Connected Vehicle Pilot Deployment Program Independent Evaluation

Stakeholder Acceptance & User Satisfaction Evaluation—Tampa (THEA)

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Research Report—June 17, 2022.
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16. Abstract

This report presents the stakeholder acceptance and user satisfaction evaluation conducted by the Texas A&M Transportation Institute (TTI) Independent Evaluation Team of the Tampa Connected Vehicle Pilot Deployment (CVPD). The purpose of the evaluation was to assess whether and how the Tampa CVPD achieved the vision, goals, and desired mobility, environmental, and public agency efficiency impacts. In addition, the information gathered from stakeholders included observations and experiences pertaining to anticipated or potential challenges (e.g., technical, institutional, and financial), adopted solutions, and lessons learned. The results are intended to be of benefit to the long-term sustainability of the connected vehicle (CV)–deployed applications and to other entities seeking to deploy CV applications.

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Chapter 1. Introduction

The purpose of the stakeholder acceptance and user satisfaction evaluation was to assess whether and how the Tampa connected vehicles pilot deployment (CVPD) achieved the vision, goals, and desired mobility, environmental, and public agency efficiency (MEP) impacts. In addition, the information gathered from stakeholders included observations and experiences pertaining to anticipated or potential challenges (e.g., technical, institutional, and financial), adopted solutions, and lessons learned. The results are intended to be of benefit to the long-term sustainability of the connected vehicle (CV)–deployed applications and to other entities seeking to deploy CV applications.

The stakeholder acceptance/satisfaction data collection for the Tampa CV Pilot Deployment (CVPD) included both qualitative and quantitative methods: qualitative interviews, online surveys, and a virtual workshop. The qualitative interviews were well suited for examining and exploring contextual issues for the deployment; perspectives on vision, goals, and desired impacts; and concerns and challenges in advance of the start of the CVPD. The survey allowed for the quantification of outcomes (both desired and not desired) from a broader group of stakeholders. The virtual workshop brought together key stakeholders in Tampa to review and discuss the findings of the interviews, assess the outcomes of the CVPD, and provide strategic and operational recommendations (and lessons learned) for subsequent activities. The Tampa Hillsborough Expressway Authority (THEA) pilot aimed to improve the safety and mobility of automobile drivers, transit riders, and pedestrians in downtown Tampa through crash prevention and enhanced traffic flow. Applications tested include:

- Vehicle-to-vehicle (V2V) applications.
- Vehicle-to-infrastructure (V2I) applications.
- V2I pedestrian applications.

The pilot equipped privately owned vehicles, buses, streetcars, and pedestrians.

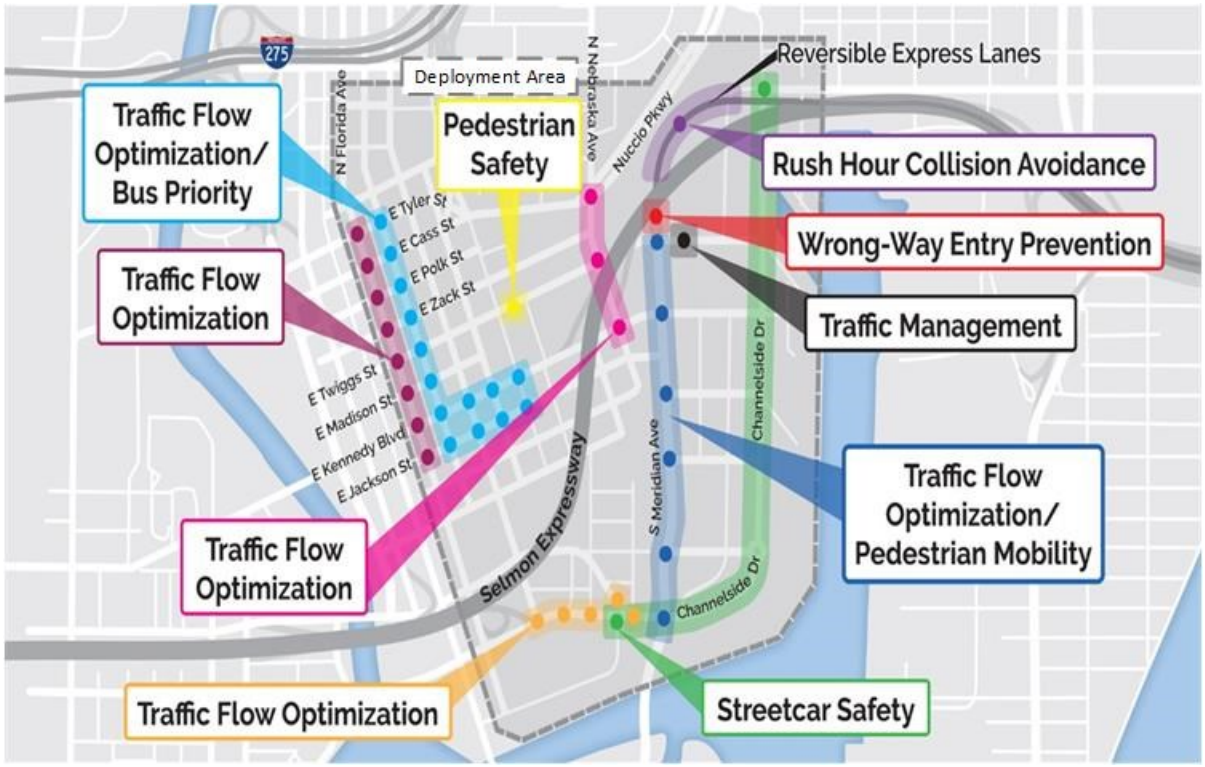
The user satisfaction data collection was conducted by the Tampa CVPD Team as part of its evaluation. Users of the CV technology in the Tampa pilot included drivers of passenger vehicles, bus operators, and streetcar operators. Researchers at the Center for Urban Transportation Research (CUTR) of the University of South Florida were primarily responsible for the user surveys design and administration. However, as the independent evaluator, the Texas A&M Transportation Institute (TTI) CVPD Evaluation Team, along with the Volpe National Transportation Systems Center, assisted CUTR in developing the survey instruments, ensuring that questions important to the independent evaluation were included, and assessing the user satisfaction survey results.

