless IP subnets in the roadside network infrastructure. Built-in IPv4 and IPv6 firewall and VPN capabilities enable secure routing and tunneling through backhaul networks. The MCNU supports transportation management (e.g., Electronic Toll Collection, Commercial Vehicle and Fleet Management), safety (e.g., Vehicle Safety/Crash Avoidance) and security applications including support of Intelligent Transportation System (ITS) VII Initiative. Therefore, the MCNU could be configured to multi-band DSRC/Wi-Fi communication technology interface.

The TS3306 [8] On-Board Unit is designed for the 5.9 GHz DSRC. It is provided for applications serving commercial vehicle operations and road tolling markets as well as for the USDOT's Connected Vehicle Safety Pilot program. In addition, it can link to a smartphone or a PDA via Bluetooth interface. It also supports USB and an optional CAN vehicle interface which can expand device versatility. Therefore, the TS3306 OBU could be configured to multi-band DSRC/Bluetooth communication technology interface.

- Savari MobiWAVE

  MobiWAVE [9] is a wireless vehicular onboard unit, designed as a flexible open platform based on Linux for deploying ITS applications to improve mobility and safety on the roadways. MobiWAVE seamlessly selects the best available uplink connectivity between DSRC, Wi-Fi and 3G at any given instance. Wi-Fi can be used in AP mode to share the 3G connectivity inside the vehicle. In addition, MobiWAVE offers display and touch-panel functionality for touch-panel based HMI. MobiWAVE provide several safety applications such as Traffic Signal Violation Warning, Curve over-speed Warning, Emergency Electronic Brake Lights, Pre-crash Warning, Cooperative Forward Collision Warning, Left Turn Assistant, Lane Change Warning and Stop Sign Movement Assistance. For efficiency application, MobiWAVE support several electronic payment applications such as toll collection, open road tolling and gas payment. Therefore, the MobiWAVE could be configured to multi-band DSRC/Cell/Wi-Fi communication technology interface.

- Denso Wireless Safety Unit (WSU)

  Denso WSU [10] supports WAVE/DSRC solution with video/audio, suitable for vehicle safety applications. In addition, the WSU also support single automotive connector such as power, ignition sense, RS-232 (GPS/PPS/serial data), CAN, Ethernet, USB and GPIO. Denso WSU provide several types of applications such as Forward Collision Warning, Lane Change Assist, Intersection Movement Assist, Electronic Emergency Brake Light, Curve over-speed Warning (e.g., speed distribution, or min curve speed methods) and in-vehicle signage applications (e.g., speed limit, construction zone, or other). The WSU could be configured to DSRC communication technology interface.

- ITRI WAVE/DSRC Communication Unit (IWCU)
  IWCU 4.0 OBU [11] is a WAVE/DSRC communication equipment mounted in a vehicle. It also provides CAN bus, Wi-Fi and 3G communications, suitable as vehicle communication gateway. It supports automotive grade operating temperature range from -40° C to +85° C. In addition, IWCU can support many different types of communication including intra-vehicle, vehicle-to-vehicle (V2V), vehicle-to-roadside (V2R). IWCU 4.0 OBU also provides several types of applications such as cooperative safety applications (e.g., Road Construction Warning, Car Accident Warning), Electronic Emergency Brake Light, Electronic Toll Collection, Vehicle Group Communication applications and RSU Management System. Therefore, the IWCU 4.0 OBU could be configured to multi-band DSRC/Cell/Wi-Fi communication technology interface.
- NEXCOM VTC 6200
  NEXCOM VTC 6200 [12] supports internal wireless communication (3.5G, GSM/GPRS, WLAN, Bluetooth). It also provides an industrial grade computing solution for in-vehicle surveillance applications. In addition, NEXCOM VTC 6200 support dual VGA output (clone mode) and one isolated GPIO interface. The NEXCOM VTC 6200 could be configured to multi-band Cell/Wi-Fi/Bluetooth communication technology interface.

Table 2.1 has been included to provide list of possible OBE devices that could be developed as Aftermarket Safety Devices for consumers. The table is an example to illustrate what industry devices are available and not meant to be a recommendation for sourcing.

Table 2.1 Comparison of different OBE suppliers

OBE Device	Kapsch*	Savari*	Denso*	ITRI*	NEXCOM*
Recommended memory	512 MB	512 MB	512 MB	512 MB	512 MB
Recommended storage	4 GB	4 GB	4 GB	4 GB	4 GB
Recommended GPS	Yes**	Yes**	Yes**	Yes**	Yes**
All above recommendations are satisfied	Yes	Yes	Yes	Yes	Yes
FCW	Yes	Yes	Yes	Yes	Optional***

EEBL	Yes	Yes	Yes	Yes	Optional***
CICAS-V	Yes	Yes	Yes	Yes	Optional***
CSW	Yes	Yes	Yes	Yes	Optional***

* The assessment is based on hardware capabilities, software would need to be developed for each application.

