PUBLIC PERCEPTIONS OF CONNECTED VEHICLE TECHNOLOGY

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EXECUTIVE SUMMARY

Federal and state agencies, in conjunction with private industry, are working to develop and implement connected vehicle technologies. As envisioned, these technologies will enable vehicles to communicate with each other and the roadway for the purpose of achieving safety, mobility, and environmental improvements to vehicle transportation. When fully deployed, connected vehicle technologies are expected to provide drivers with many benefits through the use of applications. These applications could, for example, help drivers bypass congestion and provide advanced safety warnings, reducing the number and severity of vehicle crashes.

While connected vehicle technologies have great promise, public acceptance of the technology will be required to gain support for the investments needed to successfully deploy such systems. Therefore, the Michigan Department of Transportation (MDOT) asked the Center for Automotive Research (CAR) to conduct a preliminary study on public perceptions of connected vehicle technology.

To complete the research needed to address MDOT's concerns, CAR researchers reviewed literature relevant to public perceptions of systems similar to connected vehicle systems and conducted a set of three focus groups with drivers unfamiliar with connected vehicle technology. The focus group meetings were held at the CAR offices and included a mix of individuals, ranging from college-aged and comfortable with smart phones and other mobile computing devices to older adults less comfortable with new technology. Because the literature on public response to connected vehicle technology proper is sparse to non-existent, the CAR team expanded the search to include perceptions of related and similar technologies.

CAR has completed its study, and this report presents an overview of the key concerns relating to public perceptions of connected vehicles uncovered in the focus groups, the literature, or both. Some key issues noted in the literature included concerns relating to privacy, security, cost, driver distraction, data ownership, and fairness. The focus groups confirmed that security and driver complacency were major concerns among participants. The focus group sessions also revealed that participants found the safety benefits associated with connected vehicle technologies to be very appealing, and overall, if their concerns could be assuaged, participants noted that the benefits outweigh the costs; thus, most of them would consider using it in their own vehicles.

Based on the findings reported here, the CAR researchers believe that additional work should be done to develop more specific strategies to address the concerns outlined in this report. Lessons can be learned from earlier versions of intelligent transportation systems and related technologies (such as electronic toll collection, ETC). ETC, in particular, faced public perception challenges when first introduced, but this technology is now widely deployed and accepted.

INTRODUCTION

Federal and state agencies, in conjunction with private industry, are working to develop and implement connected vehicle technologies. As envisioned, these technologies will enable vehicles to communicate with each other and the roadway for the purpose of achieving safety, mobility, and environmental improvements to vehicle transportation. When fully deployed, connected vehicle technologies are expected to provide drivers with many benefits through the use of applications. These applications could, for instance, help drivers bypass congestion and provide advanced safety warnings, reducing the number and severity of vehicle crashes.

While connected vehicle technologies have great promise, general acceptance will be required to gain support for the investments needed to successfully deploy such systems. This report presents an overview of the concerns affecting the public perception of connected vehicle technologies and, more broadly, intelligent transportation systems (ITS). Building on previous studies and on new focus groups conducted by the Center for Automotive Research (CAR), this report examines concerns that have surrounded previously deployed ITS technologies with similar characteristics to connected vehicle technologies, potential strategies for informing public opinion on connected vehicles, and current perceptions held by members of the public regarding connected vehicles.

CAR conducted this study at the request of the Michigan Department of Transportation (MDOT). The purpose of this research is to aid MDOT in its connected vehicles program. By better understanding the public's sentiment on the technology's appealing features and issues of concern, MDOT and other public and private entities will be better able to design and position technologies and deployments in a manner consistent with gaining public acceptance and support.

The remainder of this report is structured as follows: Section 1 provides an overview of connected vehicle technology basics; Section 2 describes some of the public concerns associated with connected vehicles which have been documented in the literature; Section 3 describes some methods that can be used to gain public acceptance for connected vehicle and ITS applications; Section 4 contains examples of already deployed vehicle technologies which have gained public acceptance despite facing challenges similar to those faced by connected vehicles; Section 5 describes potential connected vehicle regulations; and Section 6 describes the benefits and issues discussed in connected vehicle focus groups conducted by CAR. Appendix A provides lists and defines the acronyms and abbreviations used in this report.

SECTION 1: CONNECTED VEHICLE TECHNOLOGY SYSTEMS

At its most basic, connected vehicle technology consists of two different types of communication, along with the ability to complete transactions wirelessly. The two types of communication are vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication; thus, both mobile and stationary objects participate in the system (see Figure 1 for a high-level illustration of connected vehicle technology). V2V refers to communication directly between vehicles. V2I involves communication between vehicles and the roadway, traffic signals, and other pieces of infrastructure such as bridges. Despite the V2I acronym, this communication actually occurs in both directions – to and from both vehicles and infrastructure (indeed, it could even be infrastructure to infrastructure).

Such communication is made possible by equipping vehicles with a radio that can communicate with similar equipment installed along the roadway and at intersections. The in-vehicle technology used for connected vehicle systems is known cumulatively as on-board units (OBUs). V2V and V2I systems can exist together in the same vehicle and can use either the same radio or separate radios. These systems can enable cooperative, active safety systems in which vehicles can react on their own to avoid crashes when driver reactions would be too slow. Connected vehicles can also provide warnings to drivers, helping them avoid incidents.

The examples shown in Figures 1 and 2 highlight the applications that can be enabled with connected vehicle systems. Vehicle safety, traffic management, roadway asset management, fleet management, tolling and other payments, road-weather detection and information provision, vehicle diagnostics and prognostics, vehicle emis-

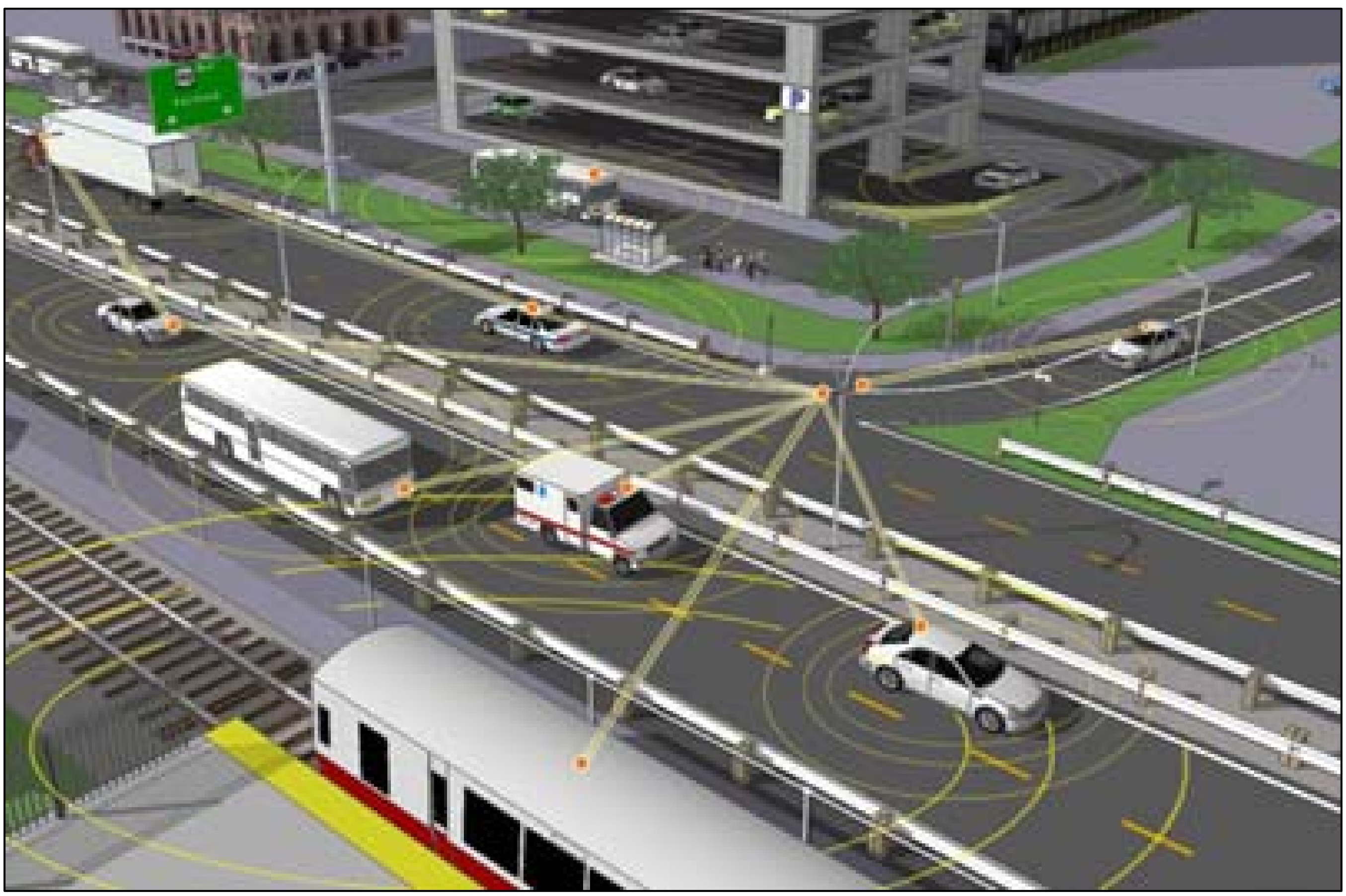

Figure 1: Concept Drawing of Connected Vehicle Technology in Operation
Source: ITS-JPO, February 2012.

sions, vehicle fuel economy, and more are all possible applications. A relatively broad category that does not readily fit into the standard connected vehicle application categories of safety, mobility, and environment is asset management. Asset management includes applications such as pothole detection, highway and bridge health assessments, infrastructure investment planning and fleet management. Applications relating to asset management would typically benefit transportation agencies or fleet managers, but could also benefit automakers monitoring vehicle performance or drivers with maintenance applications.