Summary of the Tampa Connected Vehicle Pilot Deployment

The goal of the Tampa CVPD was to transform the experience of automobile travelers, transit riders, and pedestrians by preventing crashes, enhancing traffic flow, improving transit trip times, and reducing emissions of greenhouse gases in the downtown Tampa area (*1*). THEA and its partner entities equipped buses, streetcars, and privately owned vehicles with CV technologies that allowed them to exchange basic safety messages and travel condition information with each other and with the infrastructure, which the receiving vehicles used to generate alerts/warnings as necessary. The objectives of the Tampa CVPD were to:

- Reduce morning peak-hour delays and rear-end crashes on the Lee Roy Selmon Expressway's Reversible Express Lane (REL) exit to downtown Tampa.
- Reduce vehicle/pedestrian conflicts at a busy mid-block crosswalk near the Hillsborough County Courthouse.
- Support traffic signal optimization on commuting corridors in downtown Tampa.
- Enhance transit signal priority in the Marion Street Transitway.
- Reduce vehicle and pedestrian conflicts with the Tampa Electric Company (TECO) Line Streetcar in downtown Tampa.

Figure 1 shows the corridors where THEA deployed CV technologies in the downtown areas.



Source: Federal Highway Administration, 2019 (2)

Figure 1. Map. Tampa CVPD deployment corridors.

To support these objectives, THEA deployed the following applications as part of its CVPD (*1*):

- **End of Ramp Deceleration Warning (ERDW)**—This application warns drivers to slow down to a recommended speed as the vehicle approaches the end of a queue.
- **Wrong Way Entry (WWE)**—This application warns drivers that enter the REL from the wrong direction. The application also broadcasts a warning to other equipped vehicles on the REL to be alert for wrong-way vehicles.
- **Pedestrian Collision Warning (PCW)**—This application warns the driver when a pedestrian is using a crosswalk in the vehicle's projected path.
- **Vehicle Turing Right in Front of Transit Vehicle (VTRFTV)**—This application alerts a streetcar operator when a vehicle is turning right at an intersection as the streetcar is approaching.
- **Intelligent Signal System (ISIG)**—This application optimizes traffic signal timing based on real-time CV data.
- **Transit Signal Priority (TSP)**—This application gives buses priority at traffic signals to keep them running on schedule.
- **Forward Collision Warning (FCW)**—This application warns drivers when a forward collision is imminent.
- **Emergency Electronic Brake Light Warning (EEBL)**—This application alerts drivers when vehicles ahead are braking hard.
- **Intersection Movement Assist (IMA)**—This application warns drivers when it is not safe to enter an intersection.

In the Tampa CVPD, THEA deployed CV technologies in 1020 privately owned vehicles, 10 buses, and 10 streetcars. THEA also installed 40 roadside units at strategic locations in the downtown area to support the CV applications (*1*).

Organization of Report

The TTI CVPD Evaluation Team has organized this report into the following chapters. The titles of each chapter and the major topics contained therein are:

- **Chapter 2. Target Stakeholders**—This chapter describes the target stakeholders engaged throughout the course of the CVPD and subsequent evaluation, including stakeholder type, specific stakeholder entities, and the respondents for the various evaluation efforts documented in this report.
- **Chapter 3. Interviews and Surveys**—This chapter provides the results of the pre- and post-deployment interviews and surveys conducted as part of the evaluation.
- **Chapter 4. Post-Deployment Workshop**—This chapter describes the results of the virtual post-deployment workshop held with the Tampa CVPD Team.
- **Chapter 5. User Satisfaction Evaluation**—This chapter describes the results of the user satisfaction surveys conducted as part of the Tampa CVPD.
- **Chapter 6. Summary of Results**—This chapter provides an overall summary of the results for stakeholder acceptance and user satisfaction across all evaluation activities.

Chapter 2. Target Stakeholders

For this evaluation, a *stakeholder* is defined as an entity/agency that is directly responsible for planning, designing, operating, and/or maintaining one or more of the systems or technologies associated with Tampa CVPD or that financially or institutionally influence the decision making and sustainability of the deployment. Examples of stakeholders include city and/or State departments of transportation (DOTs), transit agencies, private fleet operators, etc. Stakeholders differ from end users. For this evaluation, *end users* are those individual vehicle operators in whose vehicles the equipment is installed and that receive information from applications that might influence their travel behavior on any given trip. Examples of end users include vehicle operators, pedestrians, transit vehicle operators, etc.

Categories of Stakeholders

Six categories of stakeholders were the target of the acceptance/satisfaction information gathering activities as part of the Tampa CVPD. These stakeholder groups are:

- Deployment managers.
- Deployment team members.
- Operating agencies.
- Fleet operators.
- Supporting agencies.
- Policy makers.

Table 1 provides descriptions of these stakeholders.

Users of the CV applications are not considered stakeholders. Different data collection methods were used to collect acceptance/satisfaction information from the stakeholder types due to varying roles in the CVPDs.

Table 1. Stakeholder group types.

Stakeholder Type	Description	Stakeholder	Respondent
Deployment managers	Lead deployment agency and decision makers	• THEA	• Executive management • Project managers
Deployment team members	Individual/agencies responsible for planning, development, and/or implementation of the applications and technologies	• BrandMotion • University of South Florida Center of Urban Transportation • Global 5 Communications	• Project managers • Key technical leads (operations, development, engineering, and information technology [IT])

Stakeholder Type	Description	Stakeholder	Respondent
		• Siemens Industry, Inc., Mobility Division • HNTB	
Operating agencies	Agencies involved in pre-deployment planning and development activities as well as day-to-day operations of the pilots once started. Also, agencies involved in pass-through of funding	• City of Tampa Traffic Engineering/Traffic Management Center • Florida Department of Transportation (FDOT), District 7	• Key technical leads (operations, development, engineering, and IT)
Fleet operators	Agencies that installed and operated CV technologies in multiple vehicles	• Hillsborough Area Regional Transit (HART) and TECO Line Streetcar	• Fleet managers
Supporting agencies	Agencies that interacted with, or whose operations impacted by the pilot deployments	• Hillsborough Metropolitan Planning Organization • Hillsborough County • City of Tampa Police • Florida Highway Patrol (Tampa) • Hillsborough County Sheriff's Office • Tampa Bay Port Authority (Cargo and Cruise)	• Knowledgeable representatives (active in implementation activities/meetings)
Policy makers	Agencies that influenced the selection of the pilot site or to decide something about the deployment in the future	• THEA board of directors • Mayor's Office	• Champion for the pilot within the organization