** For time-critical and safety application, the OBE should support fast and accurate location information with its built-in WAAS (Wide Area Augmentation System) enabled GPS receiver. WASS function is optional and should be developed by suppliers.

*** In order to support safety applications, NEXCOM product should combine with IEEE 802.11p mini-PCI card (e.g., UNEX 5.9 GHz DSRC wireless mini-PCI [13]) to provide DSRC communication technology.

3 Analysis of OBE Market Forces

This section provides an analysis of market forces that may affect consumer adoption of aftermarket OBE devices.

3.1 Market products relevant to introduction of OBE

Several types of in-vehicle products are emerging in the market place and they could influence the purchasing behaviors of consumers with regards to aftermarket OBE. We review the most relevant products in this section.

- Industry Telematics Products

Telematics companies like OnStar (GM), ATX Technologies, and Hughes Telematics are well established in the global market. The comparison of various factors (such as Basic Plan, Basic Plan Pricing, Advanced Plan, Advanced Plan, Advanced Plan Pricing and Customers) for the three companies is shown in Table 3.1.

Table 3.1 Comparison of different Telematics products

Company	OnStar	ATX Technologies	Hughes Telematics
Basic Plan (Safety)	Safe & Sound Plan Automatic Crash Response, Emergency Services, Crisis Assist, Stolen Vehicle Assistance/slowdown, Remote Door Unlock, Roadside Assistance, Remote Horn & Lights and OnStar Vehicle Diagnostics	Safety Plan Automatic Collision Notification, Emergency Request (SOS), Enhanced Roadside Assistance, MyInfo, Stolen Vehicle Recovery, Door Unlock, Tele Service and Customer	Safety Plan - Automatic crash notification, roadside assistance, vehicle diagnostics and stolen vehicle tracking, as well as voice recognition to operate cell phones, audio systems and iPods

		Relations - BMW	
Basic Plan Pricing	Safe & Sound - $18.95 / month - $199 / year	Safety Plan - No charge for 4 years/ unlimited miles, then $199 per year	Basic Plan - $18.95 / month
Advanced Plan	Directions & Connections Automatic Crash Response, Emergency Services, Crisis Assist, Stolen Vehicle Assistance/slowdown, Remote Door Unlock, Roadside Assistance, Remote Horn & Lights, OnStar Vehicle Diagnostics and Hands-Free Calling, Turn-by-Turn Navigation includes eNav and Destination Download and Information/Convenience Services.	Automatic Collision Notification, Emergency Request (SOS), Enhanced Roadside Assistance, MyInfo, Stolen Vehicle Recovery, Door Unlock, TeleService, Customer Relations, Directions, Real-Time Traffic, Weather, Concierge, BMW Search and Critical Calling- BMW	Automatic crash notification, roadside assistance, vehicle diagnostics and stolen vehicle Tracking, as well as voice recognition to operate cell phones, audio systems and iPods, news, weather, sports scores, stock quotes, fuel prices and movie times.
Advanced Plan Pricing	Directions & Connections - $28.90 / m - $299 / year Convenience Plan - Safety Plan plus $199 per year	Convenience Plan - Safety Plan plus $199 per year	Convenience Plan - $28.95/month and additionally may be on a per-use basis
Customers	General Motors, Lexus	BMW, Mercedes-Benz (till end of 2009), Toyota (from MY2010), Rolls-Royce and Maybach	Chrysler and Mercedes-Benz (2009)

In Table 3.1 the OnStar system, a General Motors product, provides Basic and Advanced plans throughout the United States, Canada, and China. The Basic plan provides safety features such as automatic crash response, emergency services, stolen vehicle assistance, and roadside assistance. The Advanced plan provides some of the comfort features such as hands-free calling, and turn-by-turn navigation. The ATX Technologies safety plan which is considered the basic plan provides automatic collision notification, emergency request (SOS), enhanced roadside assistance, and stolen vehicle recovery. The ATX Advanced plan provides directions, real-time traffic, and weather information. The Hughes Telematics basic plan provides automatic crash notification, roadside assistance, vehicle diagnostics, and stolen vehicle tracking features. The Hughes Advanced plan provides voice recognition to operate cell phones, audio connectivity, news, weather, sports scores, stock quotes, and fuel prices as convenient features.