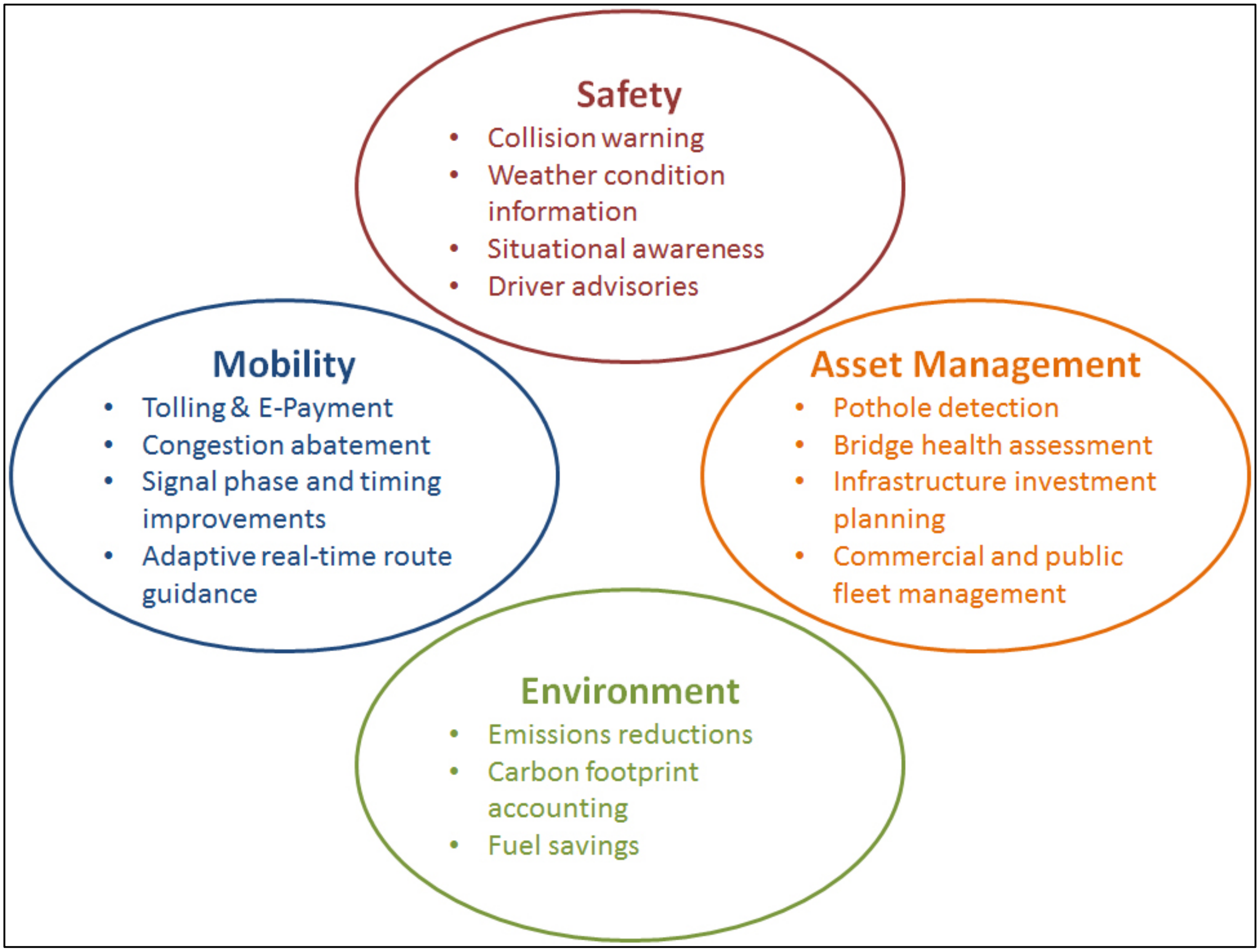

Figure 2: Example Connected Vehicle Applications in Four Domain Areas
Source: CAR Research, September 2011

SECTION 2: PUBLIC PERCEPTIONS OF CONNECTED VEHICLE AND ITS TECHNOLOGY

There are many overarching public perception issues common to the wide range of applications made possible by connected vehicle and ITS technologies. In addition, numerous application-specific issues could arise, such as broad issues of privacy, security, the cost of deploying a system, data ownership, driver distraction, and equity. Due to the wide range of potential applications and technologies, this section will focus on broader public perception issues.

PRIVACY

Privacy is a top concern among the public with regard to ITS applications. The potential uses of data obtained from ITS applications are of concern to both public and private sectors. The public sector is concerned with the potential misuses of the data which could preclude deployment if they are perceived as threats, and once a system is deployed, misuse of data could undermine the system (Persad et al. 2007). The private sector is concerned with issues of personal privacy as well as cases where privacy violations could result in the disclosure of trade secrets. Both public and private interests could benefit from connected vehicle and other ITS applications, but these systems pose threats if privacy concerns are not properly addressed. Privacy concerns should be a central consideration in decisions about how information is collected, archived, and distributed (Briggs and Walton 2000).

Technology, such as a connected vehicle system, that collects detailed travel data raises could violate drivers' expectations of privacy (Sorensen et al. 2010). Because the majority of drivers consider electronic monitoring of their driving a violation of privacy, agencies planning to deploy ITS must address privacy concerns and may have to market the benefits of the program to gain public support before deployment (Persad et al. 2007). Concerns arise about expanded government surveillance capabilities can evoke images of "Big Brother." Data on routes and stops could be potentially embarrassing and harmful if disclosed to third parties (Persad et al. 2007). Access to data could result in a variety of damages such as commercial misuse, public corruption, and identity theft.

The data collected through connected vehicles and other ITS applications could potentially be useful for purposes not related to the drivers themselves. For instance, the data could be used by state departments of transportation or other road managers for analyzing road use patterns and planning maintenance and improvements. Data could also be useful to other users such as university researchers, economic developers, and businesses. However, allowing these users access to data could present some privacy issues, and must be handled with care.

Licensing agreements could allow organizations access to data under controlled conditions and for legitimate purposes. Sharing could be done through the data collecting agency itself, or may involve a third party which would gather data, remove any individually identifiable information, and make it available to interested organizations. Such work is already being done with certain data sets with organizations such as Reebie Associates, SmartRoute Systems, ETAK, and the Texas Transportation Institute (Briggs and Walton 2000).

SECURITY

The ability of hackers to capture data or alter records is a major security issue that must be addressed before a connected vehicle system can be successfully deployed (Persad et al. 2007). If the public perceives a system as being vulnerable to attacks that could affect individual users, public support for the system will suffer. Even a single isolated incident where security is compromised could heavily influence public opinion.

In a connected vehicle study using probe vehicles, the authors found that driver privacy could be compromised because the location and identification data transmitted from their vehicles could be intercepted and used to track individual vehicles or identify drivers' homes (Hoh et al. 2006). The authors suggest to protect against these privacy and security threats that authentication and data analysis be handled by separate entities and that the connected vehicle architecture integrate encryption, tamper-proof hardware, and data sanitization techniques to ensure data integrity. The authors also suggest using data suppression techniques, such as reducing sampling frequency.

Similarly, another study recommends a framework that relies on defense-in-depth, data aggregation near the source, and user defined privacy policies to provide data protection (Duri et al. 2002, 2004). The phrase "defense-in-depth" means that each layer of hardware and software provides its own security functions. Data aggregation near the source implies that rather than having the vehicle transmit large quantities of raw data, the computing system within the vehicle can serve to aggregate the data before sending it on to service providers. User-defined policies allow for specific data handling preferences for each user, these preferences, together with solution provider policies, will form virtual contracts between users and solutions providers.

Raya and Hubaux (2005) emphasize vehicle communication systems using DSRC and describe various threats to vehicle networks. These specific attacks include providing bogus information to other drivers, cheating with positioning information to avoid liability, identifying and tracking of other vehicles, using denial of service attacks to bring down the network, and masquerading as another vehicle. To protect against these attacks, the authors propose security requirements including: vehicle authentication, verification of data consistency, availability, non-repudiation, privacy, and real-time constraints.

COST

An important determinant of the public perception of ITS applications is the cost associated with implementation (Sorensen et al. 2010). While a connected vehicle system may be costly to implement, if the public perceives the benefits as being worth the costs, there may still be widespread support for the system. Public costs will stem from the specialized methods, personnel, and equipment required in deploying, operating, and maintaining a connected vehicle system. The system may require purchasing new equipment and hiring new personnel with specialized skills or allocating resources to train current employees. Initial deployment costs and training requirements could be significant and may require a major upgrade and overhaul of existing databases and security infrastructure.

