Preparing a Roadmap for Connected Vehicle/Cooperative Systems Deployment Scenarios: Case Study of the State of Oregon, USA

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Abstract
Safety remains a problem on U.S. roadways, with more than 32,000 fatalities, 2.2 million injuries and 6 million crashes each year. Travelers, shippers and the economy are exposed to increasing amounts of congestion, unreliability, delay, emissions and excess energy consumption, which impede the efficient movement of people and goods. The U.S. Department of Transportation (DOT) had embarked upon a major research program toward implementing connected vehicle safety technologies, applications and systems using dedicated, short-range wireless communications (DSRC). Previous research by the National Highway Traffic Safety Administration (NHTSA) demonstrated that 80% of unimpaired driver crash types could be addressed by the connected vehicle technology. Through the year-long Safety Pilot that took place in Michigan from 2012 to 2013, U.S. DOT tested the effectiveness of wireless connected vehicle technology in real-world, multimodal driving conditions; collecting data about how ordinary drivers adapt to the use of connected vehicle technology; and identifying the potential safety benefits of connected vehicle technology. This work was performed in recognition of a February 3, 2014 NHTSA agency decision for light vehicles and a similar decision expected soon for commercial vehicles that will likely launch regulatory processes to require or incentivize all new vehicles to be equipped with DSRC devices. Communication among and between vehicles and the infrastructure (including traffic signals, work zone equipment, or pavement sensors, and other infrastructure elements) would also have data and mobility benefits (including data-driven applications such as traveler information for freight and passengers, transit operations, network flow optimization, traffic signal systems and incident response, emergency staging, and evacuation as well as sustainability-related applications). This paper describes an ongoing effort to explore opportunities for the state of Oregon, USA, to participate in future funded pilot deployments of mobility and environmental related applications in the coming years—possibly including a set of regional pilots as well as smaller, more self-contained projects focused on priority applications. As connected vehicle research moves into deployment, state, local and transit agencies, Metropolitan Planning

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Organizations and the private sector will start experiencing the effects of vehicles, after-market devices, mobile devices, and infrastructure with DSRC and other wireless connectivity at their cores. Along with other states and regions, the Oregon Department of Transportation (ODOT) can benefit from preliminary scoping, evaluation, and assessment of the impact of connected vehicles and infrastructure and a wide range of potential cooperative system applications. With this in mind, ODOT can determine whether or not to pursue the next phases of federal connected vehicle application funding. It can also make an informed choice about taking a potential national leadership role in the connected vehicle arena, and assess opportunities to join projects with other partners. This paper provides a summary of an internal survey conducted within ODOT along with insights gained from the analysis of the survey results. Next steps in the process are also described.

Keywords: connected vehicles, cooperative systems, state department of transportation, deployment roadmap

1 Introduction

The U.S. Department of Transportation (DOT) is currently making decisions on funding future pilot deployments of mobility and environmentally related connected vehicle applications (DOT ITSJPO). With connected vehicle research transitioning into the deployment stage, the private sector, MPOs, and state, local, and transit agencies will start experiencing pressure to incorporate these vehicles into the public fleet. This pressure is due to aftermarket devices, mobile devices, and infrastructure with dedicated short range communications (DSRC) and other wireless connectivity at their cores.

The Oregon Department of Transportation (ODOT) has been laying the groundwork for Oregon to be prepared for the future implementation of a connected vehicle/cooperative systems transportation portfolio. Through several avenues, including a funded research project and an internal working group, ODOT is considering whether to take an early national leadership role and/or to avoid being caught by surprise as developments in this area evolve quickly. This has been done by assessing ODOT’s current internal mechanisms for addressing connected vehicle/cooperative systems including consideration of technical readiness/compatibility, planning, operational, maintenance, and governance perspectives. Included is attention to ODOT’s fleet, and potential for connection to Driver and Motor Vehicle Services Division (DMV) operations. With this in mind, Oregon can determine whether or not to pursue the next phases of federal connected vehicle application funding, among other initiatives.