- Insurance Telematics

Automotive insurance industry and telematics services now represent an emerging sector of utilizing aftermarket devices to enable their business models. For example, insurance telematics products like Insurethebox [14] and Octo Telematics SpA [15] are heavily marketed around the globe. By collecting information on customers' driving patterns these companies are able to reduce the cost of car insurance for safe drivers.

- Smartphone applications

A smartphone could generally be described as a mobile telephone handset with built-in personal computing applications and Internet data access. They frequently include GPS receivers and cameras. The latest models of smartphones are easy for users to download and update applications; they are equipped with additional sensors for acceleration, ambient light, and compass direction; and have become a platform for independent software development and deployment. Add-on applications may include navigation and traffic information, and smartphones are increasingly used in place of other navigation devices.

- Integration of portable computing devices (phone, iPad, tablet, etc) and portable navigation deice (PND)

In January 2012, Garmin [16] announced the launch of Smartphone Link, the first Android app to provide live services to personal navigation devices (PNDs). Smartphone Link creates a seamless navigation experience between any Bluetooth enabled 2012 Garmin nüvi and an Android smartphone allowing them to communicate and share data. Among other functionalities, the app lets nüvi users add live services, such as traffic information, traffic camera images, weather and fuel prices to their navigation device, utilizing the smartphone's mobile data plan.

3.2 STEP model analysis.

In this section a STEP model analysis is reviewed to strategize the potential enabling of Accelerated Installation of Aftermarket On-Board Equipment for Connected Vehicles. The STEP model approach is an external analysis, which investigates four macro-environments scopes: social, technological, political, environmental factors. The goal is to understand the market before making operational decision. Table 3.2 provides a comparison of three factors (Concerned Issue, Pro and Con) that are taken into consideration in a STEP model.

Challenges will exist with any new product or system introduced into the market, and V2V/V2I systems are no exception. During the discussion of aftermarket OBE features OEMs provided insight on a tiered approach to deploying features and functions. They suggested that initial systems should focus on safety applications providing driver relevant information or warnings of upcoming events. Efficiency and comfort applications can be introduced at the same time to enhance the value proposition to the consumer.

Industry experts have identified challenges and opportunities in accelerating the deployment of the aftermarket OBE market. The identified challenges are infrastructure deployment, communication coverage, security, business case, bandwidth limitations, driver distraction, and product liability. Each challenge demands that all stakeholders work together collaboratively to identify solutions and take responsibility in implementing the required actions. Also identified by the industry as major initiatives are a government mandate, industry standards, and insurance industry incentives that should be part of the solutions that accelerate the deployment of aftermarket OBE product.

Table 3.2 STEP model analysis

Factors	Social	Technological	Environmental	Political
Concerned Issue	Aftermarket OBE benefit for the fleet managers or drivers	The car, device, carrier, service operator side technology	Communication Infrastructure (e.g. DSRC Roadside Units, 3G/LTE Base Stations, Wi-Fi Access Points)	[illegible]T obligations, mandatory regulation will be evaluated in coming years
Pro	Approximately $44 billion in achievable safety benefits Existing needs for high quality, real time, traveler information	The use 5.9Ghz DSRC for safety applications and 3G/4G/LTE for efficiency and comfort applications show the most promise for accelerated deployment	Projects like the Safety Pilot/Model Deployment program will provide collaborative environment	A mandate will require industry to deploy the technology on new vehicles. Without a mandate commercial vehicles could be the lead market to implement the technology if the value is understood

Con	High cost for OBE devices will be a barrier to entry for both commercial and normal vehicle owners	Bandwidth limitations of the wireless communication system Driver distraction for the consumer with new V2X products	Building the DSRC infrastructure will be difficult because of the cost	No clear regulation and likely no mandates for Aftermarket OBE

To garner the interest of the consumer to purchase aftermarket OBE devices, it will come down to technological and political factors. From the point of view of the technological factor, an OBE should include convenient and comfort features with safety functions. Therefore, 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. From the political factor point of view a government mandate should be issued to lead the industry to deployment of the technology (e.g., DSRC, Cellular and Wi-Fi) on new vehicles.

3.3 McKinsey 4P (product, price, place, and promotion) and 4C (consumer, competitor, company, and community) model analysis

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

In Table 3.3, we use a 4P and 4C marketing mixed analysis to address different aspects of enabling Accelerated Installation of Aftermarket On-Board Equipment for Connected Vehicles.