Costs to the public will be both direct (price premium on vehicles equipped with connected vehicle technology or price of aftermarket equipment) and indirect (taxes or fees to pay for deployment of infrastructure needed for the connected vehicle system). To convince drivers to use connected vehicle technology in their personal vehicles, they will have to perceive the cost of the technology as less than the benefits they accrue through the use of connected vehicle applications.

Beyond getting drivers to adopt the technology in their vehicles, acceptance is needed from the broader public, which through taxes and fees will be funding much of the costs associated with infrastructure deployment. If the proposed connected vehicle system is seen as a waste of public funds, it may be politically difficult to move forward on implementation. To gain broader public acceptance from taxpayers, a connected vehicle system will need to be accessible to a broad range of drivers who perceive benefits from the system and it may need to offer value even to those who do not purchase in-vehicle technology.

GOVERNANCE AND OWNERSHIP OF DATA

The organization(s) in charge of managing and protecting the data will need to be trustworthy in order to gain public acceptance. The public will also need to trust the institutional setup for collection, management, and security. Institutional separation is one design method that could be used to generate trust and support. For instance, if the activities of tracking and identifying vehicles are divided between two different organizations, it diminishes the threat of potential privacy invasion compared to a scenario where the same organization is involved with both tracking and identifying the vehicles (Briggs and Walton 2000).

There has been significant discussion as to whether ITS data ought to be collected and managed by public or private organizations. It is unclear whether the public or private sector is more capable of protecting proprietary data. The argument could be made that private sector organizations would be ethically safer options because federal and state Freedom of Information Act (FOIA) requirements would pose privacy issues, and there are questions of whether data could be more easily used by law enforcement personnel for issuing citations if the data were held by a public organization. On the other hand, public ownership and management of data could be more consistent with the use of ITS data to provide public benefits, and there is concern that the profit-driven private sector may sell data that would not be released by the public sector. When considering the advantages and drawbacks of involving the public and private sector in the collection and management of ITS data, perhaps the most important predictor of how the data will be treated is not whether the organization is public or private, but rather what its goals and operating characteristics are (Briggs and Walton 2000).

While it is unclear whether connected vehicle data held by public entities would be publicly accessible under FOIA, public agencies can take actions to protect the data by requesting rulings from their attorneys general determining whether the data are exempt under current law or by seeking new exemptions from legislatures. It is reasonable to expect that ITS data can be protected from release through FOIA, as FOIA requirements are intended to provide transparency of public institutions rather than release personal information (Briggs and Walton 2000).

It is unlikely that ITS data could be used enforcement purposes or even accessed by law enforcement. None of the public ITS agencies currently allow data to be freely accessed by law enforcement. Data is not used for speeding enforcement purposes and the data that has been used by law enforcement personnel has been for purposes such as apprehending serious criminals and accident investigations. These uses have not received public opposition (Briggs and Walton 2000). States that use ITS data for enforcement purposes make this fact publicly known and make sure that ITS users are not held to a higher standard than others.

The private sector does not have a clear incentive to sell or otherwise use personal data against the wishes of its customers. While those actions could lead to a short term monetary gain by private organizations, it would undermine trustworthiness of the organization. In addition, attracting users to a voluntary private system will likely require contracts that would guarantee security of data and disclose the ways in which data may be used. These contracts and the fear of compromising public trust would discourage the use of data for marketing purposes (Briggs and Walton 2000).

DRIVER DISTRACTION

One of the highest priorities of a connected vehicle deployment is to improve driver safety. If poorly designed, however, technologies and applications that are part of a connected vehicle system could potentially be a cause of, rather than a solution to, driver distraction and compromise safety. In addition, if the user interface is not intuitive enough, drivers may not take advantage of all of the benefits that the system can provide, or they may become confused and fail to understand important notifications. This confusion could result in negative experiences with the system and poor support for widespread deployment.

In 2010, 17 percent of police-reported crashes involved driver distraction (NHTSA 2012). The National Highway Traffic Safety Administration (NHTSA) defines distracted driving as engagement in any of a number of activities that could divert a driver's attention while driving. These activities can include a wide range of distractions such as eating, drinking, talking with passengers, texting, phone use, and in-vehicle use of electronic devices (NHTSA 2011). The severity of the driver distraction associated with a particular activity depends on both the type of distraction (some activities can be more distracting than others) and the frequency and duration of the task (some activities that require frequent or prolonged distraction can be more distracting than others) (NHTSA 2012).

Despite the safety improvements it provides, the introduction of a connected vehicle system could potentially result in visual, manual, or cognitive distraction, creating an unsafe driving environment. While many hands-free technologies for vehicles are intended to eliminate (or at least reduce) the distraction caused by operating many electronic devices, a significant amount of the cognitive distraction caused by using these devices is still present (Harbluk and Noy 2002).

Reducing the amount of distraction caused by the human-machine interface (HMI) is the subject of several studies, and many authors have proposed flexible HMIs that can be reconfigured to address issues with user interfaces (Champoux 2005; DeMelo et al. 2009; Kumar and Kim 2005; Sodnik et al. 2008). Kumar and Kim (2005) found that displaying the speed limit next to the speedometer reduces unintentional speeding and encourages slower driving. The authors suggest that a system displaying such information could use speed limit information from GPS map databases or roadside beacons transmitting data to passing vehicles.

EQUITY/FAIRNESS

The implementation of various ITS applications could raise equity or fairness concerns. The notion of equity suggests that no individual or group should be disproportionately harmed or systematically excluded from the benefits brought about through public investments. Segments of society which may disproportionately receive benefits or experience costs associated with decisions may include groups associated with particular income levels, geographic locations, minority status, and other social categories.

Researchers have identified real or perceived equity issues relating to the proposed implementation of vehicle mileage fee systems to replace gasoline taxes. In those cases, rural and low-income drivers were highlighted as possibly being disproportionately taxed (Baker and Goodin 2011). Similarly, deployment of connected vehicle systems could possibly create equity issues among rural drivers, low-income drivers, and other groups who may feel that investment is not occurring in their communities or for whom the benefits of such a system may not be accessible.

SECTION 3: CONSUMER ACCEPTANCE OF CONNECTED VEHICLES

Before a state develops a connected vehicle system, it should first have a broad based discussion of policy as it relates to public concerns. These discussions will ensure that the design of a connected vehicle system will address public concerns from the outset. In order to have informed discussions with true public participation, significant investment in programs to expose and educate the public about connected vehicle technologies will be required. Providing education and getting stakeholder feedback from a variety of sources such as focus groups, demonstrations, trials, and driver clinics will be essential to successful policy and system design.

General acceptance of and demand for connected vehicle and ITS technologies will depend primarily on three factors: availability, utility, and cost. Consumer adoption requires first that the products and services involved with deployment be made available. Once that condition is met, consumers will be able to decide whether the benefits generated by the system justify the cost in the investment (Hill and Garrett 2011).

PUBLIC EXPOSURE TO CONNECTED VEHICLE TECHNOLOGIES

The rationale for instituting a connected vehicle system will need to be established with the general public. Achieving widespread understanding could require the use of pilot programs, educational initiatives, media outreach, and other methods to convey knowledge. These venues allow experts to demonstrate to the public that a connected vehicle system is a logical, sustainable solution and that the costs of the system are far outweighed by the benefits. To gain public acceptance for a connected vehicle system, such programs must get feedback from stakeholders and fully address any objections presented. Focus group research has shown that drivers would be more accepting of new programs if the reason for the change is clearly explained (Baker and Goodin 2011).

Significant benefits, convenience, and low cost often trump privacy and other public concerns. For instance, credit card use continues to grow despite the fact that using a credit card generates data that could be used to trace where, when, and what business individuals transact (Persad et al. 2007). Credit cards have come to be seen as secure and convenient options for conducting financial transactions. Educational programs that increase familiarity with connected vehicles and effectively communicate the benefits and convenience that can be accrued through the use of connected vehicle technologies will be crucial for gaining public support for system deployment.

Public acceptance may hinge on drivers understanding specifically why data is being collected, feeling that only necessary data is being collected, and perceiving benefits to data collection. If these criteria are not met, the public may not support the use of connected vehicle technology (Briggs and Walton 2000). There is, however, a conflict between fully disclosing all uses of information collected using ITS applications and not wanting to elicit unwarranted public fears (Briggs and Walton 2000). Education programs can serve to assuage these fears, but may be too costly in some cases to be feasible. As a result, some organizations will not want to disclose secondary data uses such as planning and traffic management. Some privacy principles would permit non-identifiable secondary use of data without driver notification (such as ITS America's privacy principles), while others would not (such as ITS America's Fair Information Principles for ITS/CVO), so neither option is without precedent.

IMPORTANCE OF TRIALS

To gain public acceptance, ITS technology needs exploratory trials to examine alternate setups (technical and institutional), these trials should allow participants to try out different options associated with a particular ITS application (Sorensen et al. 2010). A central goal of trials should be to gather information on advantages and limitations of the different configurations such as technical feasibility, cost, administrative complexity, driver response, and public perceptions (Sorensen et al. 2010).

The institution managing these trials (e.g., crafting and issuing requests for proposals, awarding funding, reviewing progress reports, and compiling results) must be credible (impartial and objective). Selecting an entity perceived as biased could have a negative effect on public perceptions and political acceptance. The entity should also be perceived by the public as being unaffected by private lobbying. This institution should also provide high-level policy guidance relating to the results of the trials (Sorensen et al. 2010).