The objective of this paper is to describe the development and results of an internal survey that contributes towards the establishment of an internal inventory of the current technical and “cultural” status of ODOT activities in the context of connected and automated vehicles. From this assessment, we will gain a sense of interest and readiness for potential alignment with potential applications and the future of connected vehicles. Existing internal organizations were leveraged for input on survey questions and have received the survey results. This analysis may be useful for other states and transportation agencies that are currently grappling with these issues.

The research team worked closely with ODOT staff to design the survey. The first set of surveys were distributed at meetings of the Intelligent Transportation Systems (ITS) Opportunities Team (ITOT), the Technical Leadership Team, the Planning Business Leadership Team, the Maintenance and Operations Meeting, the Traffic Operations Leadership Team and key players from the Intermodal Leadership Team. Further contacts with ODOT staff from all regions (urban/rural) were performed via an online version of the survey. In total, there were 115 survey responses collected including 47 paper-based survey and 68 online responses. As a caveat, we note that there are about 4,600 total ODOT employees, so this was not a scientific or random sample of employees, but rather a means of providing education about the ongoing connected vehicle research project and obtaining feedback from key staff.
2 Methodology

Other surveys have been performed to gauge national level readiness for the deployment of connected and automated vehicles (UMTRI-2014-10, 2014) (UMTRI-2014-21, 2014). The survey that was distributed within ODOT consisted of two sections. The first section provided background information regarding connected vehicles (CVs) technologies and the benefits that will likely be available through CV implementation. The subjects were asked detailed questions concerning connected vehicles. These questions were used to gauge ODOT staff’s diverse personal knowledge, the general perception, and concerns regarding CVs and their prospective deployment. In terms of an ODOT employee’s ready knowledge of CVs, the team asked questions about the subject's awareness of the needed technologies needed to implement CVs, their opinion whether ODOT was prepared for CVs to be on public roads, and if they had heard about CVs before this survey was conducted. To assess a subject's general perception of CVs, a series of questions were directed towards how the subject rated CVs benefits. They were then asked about the readiness of ODOT for the implementation, and ODOT's technical preparedness for the arrival of CVs. Lastly, to address the subject’s concerns about CVs, the survey outlined detailed potential concerns that the public, ODOT managers, and the team may have about CVs. The second portion of this survey focused on automated vehicles. However, this paper focuses on the results from the CV portion of the survey.

Embedded in the survey was an option offered to each question for any specific comments that the respondent had. The survey also included a question about which division or section within ODOT the subject worked. Lastly, the team posed a question towards the subjects to identify which division within ODOT that should have the highest priority for preparing for CVs if investments were to be

![Survey respondents' ODOT division](image_url)
made. Included with the survey was a brief (256 word) introduction to CVs, which covered their safety, mobility, and environmental benefits and applications.

3 Results

The survey questions and detailed results of the potential benefits and envisioned issues with connected vehicles have been documented (Bertini et al, 2015), and the primary lessons learned are presented below. The survey indicates that of the 115 survey respondents, the largest number works in the Highway Division (37%), followed by Central Services and the Transportation Development Division (9% each). See Figure 1 for a complete breakdown.

The majority (93%) of the respondents had some prior knowledge of connected vehicles and had generally positive opinions regarding them (37% very positive and 45% somewhat positive) with only a very small proportion (2%) holding a very negative opinion. As far as the potential for benefits of using connected vehicles, more than half of the respondents believe that they are somewhat or very likely, with the exceptions of reduced driver distraction (61% somewhat or very unlikely) and reduced agency costs (55% somewhat or very unlikely). A total of 92% of respondents indicate that the safety benefits (reduced crashes) are somewhat or very likely. Opinions were divided regarding the potential for reduced insurance rates, where 40% of the respondents believe they are somewhat likely and 34% of the respondents believe they are somewhat unlikely. See Figure 2.
Figure 2: Likely benefits when using connected vehicles
Figure 3: Issues related to connected vehicles.
Next, respondents were asked about concerns related to connected vehicles. Overall system cyber security was the largest concern with 40% moderately concerned and 39% very concerned. A total of 44% were very concerned about driver overreliance on technology. Other notable concerns included safety consequences of system failure (39% very concerned and 35% moderately concerned) and vehicle cyber security (37% very concerned and 34% moderately concerned). Nearly 40% expressed high levels of concern for both data privacy and interacting with pedestrians/bicyclists. Only 6% are very concerned about learning to use connected vehicles. See Figure 3.