Source: Texas A&M Transportation Institute, 2022

Tampa Stakeholder Evaluation Goals and Objectives

The TTI CVPD Evaluation Team identified the following key stakeholder acceptance and user satisfaction evaluation objectives for the Tampa pilot deployment (*3*):

- The pilot deployment will result in improved public agency efficiency and decision making by transportation managers.
- End users will be satisfied with the performance of CV applications and with the impact of the CV deployment on their travel.
- The pilot deployment will result in end users taking appropriate action based on alerts, warnings, or advisories.
- End users will be satisfied with the performance of the CV devices.

As illustrated in Figure 2, the objective of the stakeholder acceptance analysis was to assess the perceptions of the stakeholders regarding whether these objectives have been met by the deployment throughout various stages of the deployment. Through a series on interviews, surveys, and workshops, the TTI Evaluation Team attempted to explore how stakeholder acceptance evolved throughout the deployment on a wide variety of topics and issues, such as:

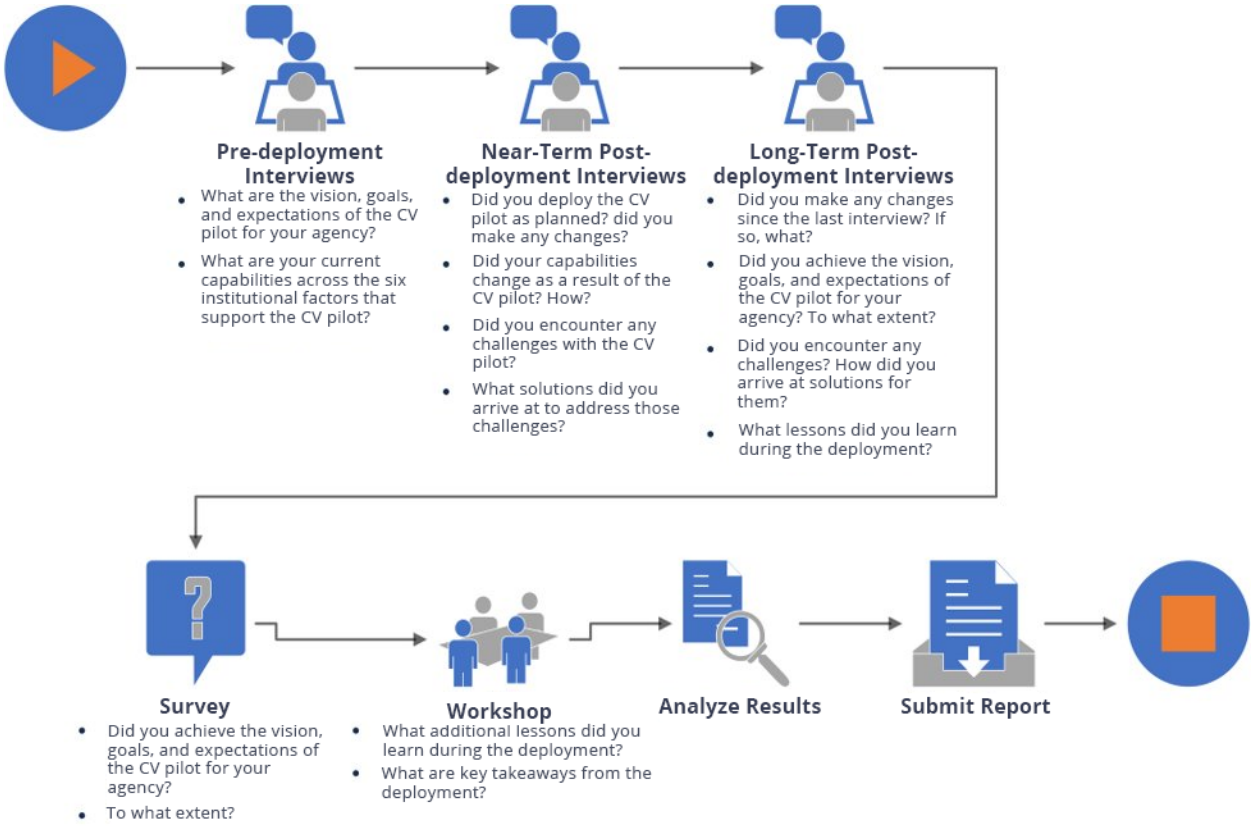
- Changing of evolving goals and objectives for the deployment.
- Changing institutional, technological, and agency factors that includes the capabilities implemented in the deployment.
- Changing stakeholder perspectives related to challenges, issues, and lessons learned through the various stages of deployment and operations.

Analysis Approach

The stakeholder acceptance evaluation used a multipronged approach for the data collection that included qualitative interviews, an online survey, and a virtual workshop. These efforts are described as follows:

- **Qualitative interviews** in the form of one-on-one discussions were conducted with deployment managers, deployment team members, operating agencies, and policy makers. These individuals were interviewed because they are the most invested and involved in the pilots and would be able to provide rich feedback. Policy makers were also interviewed given their status and potential influence on long-term sustainability of the deployments. These interviews were conducted at three points in time: immediately after the planning/design stage (i.e., pre-deployment), shortly after activation (i.e., near-term post-deployment), and toward the end of the deployments (i.e., long-term post-deployment). Pre-deployment interviews were intended to elicit vision, goals, and expectations. Post-deployment interviews served to capture information about deployment experiences, outcomes, and satisfaction.
- **A post-deployment online survey** (rather than in-depth interviews) was administered to fleet operators and supporting agencies because they were less involved in day-to-day pilot planning and execution. The survey gathered information on how well the pilot deployment program fulfilled these stakeholders' goals and objectives.