DRIVER ACCEPTANCE CLINICS

Most demonstrations of connected vehicle and ITS applications have focused on proving and presenting technical capabilities to those in the transportation community. Until recently, most connected vehicle testing has been done using trained drivers and experimenters. There has been little testing that has used inexperienced drivers that were not familiar with connected vehicles before test drives. These tests have been limited to closed test populations and self-selected groups (Hill and Garrett 2011).

From August 2011 through January 2012, the Crash Avoidance Metrics Partnership (CAMP) held driver acceptance clinics with naïve drivers that were unfamiliar with connected vehicle technologies. The clinics were held in six different locations across the country including:

- Michigan International Speedway: Brooklyn, MI (August 2011)
- Brainerd International Raceway: Brainerd, MN (September 2011)
- Walt Disney World Speedway: Orlando, FL (October 2011)
- VTTI Smart Road: Blacksburg, VA (November 2011)
- Texas Motor Speedway: Fort Worth, TX (December 2011)
- Alameda Naval Air Station: Alameda, CA (January 2012)

Each clinic involved four days of testing, involved 112 drivers, and used 24 vehicles equipped with connected vehicle technology. Each driver was accompanied by a tester who monitored the drivers throughout the clinic. Care was taken to get a diverse range of driver characteristics such that drivers were evenly divided between genders and spread evenly across different age categories (Ahmed-Zaid 2012). In addition, the clinics targeted different regional populations such as environmentally conscious drivers in California and pickup and sports utility vehicle drivers in Texas (Kuchinskas 2012).

In testing, the vehicles would broadcast information (including brake status, GPS location, rate of acceleration, speed, and steering-wheel angle) ten times each second (Kuchinskas 2012). Each of the eight participating automakers had different systems to provide safety information to drivers; these systems used sounds, lights, displays, and seat vibrations to alert drivers of various threats. Drivers tested several scenarios that involved applications of connected vehicle technology including emergency electronic brake lights, forward collision warning, blind spot warning/lane change warning, do not pass warning, intersection movement assist, and left turn assist (Ahmed-Zaid 2012). After driving through several scenarios, drivers would pull over and testers interviewed them to find out which features seemed useful (Kuchinskas 2012).

After the driver clinic trials, each location hosted a small focus group involving 16 of the drivers that participated in the clinic. The two main points made by the participants were (Ahmed-Zaid 2012):

- When it comes to accident prevention, there is nothing better than defensive driving. Overreliance on technology is bad.
- All vehicles on the road must be equipped with connected vehicle technology for the system to work. Retrofits for older vehicles will be important.

Now that the driver acceptance clinics have been completed, the project's next phase is a yearlong model deployment field test in Ann Arbor, Michigan. Testing will begin in August 2012. The Ann Arbor tests will involve 3,000 vehicles equipped with V2V devices (CAMP will provide 64 of these vehicles, including 16 which were used in the driver acceptance clinics) that will be installed on participants' vehicles and testing will occur on public roads. The tests will include cars, trucks, and transit vehicles (Ahmed-Zaid 2012).

POLICY AND PROGRAMMATIC FEATURES

The design of ITS policy can play a significant role in addressing public concerns over specific technology applications. System development will in large part be public policy driven, meaning that policymakers can address the major issues with effective policy design (Baker and Goodin 2011). Public acceptance issues can be addressed by structuring policies focused on what information is collected, how and for how long it is stored, and who has access to it. In addition to specifying how data can be collected, managed, and used, policy can be used to determine the nature of implementation, such as whether it is voluntary or compulsory, or whether implementation occurs at once or in stages.

Making participation voluntary may reduce the number of users initially, but it could help make the deployment of connected vehicle technology publically acceptable and politically viable (Briggs and Walton 2000). Under a voluntary system, drivers with privacy concerns can hold off on adopting the technology, while others who value the benefits of the system and have little concern can be early adopters. As the penetration rate of connected vehicle technology increases, many drivers who were initially hesitant about the technology may decide to adopt it in their vehicles.

If implementation occurs in stages, it will allow for the public to become comfortable with each stage before proceeding to the next one (Baker and Goodin 2011), thus increasing public support. Tensions between gradual and rapid implementation exist, however, because public support may wane if benefits are not perceived by participants and gradual implementation may postpone some of the perceived benefits of a connected vehicle system.

SECTION 4: PREVIOUSLY DEPLOYED VEHICLE TECHNOLOGY APPLICATIONS

There are many types of already deployed ITS applications that could be considered connected vehicle systems. In some cases, these product offerings have already seen widespread consumer acceptance. For instance, many drivers have advanced navigation systems or telematics systems like OnStar and SYNC (Hill and Garrett 2011). Other applications such as electronic clearance, electronic toll collection, or usage-based insurance are being adopted to save time and money. This section covers a few examples of ITS technologies (usage-based insurance and electronic toll collection) which have been able to gain consumer acceptance despite encountering some of the public perception challenges outlined in Section 2.

USAGE-BASED INSURANCE

Usage-based insurance (UBI), also known as pay-as-you-drive (PAYD), uses technology capable of monitoring driver behavior to help insurance companies better understand risks associated with specific drivers. By opting in to UBI programs, drivers with good driving behaviors (driving less and driving cautiously) can receive discounts from their insurance companies (McQueen 2008). Depending on the program and technology used, insurance providers can measure a variety of driving characteristics such as miles driven, time of day driven, speeding, hard breaking, swerving, and rapid acceleration (ZoomSafer 2011).

Demand for UBI products is relatively high as is consumer acceptance, especially for drivers who believe they can control and improve their driving behavior or feel that they are already better than average drivers (Harbage and Laurie 2011). A report by the Hamilton Project at the Brookings Institution estimated that two-thirds of households would save money on their premiums if they were covered by UBI (Bordoff and Noel 2008). Of the households that could benefit from UBI programs, there would be an estimated savings of approximately $270 per vehicle. Recent studies by Towers Watson, ISO and LexisNexis have all shown that 70-80% of consumers surveyed would consider using UBI. However, when attendees at the Insurance Telematics USA 2011 conference were polled, only about half said they would personally join a UBI program (Shuman 2011).

There is a general concern among the public about the collection and use of driving data, which has prompted many insurers to keep UBI optional and avoid the use of global positioning system (GPS) technology in data collection (McQueen 2008, Harbage and Laurie 2011). Some drivers have noted that they would not participate if GPS had been a component of UBI, voicing invasion of privacy concerns. Some insurers do include GPS technology in their devices, such as the GMAC Insurance Low-Mileage Discount Program with OnStar. OnStar does not continuously track vehicle location; however, it only uses the GPS to locate vehicles when the device is activated by special events, such as crashes or stolen vehicle reports (McQueen 2008). Gaining consumer acceptance may be further complicated concerns about the use of UBI technology for other applications such as instituting a vehicle mileage tax (VMT) or to moderating driver behavior (Shuman 2011).

Early UBI providers included a GMAC program which used data collected using OnStar and Progressive which used an aftermarket device that plugged into the vehicle on-board diagnostics (OBD) port and could later be uploaded to a computer (McQueen 2008). Since then, many other insurance providers have begun offering UBI programs such that, together, the automotive insurers that offer UBI represent more than 60% of the United States. These insurers include Allstate, Am. Family, CSAA, Esurance, GMAC, Liberty Mutual, MileMeter, Nationwide, Progressive, The Hartford, Travelers, State Farm, and SoCal AAA (Harbage and Laurie 2011).

Consumers who use UBI programs tend to be self-selected safe drivers. In addition, UBI programs may have safer drivers because the knowledge of being monitored could influence actual driving behavior, making drivers safer and directly reducing potential costs to insurers. This impact has already been seen with commercial vehicle operators that are already using feedback from monitoring technology to reduce accident risks. As UBI programs have developed, insurance companies have been able to further improve safety by offering consumer services using UBI technology. These services include teen safety applications, automatic notification for emergency assistance, theft tracking, and driver performance coaching (Harbage and Laurie 2011).

ELECTRONIC TOLL COLLECTION

Another application of ITS that has seen successful deployment in the United States is electronic tolling collection (ETC) such as E-ZPass. The general setup of an ETC involves a toll booth that has specially outfitted lanes that have antennas positioned above each toll lane that can interact with transponders located inside vehicles to process tolls electronically. To do this, the antenna identifies the transponder and reads account information stored on the device and corroborates this information with information stored on a central database, then deducts the appropriate toll amount from the account associated with the transponder.

Some civil liberties and privacy rights advocates have expressed concern about the data collected using ETC systems. For instance, in several states where ETC systems exist, data collected by these systems has been subpoenaed by criminal as well as civil courts (Newmarker 2007). Beyond court use, there is some concern that the data is being collected and used for purposes other than just toll transactions. Position data can be collected in locations outside of the toll plazas and used to provide travel time estimates along certain routes and assist with traffic management activities. While ETC transponders are used for these applications in New York, for instance, driver privacy is protected by encrypting the data and deleting it soon after it is received. In addition, individual vehicle information is not made available to government agencies (Breen 2007). There have also been longstanding concerns that ETC technology will be used to issue speeding tickets; however, agencies have repeatedly denied any plans to use ETC data to issue traffic citations (Weibezahl 2007).