More than 70% of the respondents held a positive attitude (very promising to somewhat promising) for the involvement of ODOT in the development of the infrastructure of connected vehicles with 22% of the respondents remaining neutral. See Figure 4.

About 45% of the respondents are skeptical regarding ODOT’s technical preparedness for connected vehicles, with 24% having a neutral stand and 28% considering it somewhat promising. For ODOT’s cultural preparedness, 55% of the respondents believe that the agency is not prepared, and interestingly, 16% of the respondents did not answer the question. See Figure 5.

Figure 4: Responses to the question: “How promising would it be if ODOT were to become engaged with development of connected vehicle related infrastructure?”
When asked about which division of ODOT should receive the highest priority for connected vehicle preparation, the largest response was for the Transportation Development Division (TDD), at 26%. TDD includes sections and units related to Research, Planning, Transportation Data and Active Transportation. A total of 23% of the respondents indicated "None," with the next largest groups mentioning Safety, Central Services and the Office of the Director. Respondents were asked to think about choosing one area to invest in for technical preparation for connected vehicles. A total of 13% of respondents chose None/Don't Know or did not answer. The next largest groupings aimed at efforts to
monitor technology, invest in Intelligent Transportation Systems (ITS) and/or traffic signals, planning/research, safety/security and data management/GIS. See Figure 6.

In terms of “cultural” preparation for connected vehicles, 23% of respondents mentioned training and education, and 12% mentioned outreach and public information. The area of safety and enforcement received an 8% response. Others emphasized the need to examine potential legislation, regulation and liability issues.

Figure 6: ODOT division priority for preparing for connected vehicles

A question was asked about potential ODOT investment in preparation for connected vehicles—no specific dollar amounts were specified here, but the notion of investment could take many forms. Examples could include allocation of staff for monitoring technological developments and inclusion of extra space and power sockets in traffic signal controller cabinets or other roadside hardware construction. Investment could also include “in kind” participation and contribution to a potential U.S. DOT CV Pilot project. Approximately three quarters (73%) of the respondents believe that ODOT should invest financially into preparing for connected vehicles. Along these lines 75% of respondents felt that ODOT should in fact play a role in upcoming U.S. DOT connected vehicle pilots. One fourth
of respondents felt that safety/security would be a worthwhile and promising area to pursue for a connected vehicle pilot. Some specifically mentioned an urban pilot (7%), others mentioned a rural pilot (7%) and others favored a pilot focusing on a corridor (5%). Other categories receiving notable responses included planning/bicycle/pedestrian (5%), fleets/freight (5%) and ITS/traffic management (7%). See Figure 7.

![Figure 7: Most promising areas for U.S. DOT connected vehicle pilot](image)

4 Discussion

The focus of this section of this paper is to gather in-depth responses from a set of selected ODOT employees regarding their opinions on connected vehicles, as well as how technically and culturally ready ODOT is to handle this new technology.
A total of 115 questionnaires were collected, 68 of which were online and the remaining 47 were paper-based. When the participants were asked their general opinion regarding connected vehicles, their responses were mixed. A large number of responses were concerned with the computer on board taking control from the driver and controlling the vehicle at any time. From this, they are concerned with the ability for an outside entity to have the ability to take control of the vehicle. There was also the mention of privacy and “big brother,” mentions of implications for personal responsibility of drivers, in addition to needing funding to upgrade current facilities to accommodate this new technology.