- **A virtual post-deployment workshop** was held after interviews were completed to foster additional dialog among deployment managers, deployment team members, and operating agencies. The workshop was structured to capture distinct information. The workshop was also used to foster cross-stakeholder dialog and discussion about challenges, solutions, and lessons learned. The workshop confirmed and clarified key findings.



Source: Texas A&M Transportation Institute, 2022

Figure 2. Flowchart. Stakeholder acceptance and user satisfaction evaluation process.

Survey instruments and interview guides for each of these activities are presented in this document in the appendices. These instruments only collected qualitative input from stakeholders on safety impacts because the Volpe National Transportation Systems Center was responsible for conducting the safety evaluation. Table 2 shows the distribution of data collection activities across stakeholder types.

Table 2. Data collection method by stakeholder type.

Stakeholder Type	Pre-deployment Interviews	Post-deployment Interviews—Near Term[1]	Post-deployment Interviews—Long Term[2]	Survey	Workshop
Deployment managers	Yes	Yes	Yes	No	Yes
Deployment team	Yes	Yes	No	No	Yes
Operating agencies	Yes	No	Yes	No	Yes
Fleet operators	No	No	No	Yes	No
Supporting agencies	No	No	No	Yes	No
Policy makers[3]	Yes	No	Yes	No	No

Notes

[1] Near-term post-deployment is 2–3 months after activation.
[2] Longer-term post-deployment is 9–12 months after activation.
[3] Champion may not be in office post-deployment; incumbent would be interviewed instead.

Source: Texas A&M Transportation Institute, 2022

Summary of Data Collection Approach

Table 3 summarizes the data collection approach for the stakeholder acceptance evaluation plan for Tampa.

Table 3. Summary of data collection approach—Tampa.

Data Collection Activity	Purpose	Timeline	Target Group
Pre-deployment interviews	Vision, goals, and expectations. Gather financial and institutional preparedness.	Prior to activation	• Deployment managers • Deployment team members • Operating agencies • Policy makers
Near-term post-deployment interviews	Early deployment experiences, challenges, and solutions.	1–3 months after activation	• Deployment managers • Deployment team members •
Long-term post-deployment interviews	Vision, goals, and desired MEP impacts achieved. Experiences/ observation pertaining to challenges (e.g., technical, institutional, and financial), adopted solutions, and lessons learned. Satisfaction with pilot outputs/outcomes.	9–12 months after activation	• Deployment managers • Operating agencies • Policy makers
Workshop	Cross-stakeholder dialog concerning the lessons learned and major takeaways. Information for financial and institutional assessments.	9–12 months after activation	• Deployment managers • Deployment team members • Operating agencies
Survey	Data from stakeholders who are important but less engaged in day-to-day operations about whether and how the CVPD achieved the vision, goals, and desired MEP impacts.	9–12 months after activation	• Fleet operators • Support agencies

Source: Texas A&M Transportation Institute, 2022

Chapter 3. Interviews and Surveys

The TTI CVPD Evaluation Team conducted pre- and post-deployment interviews with deployment managers, deployment team members, operating agency staff, and policy makers that were involved in the Tampa CVPD as well as a small online survey with fleet managers and supporting agency staff (*4*). The objectives of the pre-deployment interviews were to gather in-depth baseline information on vision, goals, and desired impacts; anticipated or potential challenges; and desired outcomes. The post-deployment interviews were used to assess whether the pilots achieved their vision, goals, and desired impacts as well as to derive lessons learned for future CVPDs. The post-deployment interviews were conducted at two points in time:

- Shortly after deployment to get initial feedback (i.e., near term).
- Toward the end of deployment to gather comprehensive information (i.e., long term).

All interviews were conducted by telephone. The two online surveys were conducted at the same time as the long-term post-deployment interviews.

Identification, Selection, and Invitation of Interviewees

The target stakeholders for interviews are deployment managers, deployment team members, operating agencies, and policy makers. The evaluation plan outlined that deployment managers would be interviewed at three points in time, deployment team members at two points in time, operating agencies at two points in time, and policy makers at two points in time. This plan was accomplished except for policy makers (see Table 4).

The Tampa CVPD manager identified the persons to be interviewed. He identified individuals from target stakeholder entities that were especially knowledgeable about or had history with the CVPD.

Table 4. Numbers of Tampa CVPD stakeholder interviews by type and timepoint.

Stakeholder Type	Pre-deployment	Near-Term Post-deployment	Long-Term Post-deployment
Deployment managers	2	2	2
Deployment teams	10	8	Not applicable
Operating agencies	5	Not applicable	2
Policy maker	1	Not applicable	0
Total interviews	**18**	**10**	**4**

Source: Texas A&M Transportation Institute, 2022

The TTI CVPD Evaluation Team sent email invitations to identified individuals to participate in the interviews. The email contained information about the study purpose, interview method, content, and duration. An informed consent document was attached to the email invitation. The participants who replied in the affirmative to the email invitation were asked to provide their availability, after which a suggested date and time for the interview was communicated.

Interview Guide

A semi-structured interview format was used. In semi-structured interviewing, a guide is followed, with questions and topics that must be covered. An interviewer has some discretion about the order in which questions are asked, but the questions are standardized, and probes are provided to ensure that the researcher covers the correct material. This kind of interview collects detailed information, which is needed for the stakeholder assessment, but in a way that is consistent yet conversational.

The pre- and post-deployment interview questions covered the following topic areas:

- Visions, goals and objectives.
- Pilot effectiveness.
- Policy challenges.
- Institutional challenges.
- Culture.
- Collaboration.
- Financial issues.
- Business processes.
- Performance measurement.
- Systems and technology.
- Workforce development
- Outreach.
- User experience/satisfaction.

The pre-deployment and long-term post deployment interview guides were about equal in length, whereas the near-term post-deployment interview guide was shorter. Although the interview guides contained a few of the same questions across the time periods, many of the questions were different across deployment stages. The actual interview guides are presented in Appendix A. It was anticipated that many of the questions were pertinent to all stakeholder types, but to target the interview and to reduce burden on the interviewees, interviewees were advised to answer only those questions for which they felt comfortable and knowledgeable in answering.