The goal of electronic toll collection is to make traffic flow faster by streamlining the toll collection process. In addition, the toll collection agency's costs of toll transactions are reduced because labor hours spent collecting tolls can be reduced (Hill and Garrett 2011). In addition, ETC can be used to help alleviate congestion along toll roads, reducing the need to build additional infrastructure, also saving money for the collecting agency.

In areas where ETC has been implemented, consumer acceptance has been high, especially among commuters who regularly use toll roads. For frequent toll road users, using ETC allows them to save time on daily commutes as well as money paid to toll collectors. High consumer acceptance of ETC in the U.S. implies that consumers will likely be willing to use other ITS technologies, such as connected vehicle technologies, that can provide obvious benefits to drivers (Hill and Garrett 2011).

SECTION 5: REGULATIONS FOR CONNECTED VEHICLE TECHNOLOGIES

In 2013 NHTSA will make a decision whether or not to create requirements involving connected vehicle technology in light vehicles. That decision will be followed by a 2014 agency decision on whether or not to make a ruling regulating such technology in heavy vehicles. Such regulations could have a dramatic effect on deployment of connected vehicle technology, and as more vehicles on the road are outfitted with V2V and V2I capabilities, positive networking effects will enhance the value that the systems provide. Consumers, seeing the benefits created by connected vehicle systems, will be more likely to accept the technologies and add connected vehicle devices to their current vehicles, driving trade in connected vehicle aftermarket devices.

Public acceptance of connected vehicles and its effect on adoption may be less of an issue if the government mandates its inclusion in new vehicles for safety purposes. Many of the same issues such as security, privacy, availability, cost, and value will still need to be addressed in evaluations leading up to the mandate, but there will be less need for direct consumer outreach and education (Hill and Garrett 2011). In the absence of such a mandate, public acceptance and adoption of connected vehicle technology will likely follow the pattern of other voluntary ITS technologies such as usage-based insurance and electronic tolling. Unlike other ITS applications, however, the broad range of applications offered by connected vehicle technology could serve as a greater incentive for automakers to include these systems initially in luxury vehicles and, over the years, in less expensive models.

SECTION 6: FOCUS GROUPS

As part of this study, CAR conducted a series of three focus groups geared towards gaining a better understanding of public perceptions of connected vehicle technology. Each focus group involved a short presentation covering the basics of connected vehicle systems followed by a directed discussion on the topic. During each session, detailed notes were taken, recording the participants' comments. At the conclusion of each session, participants were asked to rate how appealing or concerning they considered various aspects of connected vehicle technology, and these ratings were then collected and recorded. A total of 14 people participated in the groups.

PARTICIPANT RATINGS OF BENEFITS AND CONCERNS

The benefits and issues discussed during each session were somewhat unique to each particular session, and as such, each session had a slightly different list of benefits and issues to rate. There were, however, several common themes which were brought up in each session, and these overarching issues are discussed in detail and analyzed on the basis of participant demographic data in the following subsections.

OVERALL RATINGS

Benefits relating to safety, mobility, and environmental performance were discussed in all three focus groups. Of these three types of benefits, participants rated safety as the most appealing, followed by mobility and environmental performance. All three benefits were rated by most participants as appealing (a 4 or 5 on a scale of 1-5, where 5 indicates very appealing and 1 indicates not at all appealing). Across the three benefits, less than 12 percent of the ratings were neutral (3) and none of the participants selected a 1 or 2 rating. Participants' overall ratings of benefits can be seen in Figure 3 below.

There were five concerns that were discussed and rated in all three focus group sessions, and they included issues relating to security, driver distraction, complacency, cost, and privacy. Of the five issues, security was rated as the top issue, followed by driver distraction and complacency. Cost and privacy were discussed as issues, but 50 percent or fewer of the participants rated them as concerning (a 4 or 5 on a 1-5 scale where 5 indicates very concerning and 1 indicated not at all concerning). Participants' overall ratings of concerns can be seen in Figure 4.

In addition to the benefits and concerns that were discussed in all sections, several aspects of connected vehicle systems were brought up in just one or two of the focus groups. Beyond safety, mobility, and environmental performance, other benefits discussed included pedestrian safety devices or crosswalk infrastructure, driver comfort, driver peace of mind, law enforcement use, and diagnostics. Pedestrian/crosswalk safety, driver peace-of-mind, law enforcement use, and diagnostics were generally considered worthwhile

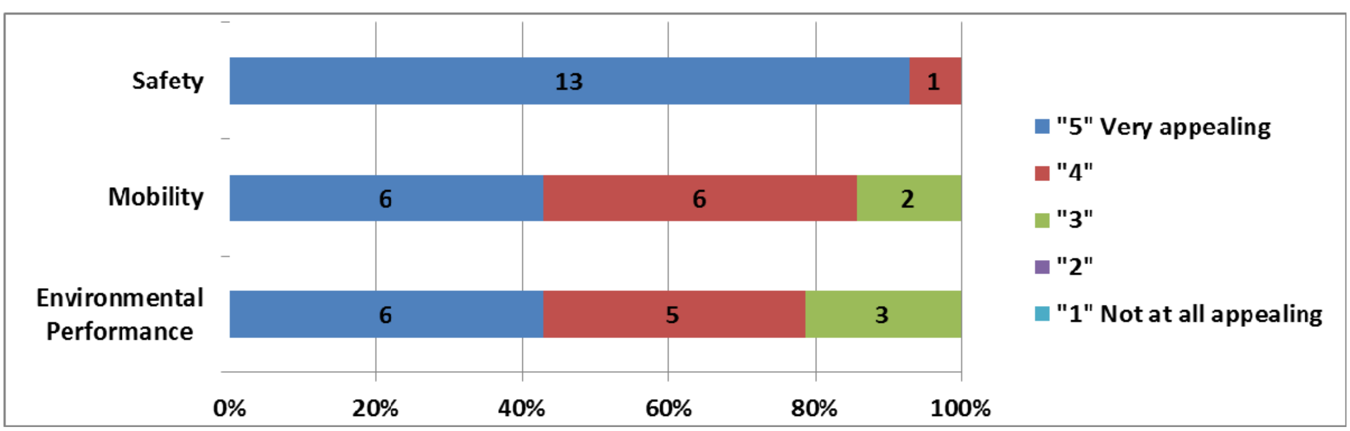

Figure 3: Overall Participant Ratings of Benefits
Source: CAR, May 2011

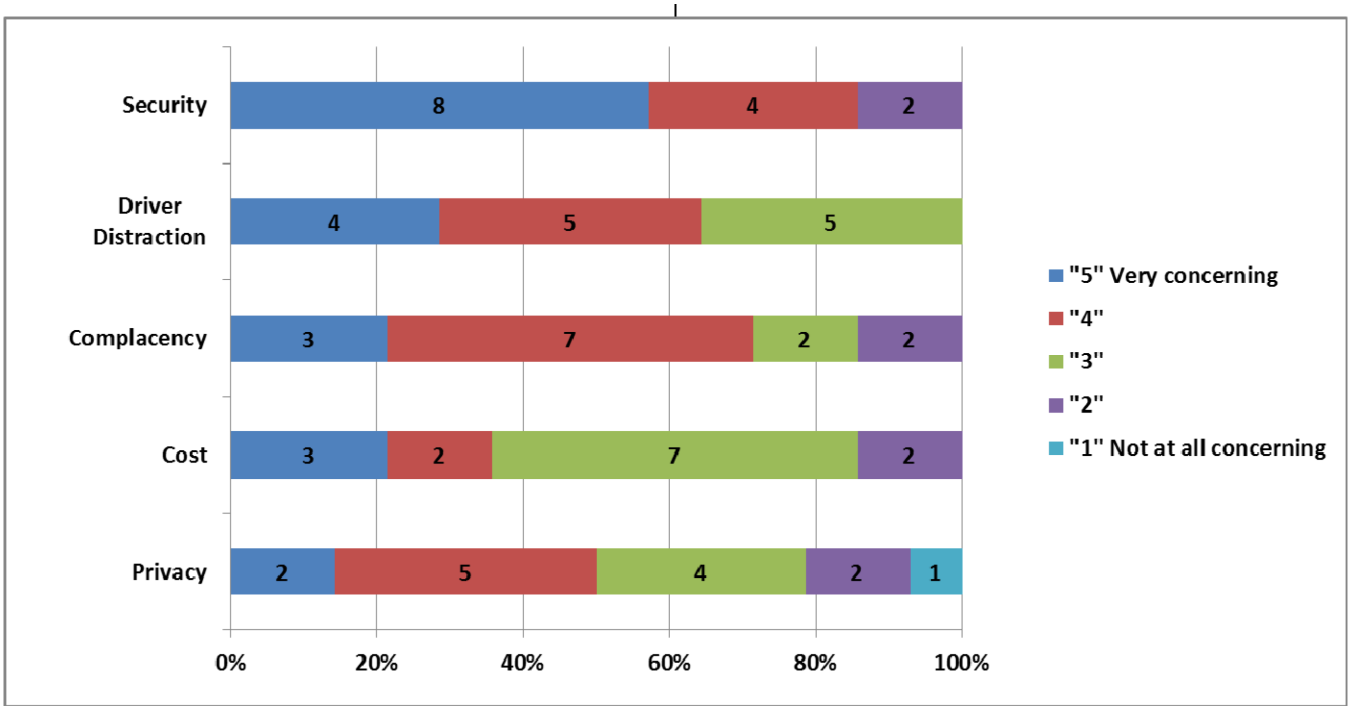

Figure 4: Overall Participant Ratings of Concerns
Source: CAR, May 2011

benefits and were rated as appealing or very appealing by most participants; on the other hand, comfort received more neutral ratings from participants.