Table 3.3 McKinsey 4P and 4C model analysis

	Product	**Price**	**Promotion**	**Place**
Consumer	Product features: Emergency Braking Warning Curve Speed Warning, Traffic Information: Real Time Traveler	Price range is $100-500 Most acceptable average price $200	CES Exhibition Automotive show Electronics Show	Auto repair shops for commercial vehicles Retail stores followed by automotive electronics for

	Information Roadway Condition: Weather			Ordinary user
Competitor (Existing)	GM OnStar ATX Hughes	Basic plan (please refer to Table 3.1) Advanced plan (please refer to Table 3.1)	Insurance companies Automotive companies	Rental car Insurance companies New car
Company	Several features including potential V2V/V2I applications and non-V2V/V2I applications. The safety-related features are their top priority	Due to low volumes currently in the industry OBE price ranges from $2,000 to $4,000	Incentives or discounts for insurance companies or consumers Combine features with current products with little additional hardware costs	Online purchase can be a good venue if installation can be done by consumers themselves Aftermarket stores or Automotive dealers are nature choices
Community/ Channel	Collision warning Timely assistance of information optimized for passenger car	NHTSA will not mandate a monthly fee to consumers to have an embedded cellular connection for safety	Safety messages to promote the technology value to the customer	Products should be sold or available in all markets throughout the US

Based on the focus group interviews, Consumers would like to see some aftermarket OBE products in the market within 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 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 products at existing distribution channels of the aftermarket industry.

4 Recommendations

In this section, we discuss the potential approaches that can enable faster installation of aftermarket devices, based on the analysis from preceding sections as well as findings from previous reports.

4.1 Recommendations to foster the rapid introduction of Aftermarket OBE

- Government Mandate & Connected Vehicles Deployment
    - It is well documented in studies by government and industry that consumers typically don't pay for safety features directly. Instead, they expect safety in the vehicles they purchase. Traditionally, many safety features have been introduced through a mandate to achieve a high market penetration rate. Since the envisioned benefits in Connected Vehicles will be greatly enhanced by high market penetration, it can be realized with a government mandate especially when safety and mobility benefits can be justified. On the other hand, with regards to convenient and confront features, consumers currently pay for these types of products without the need for a government mandate.
    - It would be more sensible to issue a mandate for commercial vehicles before consumer vehicles. The main reason is that commercial vehicles can leverage fleet operational considerations to justify a business case to deploy OBE devices with safety features. In addition, the added equipment cost of an OBE is a relatively lower percentage of vehicle capital investment costs. The commercial vehicle fleet, if successfully marketed, would be a large scale deployment that extends beyond the current safety pilot program, and it could provide further validation of the technology for all stakeholders prior to a full scale consumer vehicle deployment. Furthermore, the commercial vehicle platforms, due to its tradition of being more flexible and receptive with supplementary components and add-ons, would be highly suitable for adopting an aftermarket OBE device.
    - It will take the automotive industry a great deal of resources and a stringent evaluation process to justify, develop, and deploy V2V safety features into new vehicles without a government mandate. The focus of the industry will remain on convenient and confront features that currently have viable business cases in telematics and connectivity products. The rapid deployment of aftermarket products will be difficult to materialize before a formal introduction of OEM OBE products.
    - Another venue to exercise significant deployment of Connected Vehicles technologies will be the operation of special vehicle fleets, such as public transit

buses, police vehicles, and fleets maintained and operated by government agencies. These vehicles tend to operate frequently in a local region or on fixed routes, thus offering a structured and defined platform to demonstrate the featured functions of an OBE. These types of deployment initiatives may also lead to greater awareness by the public, which will promote faster market penetration of aftermarket OBE devices.

- Insurance Incentives
    - Since safety is the top priority of the government with regards to V2V and V2I products the insurance industry plays a key role in the aftermarket OBE market. Similar to insurance premium reduction to good drivers, the insurance industry can promote the acceptance of OBE by leveraging the potential safety features of aftermarket OBE products with incentives as a catalyst for OBE installation. The government mandate, coupled with insurance incentives, will entice greater consumer demands as well as faster introduction of OEM products. Jointly, these market forces will help realize the envisioned benefits thus leading to greater acceptance by the public.
- Enriched OBE Capability

To enhance the appeal of OBE, technological developments should be leveraged to offer the greatest potential utilization.