Many of the interview questions were modeled after the American Association of State Highway and Transportation Officials *Transportation System Management and Operations Capability Maturity Model (CMM) Guide* [(5)] such that questions are structured to obtain stakeholder input on the six agency capability maturity dimensions in the CMM: business processes, systems and technologies, performance measurement, culture, workforce development, and collaboration.

Implementation of Interviews and Schedule

All interviews started with an explanation of the evaluation purpose, scope, and sponsors, and a description of the purpose and process for the stakeholder interviews. The confidentiality of the collected information was highlighted (i.e., responses will not be attributed to specific individuals) and the need for IRB/human subject protection requirements even though the efforts were not determined to be human subject research. Following this introduction, the main body of the interview began.

The first five pre-deployment interviews served as a rolling pilot to test the question wording for clarity and efficacy. A set of evaluative questions were asked of the interviewees after the interview was completed. The following are sample questions:

- How relevant were the questions?
- Were the questions clear and understandable?
- Were there any biased questions?
- What questions should I have asked (i.e., possible missed questions)?

Afterward, no questions were added, but the wording of some questions was tweaked. In addition, two members of the TTI CVPD Evaluation Team participated in the pre-deployment interviews for quality assurance purposes. One individual led the interview, asked the questions, and facilitated the discussion. The second individual took notes. This was not continued for the post-deployment interviews. One person conducted each post-deployment interview.

The questions were sent to the interviewees in advance of the interviews to help facilitate discussion. The durations of the interviews varied, depending on the number and type of questions answered, with an average of about 30 minutes per interview. The following is a breakdown of the interview durations by stage:

- Pre-deployment interviews with deployment managers, deployment team members, operating agencies, and policy makers lasted no more than 45 minutes.
- Near-term post-deployment interviews lasted about 20 minutes.
- Long-term post-deployment interviews lasted no more than 40 minutes.

Upon completion of the interview, interviewees were asked if they would like the opportunity to review the interview summary. If yes, it was sent to them for review, edit, and approval. About one-third of interviewees asked to review the summary.

According to the Reference (6), the Tampa CVPD Team the pre-deployment period ran from February 4, 2019, through January 31, 2020. The post deployment valuation period ran from February 30, 2020, through March 20,2020. On March 20, 2020, THEA set the REL operational direction to eastbound (leaving the downtown area) on a 24-hour basis in response to the COVID-19 pandemic. Table 5 shows the general time frame for the execution of interviews for each of the points in time.

Table 5. Interview schedule.

Interview Type	Tampa CVPD Interviews
Pre-deployment	February–March 2019
Near-term post-deployment	November–December 2019
Long-term post-deployment	July 2020

Source: Texas A&M Transportation Institute, 2022

Interview Analysis Methods

Immediately following the interviews, the responses of each stakeholder to every question were summarized. Information was anonymized. The summary reports were organized by topic area and interview question, with a final section asking for concluding thoughts.

Pre-deployment Interviews

The findings in this section represent the results of 18 interviews with deployment managers, deployment team members, and operating agency staff, as well as one policy maker in February and March 2019.

Vision and Goals

Most interviewees indicated that their agency or organization's primary goal in participating in the pilot was increasing safety for the road users by reducing collisions, reducing instances of wrong-way driving, and reducing the number of pedestrian-related fatalities. Interviewees also identified secondary goals and objectives, such as improving mobility and system capacity; preparing the city for the next phase of smart infrastructure development; assessing environmental benefits associated with the CVPD; identifying future business opportunities associated with the pilot; and acting as a laboratory to provide meaningful results that can be used by other organizations interested in implementing CV systems as goals of the CVPD.

Interviewees indicated that the primary indicator of success was the collection of data necessary to implement the pilot program. Tampa CVPD Team members hoped that this evaluation would demonstrate improved safety and mobility, as well as serve as a fundamental building block for a national CV framework. Additional indicators of success included meeting the project schedule on budget and gaining a better understanding of how the deployment process could be improved.

Policy Challenges

The interviewees reported that the project benefited overall from the progressive and tech-friendly attitudes of State and local policy makers. The Florida Legislature has been very supportive of the CVPD. But interviewees did note a few challenges, nonetheless. One involved managing public perceptions and included educating the public on the differences between autonomous vehicles and CVs and informing them that the pilot was just CVs. The team needed to provide sufficient information to the public to put them at ease regarding the security of their personal information with installed CV technology.

Interviewees noted that other challenges included assuring the public and policy makers that the new technology was developed with an open architecture that is interoperable between vehicles and transportation management systems. This last point required well-thought-out nondisclosure agreements among stakeholders on which everyone could agree. Interviewees indicated that moving forward, policies will need to be put in place for dealing with security protocols. More specifically, policies should identify the entity that would be responsible for ensuring system security and establish a standardized security credential management system (SCMS). Because most mid-size cities have utility infrastructure that is owned by multiple entities, reaching agreements across the board can be challenging.

Liability was reported as an issue that will need to be addressed once the pilot is completed. For example, in the case of an accident, who is liable—vendors or drivers?

The topic of spectrum sharing was raised. There was a perception that as CV technology advances, there will be issues with who controls the communication channels/bandwidth. One interviewee indicated that there is concern from the public sector that they would have to cede control of public bandwidth to the private sector. Furthermore, the private sector's pursuit of dedicated short-range communication (DSRC) technology would make it less accessible to others because the cost would go up too. This individual also believed that there should be a combination of 5G and DSRC communication in the future though there was concern that the private sector would focus only on technology that was compatible with 5G only. The public sector was concerned that this could result in public agencies being "captive to the tech" with the private sector having unreasonable control over who has access and at what cost.

Institutional Challenges

Interviewees explained that one of the most significant institutional challenges was educating all stakeholders on the benefits of the CVPD. A lot of stakeholders had preconceived notions regarding safety and security issues. Once stakeholders were educated, they were stronger advocates for the pilot.

Several interviewees mentioned that the schedule was an issue for multiple reasons. It was extremely aggressive. When unanticipated events occurred (e.g., the need to educate stakeholders and delays with adjacent projects that affect the CVPD, such as installation of fiber downtown), it exacerbated having to deal with an already limited schedule. Furthermore, some felt that the phased nature of the schedule would result in technology adopted in the pilot being outdated in later phases.