Other concerns beyond those discussed above included functionality, retrofitting, law enforcement abuse, human override, market penetration, and bandwidth availability. Participants generally rated functionality, law enforcement abuse, and human override as concerning or very concerning. Retrofitting was rated as a concern for some, neutral for others, and not a concern for some. Market penetration and bandwidth issues were generally rated as not being very concerning for participants.

A major concern relating to functionality was what would happen if connected vehicle systems fail. Participants noted that if drivers became overly dependent on the technology but then something malfunctioned there could be serious, negative consequences. Some noted that new technologies always have bugs that need to be fixed, but that failure of connected vehicle technology is uniquely dangerous since it involves driving. One participant also noted that it would be difficult to replace a vehicle if some technology failure would render it inoperable. Another participant astutely brought up concerns over how insurance would work with this technology, and who would be liable in a crash scenario. This issue in particular will have to be determined before any widespread technology deployment is achieved.

Much of the discussion on human override involved participants expressing a desire to have some ability to deactivate their connected vehicle system. A few participants indicated that an override option would be required for their acceptance; however this requirement was less important if systems did not have the ability to autonomously control the vehicle (e.g. automatically applying the brakes when dangerous situations are detected rather than just issuing a warning using visual, audio, or haptic cues). In addition, participants in one focus group mentioned that having the ability to customize warnings (not necessarily the option to turn off warnings, but to adjust settings of audio, visual, and haptic cues) would help mitigate some resistance to connected vehicle systems in their vehicles.

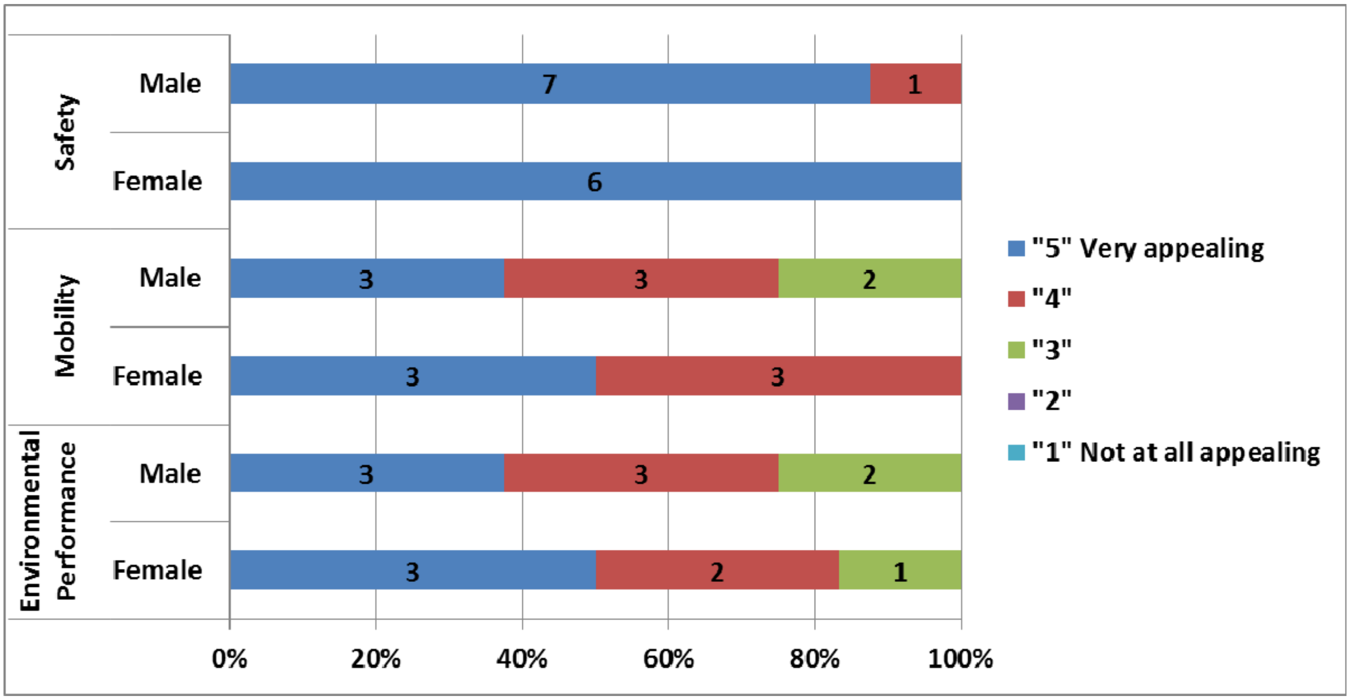

Figure 5: Participant Ratings of Benefits by Gender
Source: CAR, May 2011

RATINGS BY GENDER

Males and females have similar opinions when it comes to the benefits of safety, mobility, and environmental performance, though males tend to rate all three categories as slightly less appealing than do females. Participants' ratings of benefits organized by gender can be seen in Figure 5 below.

For the most part, males and females have similar concerns regarding security and driver distraction. On the issues of cost, complacency, and privacy, however, participants' views differed on gender lines. Females were more concerned than males about the potential cost to purchase and install the new technology. Males were more concerned about issues arising from increased driver complacency on the road as well as the potential for privacy invasion as a result of the technology. Participants' ratings of concerns organized by gender can be seen in Figure 6.

RATINGS BY AGE GROUP

To compare differences across age group, participants were classified as being 40-years-old or younger or over 40-years-old. Due to the smaller sample size of the participants identified as over 40-years-old, it was difficult to make inferences as to trends based on age. The two age groups found most benefits similarly appealing. Among both groups, more participants rated safety as more appealing than mobility, and mobility as more appealing than environmental performance. The biggest difference for ratings in benefits is that the older participants tended to rate mobility as appealing, while the majority of the younger participants rated mobility benefits as very appealing. Participants' ratings of benefits organized by age group can be seen in Figure 7.

The two age groups were similarly concerned for most potential issues. Older participants were somewhat less concerned about driver complacency compared to the younger participants. Participants' ratings of concerns organized by age group can be seen in Figure 8.