- Dynamically configurable multi-band OBE devices
    - As discussed in Task 3 Procurement Guidance report, the OBE should ideally be dynamically configurable between multi-band wireless communication interfaces (such as DRSC/Cellular/Wi-Fi/WiMAX/Bluetooth), depending on its application requirements.
    - For safety applications and inter-vehicle short range (500~1000m) communications, the OBE can be configured to DRSC interface to satisfy low latency and high bandwidth requirements.
    - For efficiency applications, the OBE can be configured to Wi-Fi or Bluetooth interface to get real-time traffic information via portable navigation devices (PND).
    - For entertainment or V2I data exchange applications, the OBE can be configured to Cellular or WiMAX interface to access Internet backbone.
- Integration with existing in-vehicle products
    - The OBE should interface with onboard vehicle communication network to leverage the available data elements into OBE functionalities.
    - In order to access the on-board data network for detailed display and analysis of the vehicle's performance (such as safety inspection), the OBE should connect to the vehicle's On-Board Diagnostic (OBD-II) port for probing

vehicle data.

- When possible, the HMI of Aftermarket OBE should also be seamlessly integrated with on-board HMI to minimize the potential overload of interaction demands on the drivers.

4.2 Recommendations to garner consumer interest to purchase aftermarket OBE

- Tailored Product Features to Meet Customer Needs

User of different type of vehicle platforms may demand different features in OBE.

  - For light passenger vehicle, drivers will prefer a package that includes comfort and convenience functions along with safety functions.
  - Transit vehicle drivers will prefer functionalities that help enhance driving safety and provide ease of operations.
  - Commercial vehicle drivers are likely to appreciate applications that can help alleviate workloads and minimize driving risks as well as maximize operational efficiency and mobility benefits.

- Price and Packaging
  - In terms of economic benefits, consumers are generally very sensitive to the costs that are to be incurred with the installation of any device on their vehicles and will base their purchasing decisions on perceived values.
  - A value proposition will ideally include convenient and comfort features to stimulate the interests of consumers, while incorporating safety functions.
  - In the focus group interviews consumers were interested in purchasing aftermarket OBE products through current aftermarket retail channels. The distribution channel should allow access to easy purchase and installation.
  - It was found in the focus group interviews earlier in the project that consumers are only willing to pay at most a few hundred dollars for an OBE.
- Insurance Incentives
  - Not only will insurance incentives be a catalyst for the industry to rapidly deploy aftermarket OBE devices they can also assist with the pricing challenges that may inhibit consumers interest in purchasing OBE’s. For example, currently in the US Progressive offers a product called Snapshot [17] where the customer’s driving is monitored with a device that is installed in the vehicle. Based on the driver’s usage and behavior a discount of up to 30% received.

5 Conclusions

There are several primary themes that have emerged through all of the reports that are generated in this project with regards to V2V and V2I technologies. These themes, representing both challenges and opportunities, have a significant impact on the deployment of aftermarket OBE devices. The main challenges are viable business cases, infrastructure deployment, security, scalability, driver distraction, and product liability. The main opportunities are a government mandate, standards, and insurance incentives.

For each of the challenges, a key area of strategic approaches can be identified. For example, safety features bundled with comfort and convenient features or a current aftermarket product may be required to develop a viable business case. When looking at infrastructure deployment the key stakeholders - federal, state, and local governments will have to collaborate on a sustainable plan. The challenge of network security will require industry and government experts working together toward a common goal to resolve this issue. For scalability large scale deployments like the safety model deployment project conducted by USDOT will help identify potential issues. To address driver distraction, guidelines developed in cooperation between government and industry can overcome this challenge. Finally, product liability will require the commitment from all stakeholders to identify appropriate solutions. In all, any of the challenges mentions can be resolved with commitment and collaboration by all involved.

For each of the identified opportunities, a key stakeholder is critical for its success. For example, the government will play the most critical role in mandating V2V and V2I technologies. As for standards, the key stakeholder will be industry and their able to develop robust and reliable standards for the technology. Finally, the insurance industry will be the main stakeholder with regards to incentives to encourage consumer acceptance of OBE devices. In all, for the opportunities to make a difference each of the stakeholders will need to lead their respective area with support from one another.

The rapid introduction of Aftermarket OBE devices will require a government mandate, demonstrable advantages, user incentives, and OBE's with enhanced capabilities. It is certain that a government mandate will drive the development and deployment of V2V and V2I technologies quicker than no mandate. Consumers will be motivated to adopt aftermarket devices if they can obtain perceivable benefits and receive financial incentives. Finally, the enhanced capabilities of OBE devices are important in order to accommodate all possible vehicles and markets.

The interest of the consumer to purchase aftermarket OBE devices will come down to product features, product pricing, installation costs, and insurance incentives. Not all product features are created equally therefore it will be critical to match the product features with the appropriate customer/market. Product pricing will be the greatest challenge for OBE devices; the value must be evident to consumers for success. Installation will also play a key role in consumer acceptance it should be low cost and simple. Insurance incentives will be a big plus to promote consumer acceptance in accelerating the deployment of OBE devices.

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