However, other participants felt that there would be a large decrease in crashes. For those participants who have grown up around technology, they felt no qualms about turning over personal privacy in exchange for increased safety on roads. Some said that having the vehicles controlled by computer would be much better than some drivers in the general public. This was in large part contributed to by the speed at which computers can respond compared to human reaction time.

Another question that the participants were asked was: if the Oregon DOT were to become engaged with the development of connected vehicle related infrastructure, how promising do you think this development would be? Many responses were focused on how this could negatively affect current levels of funding in order to retrofit current roadway systems for these vehicles. Multiple participants proposed that ODOT should look into third party/private developers. Participants also expressed concerns about the failure of a project this size, in that if anything were to go wrong, Oregonians and the nation would never forget. However, along with these concerns, there was expressed interest on the gains in data collection that could be obtained for future vehicle studies (speed, usage priority, travel paths, etc.).

This study also revealed whether or not ODOT’s employees felt that the Oregon DOT is technically prepared for the arrival of connected vehicles. Some expressed that as an agency, they have a spirit of openness to innovation, but were not sure whether they have the technical capacity for this specific work or funding for this kind of retrofit, regarding the increase in time and money that would need to be generated to get the software to work across the state and at the standards of ODOT. Participants even conveyed how ODOT would not be prepared for the implementation of this new technology. There were expressed concerns that state agencies are notorious for not handling implementation of large information technology (IT) projects very well.

This survey also asked participants to what extent they believe that the Oregon DOT is culturally prepared for the arrival of connected vehicles. There were some participants who are very reluctant to rely on any form of technology, and there are others who had never heard of CVs before taking the survey. Concerning rural communities, they tend to receive less consideration because of the relatively sparse population balance, however it is anticipated that the large and widespread rural communities will be culturally resistant to adoption of CVs, even within the agency. Regarding the aspect of tracking the movement of an individual’s vehicle, there was increased concern for the public being willing to participate for any reason other than criminal investigation due to privacy rights being infringed upon. ODOT personnel provided details about how organizational change will be needed, and that is never easy for the agency or for the public to accept these new changes. Overall, those participants who are in favor of this change stated that the society that we are currently living in wants the newest technology that simplifies work, and this will in turn improve public safety.

The last subject focused on for this survey was asking participants to identify one area that needed to be invested in, through time or resources, for preparing culturally for the arrival of connected vehicles. The ODOT employees surveyed stated that there were three areas that need to be focused on in order to implement connected vehicles: education, training of ODOT personnel, and ODOT’s stance on the implementation of connected vehicles.

When focused on education, ODOT employees suggested using videos or public service announcements (PSAs) to get people excited about the new changes to come, and persuade the public on how the use of these technologies would not result in a constant watching of the public activities.
Additionally, the PSAs would enable the public to understand how these technologies can help ODOT, as well as discussing the technology’s strong and weak points. ODOT participants felt that implementation outreach programs, including demonstrations and materials that clearly demonstrate both the promises and the limitations (transparency builds trust), would need to be completed.

Pertaining to the training ODOT personnel would need on connected vehicles, there will need to be clearly defined duties that match the responsibilities within their division, such as the impact of vehicles on infrastructure and interaction with other vehicles, field staff for maintenance and operations, and recognize the generational issue that is consistent with these new technologies. There will need to be increased communication between those personnel working in the field and designers focusing on understanding how current roadside equipment will be affected by this change, and what will be needed and included in ODOT’s maintenance work.

The final investment indicated by the contributors of this study, is that ODOT staff needs to internally decide if they can collectively handle another new initiative at this time. Then, they need to start development of a comprehensive plan that identifies all affected organizational areas. This document should identify what ODOT units will be affected, how it will affect them, when it will affect them, and what the staff should be doing now to get ready. Participants believe that IT would benefit greatly from this technology. However, there was expressed concern on the needed safeguards currently in place to minimize information security risks.

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