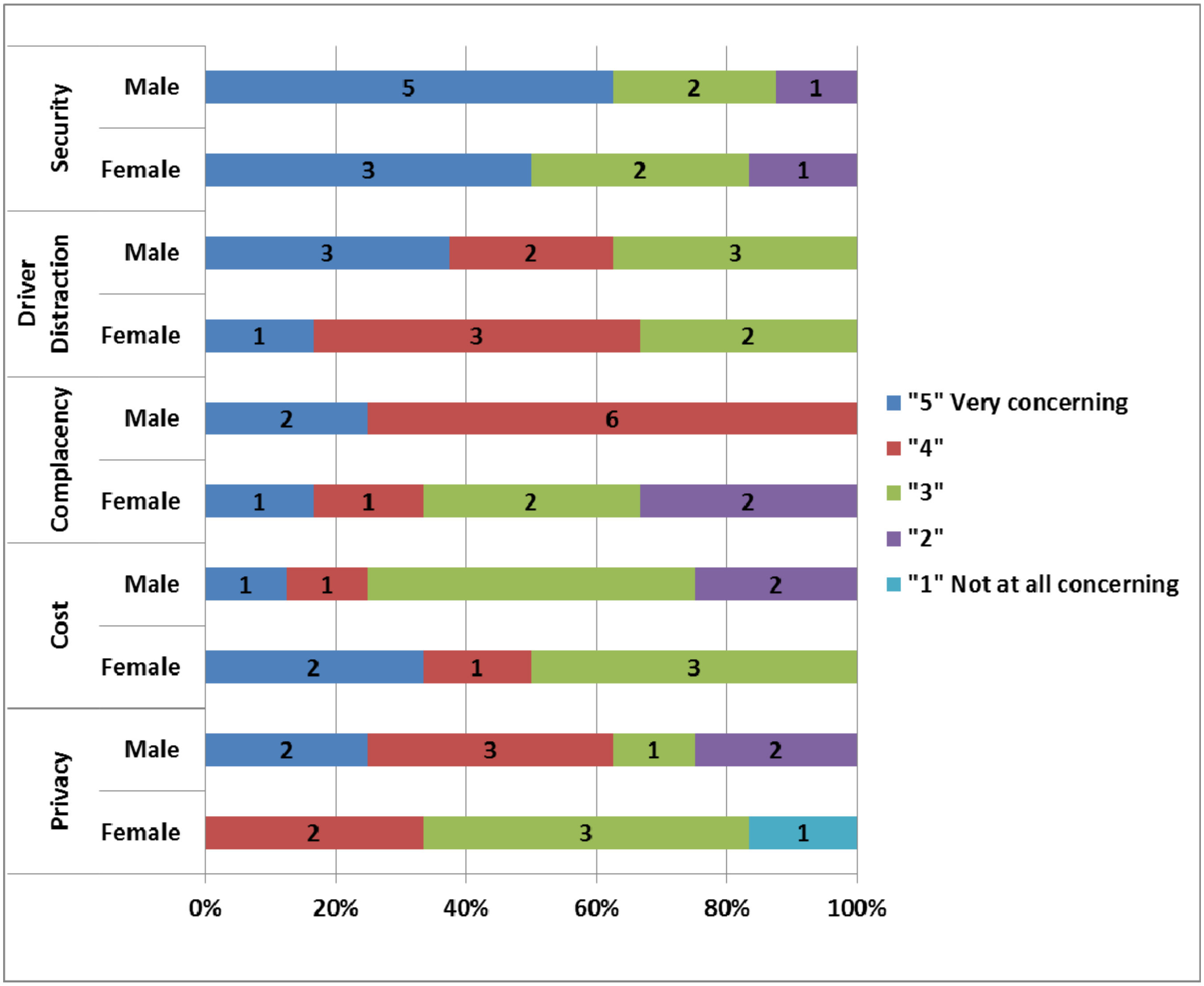

Figure 6: Participant Ratings of Concerns by Gender
Source: CAR, May 2011

RATINGS BY EDUCATIONAL ATTAINMENT

Due to the smaller sample size of the participants identified as having less than a 4-year college degree it was difficult to make inferences as to trends based on education. The two educational attainment groups found most benefits similarly appealing. The biggest difference for ratings in benefits is that the participants with college degrees tended to rate environmental performance as more appealing than did those without college degrees. Participants' ratings of benefits organized by educational attainment can be seen in Figure 9.

The two educational attainment groups found most issues similarly concerning. The biggest difference for ratings was that the those with college degrees tended be less concerned about issues relating to privacy and security and more concerned about the potential for driver complacency than their peers without college degrees. Participants' ratings of concerns organized by educational attainment can be seen in Figure 10.