Some noted the existence of friction between civil engineers (who are very process driven) and software engineers (who are more used to acting in a fluid manner). Others noted that the new equipment required for the pilot placed a heavy burden on the city. These burdens took the form of cost (having to purchase the equipment) and labor (having to install the equipment). At least one individual mentioned that the media's inconsistent recognition of THEA as the team leader led to some frustration because the team had gone to lengths to highlight THEA's role (such as using the THEA logo in branding the project).

Culture

All interviewees confirmed that their respective organizations supported the pilot and that the pilot benefitted from this support.

Collaboration

Most interviewees agreed that at the end of the day, consensus existed among the various stakeholders, even if stakeholders needed occasional reminders regarding what the overall goals were. One interviewee stated it well by saying, “Everyone’s main goals were the same, [but] priorities were a little different. It did not result in any delays but definitely some heated conversations. We always found some sort of common ground.”

Interviewees indicated that the primary mechanisms for collaboration were regularly scheduled stakeholder meetings and phone calls that kept all team members up to date regarding the progress of the pilot. Most interviewees mentioned that process was cooperative and top-down, with all stakeholders having the opportunity to participate in stakeholder meetings and provide input on the decisions made. One interviewee explained that there was a formalized plan for post-deployment, and operating agreements were in place between agencies to help ensure that when the demonstration was over, the system would not just fade away. An interviewee commented that there is a CV business plan for the State that establishes uniformity and consistency with vision across the entire State. But multiple interviewees stated that while business processes and procedures were being discussed, nothing had been finalized. Therefore, for the most part, it was “business as usual.”

Financial Issues

Most interviewees believed that there was a shared commitment to the successful execution of the pilot. Some felt some organizations were more committed than others, but at the end of the day, everyone was committed. One interviewee explained that sometimes his personal perception was that the team thought the State had tons of money to throw at pilot issues that would arise downstream. This was not the case, and as issues arose, team member commitment was tested. Similarly, one individual felt that the State should have been given some formal type of maintenance agreement to ensure clarity of financial responsibility, but this has yet to happen. One interviewee felt that having THEA lead the effort was a luxury because there seemed to be less concern with having to address the issue of whether a CV system is an appropriate use of general revenue as opposed to revenue generated through user fees.

Most interviewees were not familiar with a long-term plan for funding/financing of the CVPD. On the other hand, THEA stated that funding to complete and maintain this project was fully programmed, with additional funding programmed to seek opportunities to grow CV applications. Furthermore, THEA would continue to seek opportunities to leverage its investments in the pilot.

Business Processes

The Tampa CVPD was organized such that the public sector assumed responsibility for the infrastructure aspects of the system and the private sector the installation of vehicle equipment. Interviewees indicated that this approach was generally followed. But for the pilot, the team selected a vendor for the onboard units (OBUs) and then selected a firm to market, recruit, and install the in-vehicle equipment. In addition, during the pilot, these vendors were funded through the grant; however, post-pilot, there will have to be a determination of how OBUs (hardware and installation) will be funded.

Most interviewees indicated that there were no business process changes due to the pilot. For the most part, organizations were able to conduct business as usual. Some maintenance staff suggested that they would fold the cost of maintaining the CVPD system into their existing operating budgets, with crews responsible for the maintenance. It would be managed like an intelligent transportation system program.

Performance Measures

Interviewees envisioned the following impacts when deciding to participate in the CVPD:

- Increased safety.
- Improved mobility.
- Demonstration that a small to moderate-sized transportation agency can play a leadership role in a pilot like this and implement these technologies.
- Reduction in the negative impact of transportation on the environment.
- Improved system reliability.

Most interviewees were unaware of how performance measures would be used to support business decisions related to future CVPD activities. One interviewee expected the operations staff of THEA and public agency partners to glean understanding from the data that would help guide future investments.

Systems and Technology

The most mentioned and most significant technology-related challenge was the lack of maturity of the hardware (OBUs and roadside units [RSUs]) and the software (unstable firmware). Interviewees frequently indicated that the vendors were not able or capable of delivering technology that was “road hardened.” Many interviewees indicated that they expected that the technology they would be receiving would be “ready for primetime,” but what they received was not adequately tested and was essentially still at the prototype stage.

Multiple interviewees mentioned a challenge with the confidentiality and integrity of communication channels. More specifically, the availability of secure frequencies was an issue because of a rogue ham radio operator in the area that was authorized by the Federal Communications Commission to broadcast but whose programming was interfering with the system. Several interviewees mentioned communication issues that could have been resolved if fiber had been in place, as was assumed.

Another challenge was making sure the team had good global positioning system (GPS) and survey information to generate accurate maps in the RSUs to ensure the information was accurate. The team occasionally got false positives, such as a warning from an OBU when a right turn was made yet no car was coming. The team found that this was because the RSU map was inaccurate. There were some issues with the parameters being loosened for the geofencing but only in the beginning.

One interviewee explained that the biggest challenge was whether the team would implement a sustainable communication scheme with DSRC or with cellular. Furthermore, some of the applications were mature enough, while others were not. The streetcar-related technology, V2V applications, and wrong-way entry applications were considered mature enough.

One interviewee mentioned an issue with the over-the-air software update. More specifically, the system needed to have a way to update software and configuration settings on 1000 OBUs after they had been installed in participant vehicles. OBUs do not have any network connection other than the DSRC connection with RSUs. So, the only way to send an update was from the RSUs. A naïve implementation where each OBU downloads the update using a unicast TCP connection to a server has severe scalability and reliability issues. A solution based on broadcast messages was needed.

The big security challenge was that the SCMS software was not ready at the outset of the pilot. The U.S. Department of Transportation (USDOT) was developing an open-source software, but it was not stable.

The pilot switched vendors midstream. This caused delays and budget issues, but the new SCMS software functioned in a more stable manner.