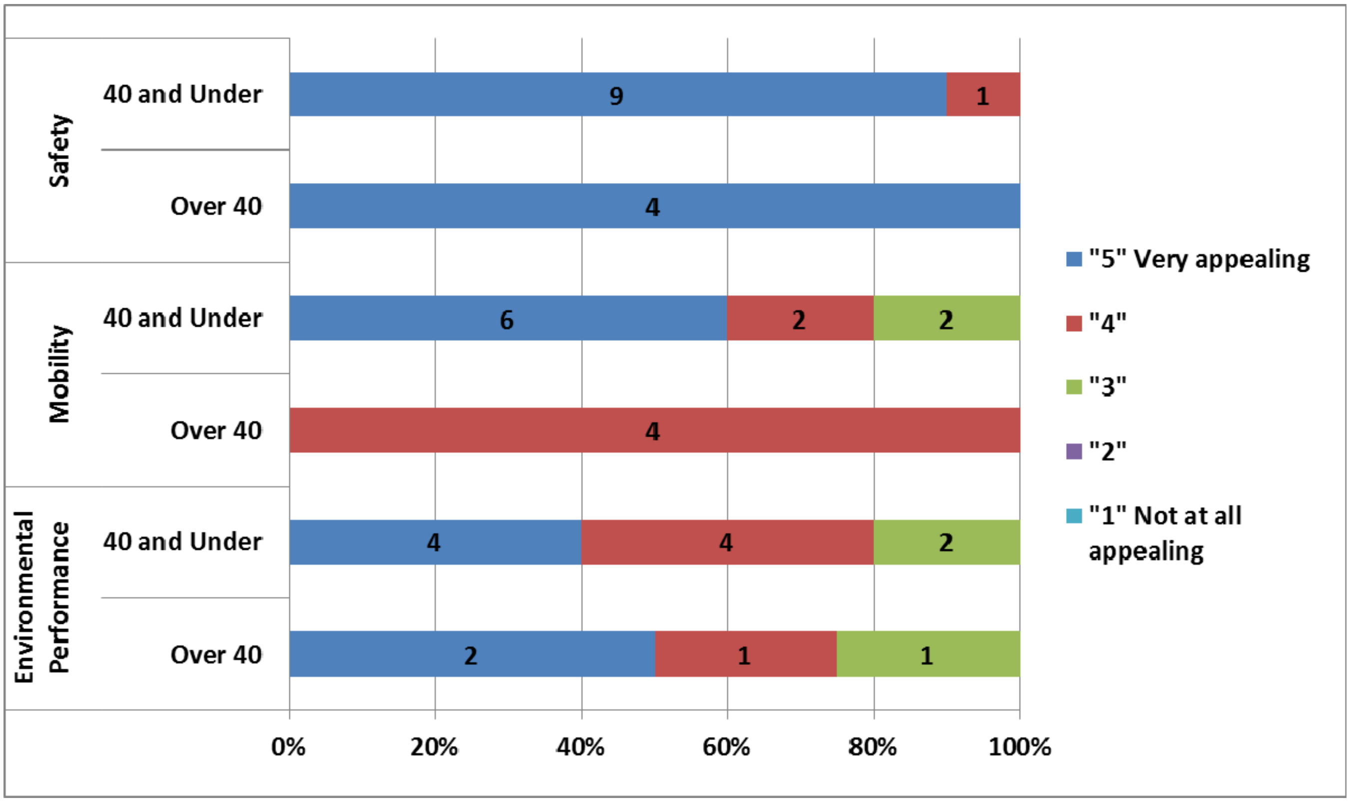

Figure 7: Participant Ratings of Benefits by Age Group
Source: CAR, May 2011

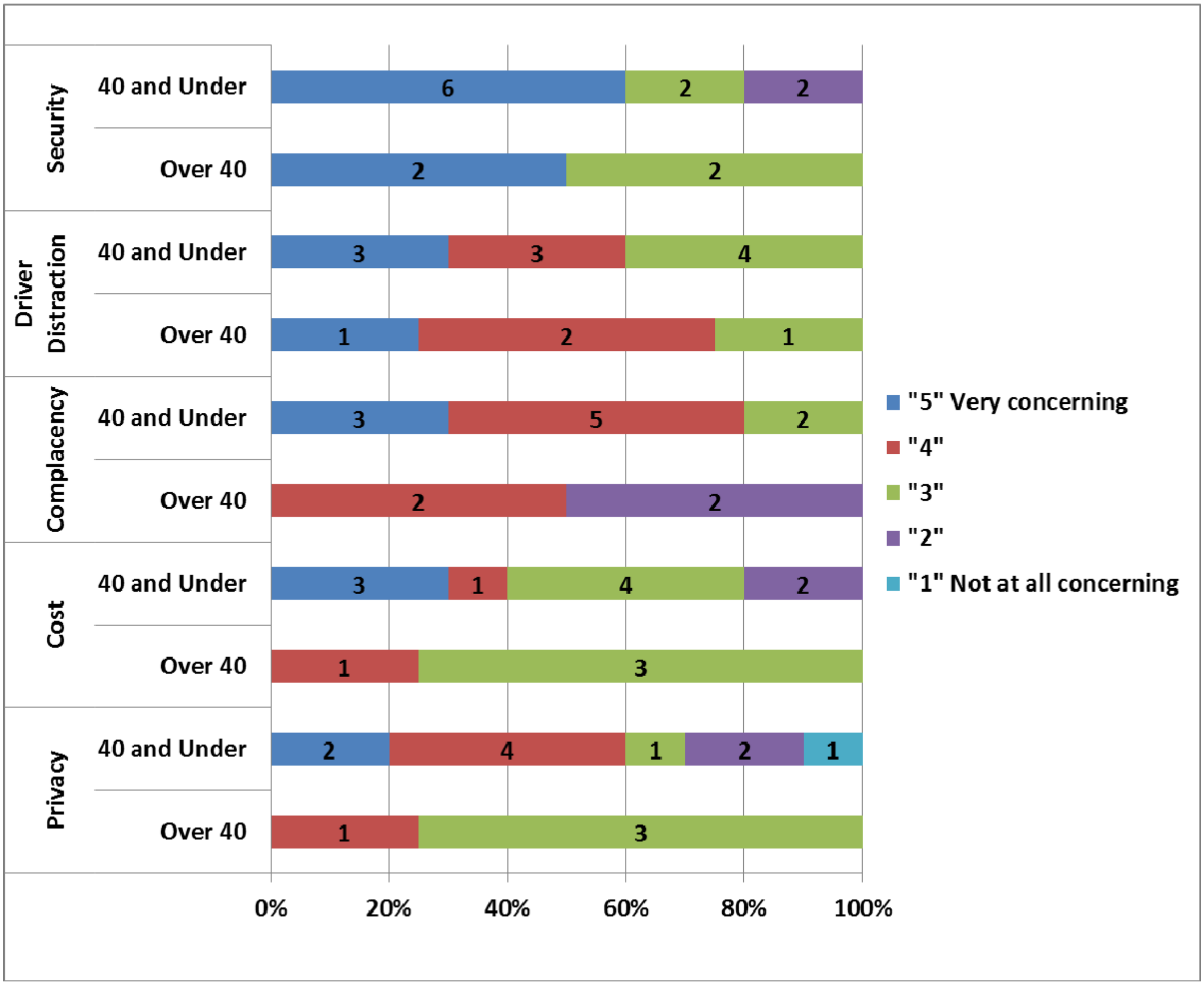

Figure 8: Participant Ratings of Concerns by Age Group
Source: CAR, May 2011

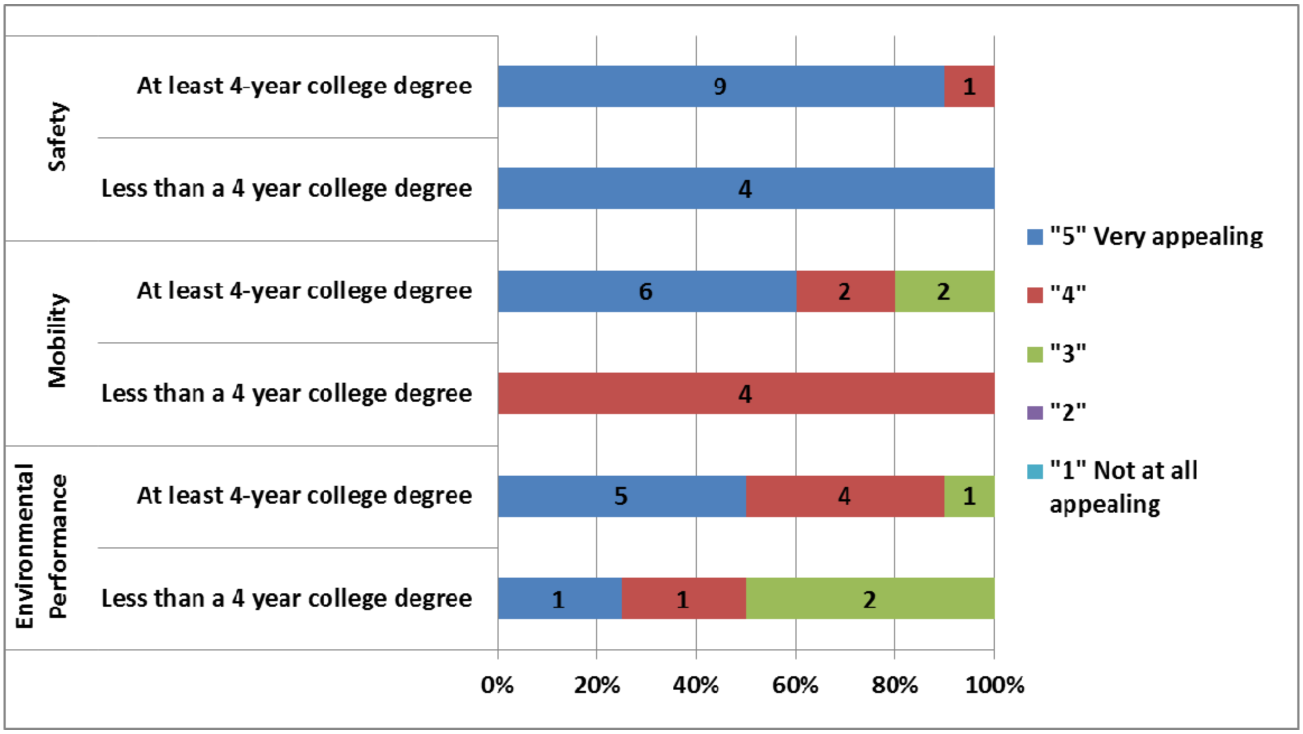

Figure 9: Participant Ratings of Benefits by Educational Attainment
Source: CAR, May 2011

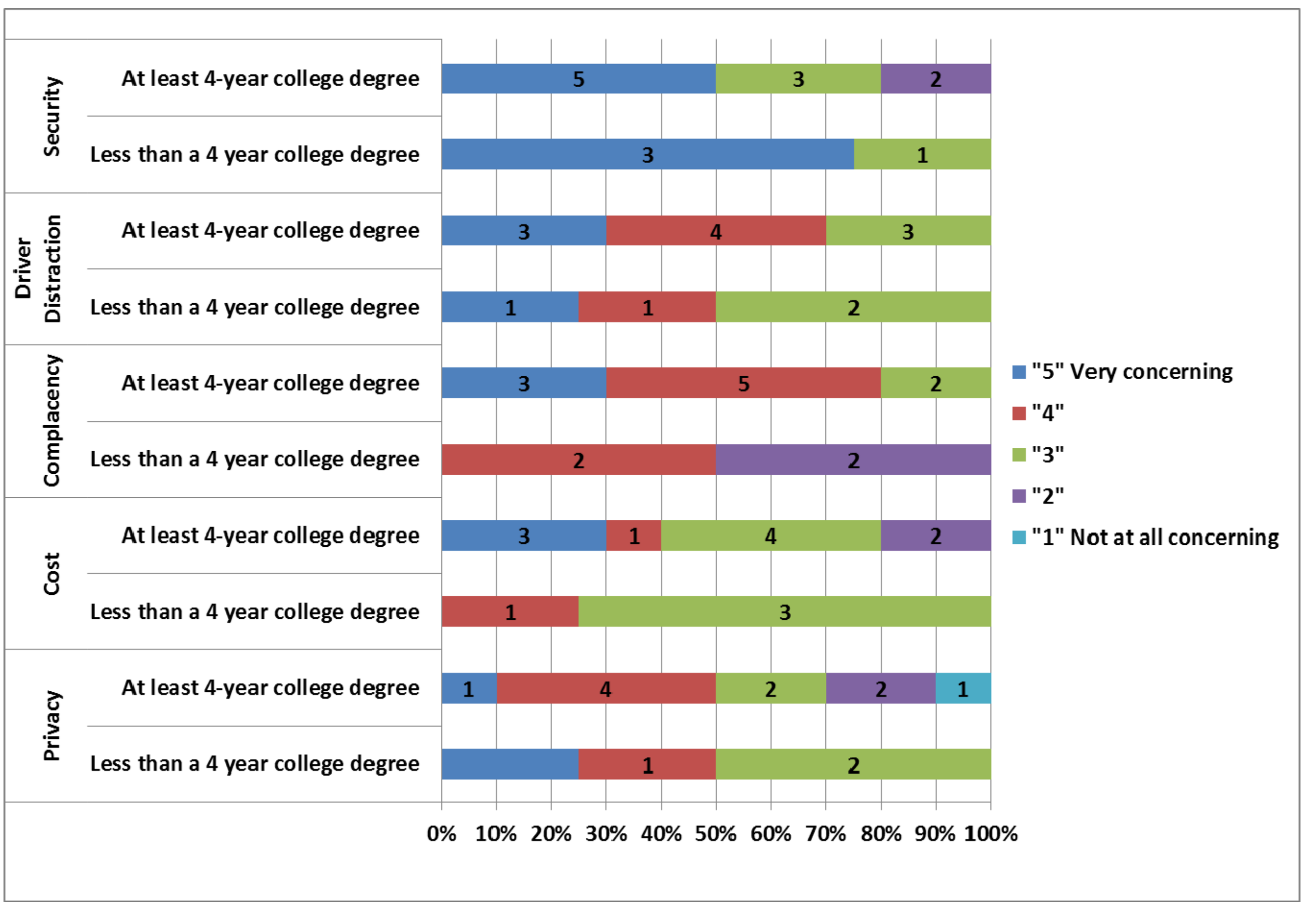

Figure 10: Participant Ratings of Concerns by Educational Attainment
Source: CAR, May 2011

CONCLUSIONS

As envisioned, connected vehicle technology will enable vehicles to communicate with each other and the roadways they traverse, resulting in improved safety, mobility, and environmental performance in surface transportation systems. This vision, shared by public and private entities alike, will require widespread public acceptance and support if it is ever to be fully realized. To gain acceptance for connected vehicle systems, advocates will need to address numerous concerns associated with the technology and demonstrate, through trials, clinics, and education programs, that risks and other costs have been properly mitigated.

This report has presented an overview of the key concerns relating to public perceptions of connected vehicles. Some key issues noted in the literature included concerns relating to privacy, security, cost, driver distraction, data ownership, and fairness. The focus groups confirmed that security and driver complacency were major concerns among participants. The focus group sessions also revealed that participants found the safety benefits associated with connected vehicle technologies to be very appealing, and overall, if their concerns could be assuaged, participants noted that the benefits outweigh the costs and they would consider using it in their own vehicles.

Additional work should be done to more specifically develop strategies to handle the concerns outlined in this report. Previous sections have addressed potential methods of engaging the public and gaining broad acceptance for deployment, as well as outlined ITS and vehicle telematics technologies, such as UBI and ETC, which have involved similar public concerns, but have overcome these concerns and gained public acceptance and achieved successful deployment. Expanding on these general ideas and case studies, future research could examine the public perception challenges faced by a Michigan connected vehicle deployment and the potential to resolve concerns and leverage previous work to gain broad acceptance for the technology.

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APPENDIX A: ACRONYMS AND ABBREVIATIONS

AASHTO – American Association of State Highway and Transportation Officials

CAMP – Crash Avoidance Metrics Partnership

CAR – Center for Automotive Research

DOT – Department of Transportation

DSRC – Dedicated Short-Range Communication

FHWA – Federal Highway Administration

ITS – Intelligent Transportation Systems

ITS-JPO – Intelligent Transportation Systems Joint Program Office

NHTSA – National Highway Traffic Safety Administration

OBU – On-Board Unit

RITA – Research and Innovative Technology Administration

V2I – Vehicle-to-Infrastructure

V2V – Vehicle-to-Vehicle