RSUs were monitored in real time, and the OBUs were monitored in two parallel ways. One was by analyzing basic safety message (BSM) data collected by the RSUs. The second was by transferring data logs from OBUs to the backend system via RSUs. One interviewee seemed very concerned with this approach. This individual was unclear as to whether the code developed for monitoring RSUs could be used with other CV technology. For continuity of applications, this person perceived a risk in not having consistent code, felt that the system was too software heavy, and felt that there was a real need for more continuity.

Workforce Development

There seemed to be differences of opinion about whether enough people were trained to manage, operate, and maintain the CV system. One interviewee felt that the training conducted by deployment vendors was sufficient. Conversely, multiple interviewees felt that there was a lack of sufficiency, and that the pilot served to identify where training was needed for not only the continuation of the CV work in Tampa but other CVPDs around the world. One significant question was: What type of entity is best suited to coordinate training efforts in the future?

A combination of in-house staff and additional contractors was used to meet the demand of installing and maintaining the CV system. Most interviewers expected that staffing needs would grow, particularly for equipment installation, system engineering, and system maintenance. This will need to be done through direct hire or consultants. Staffing will be a challenge because this is a very specialized skill (not a lot of people have it), and it may be a challenge to convince executive-level staff to offer competitive pay scales for the few that do have this skill. One interviewee commented, “THEA is being watched by many DOTs with a lot of interest as the staff requirements are a big item of concern for public agencies.”

Outreach

Various types of outreach activities were conducted:

- Conference presentations (to the Institute of Transportation Engineers, Society of Automotive Engineers, American Planning Association, and ITS America).
- Demonstrations.
- Surveys.
- Participant recruitment incentives (toll discounts).
- A USDOT-required outreach and training plan.
- A Discovery Channel segment.
- Press releases.
- Academic papers.
- Webinars.
- A CVPD website.
- Social media.

Initial Deployment Issues and Challenges

The persons interviewed, by and large, were satisfied with the Tampa CVPD to date. A couple of issues stood out to them. Recruitment of persons to have CV equipment installed in their vehicles was a greater challenge than anticipated. The entire process from pre-screening to installation took a couple hours and was a big ask of the public. The flexibility of the procurement aspects of the pilot was a significant success factor. It ensured that the team could work fast. THEA's decision to have an in-vehicle integrator handle all in-vehicle technology (one single point of contact) was a very smart decision because it lessened institutional/turf issues and streamlined the process.

Near-Term Post-deployment Interviews

This section summarizes the information captured during 10 telephone interviews with deployment managers and deployment team members in November and December 2019.

Vision and Goals

Seven of the interviewees indicated that their expectations of what the CV system was capable of were adjusted based on the results of deployment to date. The modified expectations were due to some of the technical challenges faced during the pilot (primarily over-the-air updates, OBUs and, to a lesser extent, RSUs).

Pilot Effectiveness

Pilot goals stated during pre-deployment interviews were the following: increasing safety for road users (e.g., by reducing collisions, instances of wrong-way driving, and the number of pedestrian-related fatalities), improving mobility and system capacity, and assessing environmental benefits. For most interviewees, it was too early in the deployment to gauge pilot effectiveness. Formal evaluations have not been done.

However, one interviewee indicated that expectations about the positive impacts had increased due to social media posts by users, stating that the system was effectively improving safety. For this person, technical challenges did not impact perceptions about the potential positive impacts of the applications. Two other interviewees also cited anecdotal evidence suggesting that safety has been increased because of the CV system.

On the other hand, an interviewee thought the sparse penetration of OBUs in the environment was hampering the capability of evaluating whether the project was meeting its goals. This person explained that the technology at full deployment (beyond the scope of the Tampa pilot) has the capability of meeting the goals, but currently in the pilot environment, not enough data existed to determine this. RSUs can be implemented by local governments, but with the penetration challenges with the OBU technology, the RSUs have nothing to connect to.

Pre-deployment interviews specified the primary indicator of success was the collection of data necessary to implement the pilot program and demonstrate improved safety and mobility. Seven interviewees indicated that this was still a viable indicator of success. One interviewee indicated that the delays in the project mean that it was not completely successful but acknowledged that dealing with new technology makes the occurrences of delays reasonable. Two interviewees added that additional indicators of

success were the many lessons learned along the way, especially based on unforeseen challenges, which is different from that stated at the outset of the pilot.

Institutional Challenges

Five interviewees identified coordination with the City of Tampa as an institutional issue that led to challenges. Interviewees explained that the city was not as involved in the planning of the system as other stakeholders. Plans were to install infrastructure (transit priority) on city traffic signals. The city's signal controllers needed to be upgraded for the pilot (which was unexpected), and one of the deployment team's infrastructure vendors offered upgraded signal controllers for very nominal cost—but the City of Tampa did not agree to purchase. So, in the end, this aspect of the system was not implemented. Four interviewees also indicated that permitting was an issue with the City of Tampa because acquiring permits took much longer than expected (e.g., installing RSUs on poles in Tampa). This process added to delays.

One interviewee indicated that having team members that were geographically spread out (some in different countries, time zones, etc.) led to challenges with being able to rapidly troubleshoot technical challenges when they arose. Another noted that the overall goals of some team members were divergent (e.g., the private sector was interested in profit, and the public sector was interested in public good). A lot of effort was required to get everyone on the same page.

As a positive, one interviewee indicated that THEA's flexible procurement process was extremely important in the pilot's ability to rapidly develop and implement the CV technology.

Financial Issues

Two interviewees indicated that tolling agencies are in the best position to deploy V2X systems because of their sustainable financial position and agile governance model. The lead agency for these deployments must be able to quickly respond to the changes, requests, and needs that inevitably arise when working with new technology. Similarly, one interviewee indicated that agencies such as DOTs will not have the resources to implement and manage these systems.

A lesson learned mentioned by many interviewees was that there will be many unexpected "curveballs" that arise during deployments and lead to budgets being strained. They explained that there is a high cost associated with acquisition, deployment, and management of a CV system (e.g., managing the data that are developed). For example, many stakeholders (specifically the OBU vendors) did not consider the resources that would be required to meet the extensive needs of a deployment of this magnitude. An unforeseen cost was the maintenance and repairs of vehicles that had OBUs installed. Also, RSU providers needed to work with local agencies to bring costs down. An example provided was agreements among local agencies and RSU providers where the providers might install RSUs for a more favorable cost—but build in service agreements or data ownership considerations. Cellular costs were not anticipated to be as high as they were for the pilot. What seemed like a small/reasonable amount per RSU in theory was much higher when relying on the cellular network for, say, 100 RSUs.

Performance Measures

There was an initial concern among stakeholders that there would not be enough participants consistently traveling through the study area, which would lead to a lack of data. But at the time of the near-term deployment interviews, this did not seem to be the case. Three interviewees explained that the demonstration team relied on the data from CUTR to understand where OBUs and RSUs were not

performing well. Examples include identifying where OBUs were providing false positives and identifying whether RSUs were operating/connecting properly based on the consistency of readings from a parallel system.

Systems and Technology

Most of the technology-related challenges mentioned in this round of interviewing were the same as noted in the pre-deployment interviews. For example, all interviewees indicated that the pilot suffered from the technology not being mature enough to deploy in a real transportation environment. Many interviewees indicated that they expected the OBUs to be off-the-shelf, but they were no more than prototypes. Six interviewees identified challenges with the over-the-air communication between OBUs and RSUs (e.g., firmware updates and data packets) and from RSUs to the traffic management center. One interviewee likened the challenge of OBU-to-RSU communication to cell phone communication where interruptions can occur when a device is traveling at high speeds, like a dropped call when driving. Interviewees indicated that performance testing for problems has been the primary approach to solving these challenges. One interviewee discussed the challenges with getting the warnings on OBUs to appear at the correct time for participants to have time to react.

Three interviewees indicated consistent challenges with getting the various vendors' technologies to integrate with one another when deployed (primarily the OBUs with RSUs). This has led to extensive time for testing, reconfiguring, and retesting, which has caused extensive delays.

Three interviewees explained that the GPS technology that the OBUs use has been extremely problematic because the locations are not accurate. One interviewee explained that this is largely due to being in an urban environment.

New items raised at this point in time included:

- OBUs on transit vehicles were not working though the interviewee did not know why.
- Three interviewees indicated that the cell phone application did not work out (the interviewee did not know technical details).
- Two interviewees explained that the RSU performance was impacted by electrical storms that were consistent during the summer in Tampa.
- One interviewee explained that the size of the data packets that were being sent from OBUs to RSUs and then on to CUTR were too large and were not completely downloading when the cars were in range (about 30 seconds), so they had to develop an algorithm to reduce the size of the packets.
- One interviewee explained that the system needed to "start over" every time there was an update to the security protocol.

Nine of ten interviewees believed that the system had appropriate levels of cyber security incorporated into system design: interviewees addressed hacking and privacy, and certificates are being issued in a timely manner. One participant explained that the team went to extra lengths to ensure the cyber security of the system and hired a white-hat hacking company to do penetration testing on RSUs. This company also tried to access the back end through penetration tests, and the company came back with the following recommendations that the team addressed:

- Remove all unnecessary protocols because they represented access points for hackers
- Ensure consistent monitoring and response plans were in place if there was a breach occurred.

Some issues occurred with maintenance monitoring for both vehicles and field equipment. Interviewees explained that the process of monitoring OBUs depends on OBUs sending monitoring messages, and if they were not sent, the team knew there was something wrong with the units. However, one interviewee indicated that many OBUs were not showing up, and the evaluation team asked the outreach team to contact participants to determine if they were driving in the deployment area. The interviewee explained that these calls were identifying technical issues with OBUs that were previously unknown. One participant noted that if there was a way for the OBUs to send a ping out periodically that they were alive/active/working, that would be very valuable. The team noted that the system was not designed to live-monitor OBUs due to privacy concerns, so this hampers the team's ability to quickly and rapidly diagnose and fix problems.

Four participants indicated that the RSU monitoring is effective because there was a live feed of these units, and the contractor sent daily updates on the health of the system. Additionally, most of the issues with these units were easy to address. An interviewee noted that while the issues were easy to fix, the process of fixing the units take longer than desired due to the logistics of finding and getting parts delivered.

The Tampa CVPD Team instituted a performance evaluation team, which monitors OBUs and RSUs and determines whether they were functional. The existence of this team has been invaluable to the deployment. If the performance evaluation team found an issue with an OBU, the information was sent to the vendor to fix. If the team found that an RSU was not functioning over the course of a day, the Tampa CVPD Team exerted pressure on the RSU provider to fix it.

Satisfaction with Pilot Rollout

The 10 interviewees expressed mixed levels of satisfaction with the pilot rollout. Six persons were generally positive:

- Two interviewees expressed positive opinions of the pilot rollout since this is the first time a deployment like this has been implemented.
- Three persons noted their satisfaction with the project team and its ability to work well together and overcome challenges.
- Another felt the pilot has been successful based on the number of transactions that are seen every day; they are seeing 50 to 60 percent of the 1000 OBUs between Monday and Friday. This person believed that this is where a toll facility provides a benefit for this type of pilot deployment because it can get a lot of frequent participants, resulting in a higher penetration rate of OBUs because participants use the facility every day.

Four persons were less positive:

- There was disappointment that the internal target dates were not met and that there were issues with OBU software—some applications were not working, and the amount of data expected was not obtained.
- There was frustration with how the SCMS delays impacted the recruitment of participants. The team had recruited several thousand participants, but delays caused a lot of those participants to drop out, and in the end, they only recruited a total of 1000 participants, which was short of the goal of 1600.
- There was concern that maintaining the 1000 active participants would remain a significant challenge. Ongoing recruitment, installation, and maintenance were thought to be necessary in future deployment processes (with appropriate resource allocation).

- The gap between early expectations for the CV systems and the actual maturity levels of the technology was acknowledged. The systems were making progress, but there were a lot of moving parts and a lot of changes in technology.

Yet, all but two interviewees expressed satisfaction with the training provided for application users. Numerous training options were provided: video, materials to take home, one-on-one with each participant, and a website with all training materials. In addition, an interviewee noted that the team provided a helpdesk that participants could call once they left the installation facility—the interviewee felt that this was an extremally useful resource for participants. The two interviewees who did not express satisfaction noted that they are currently conducting an analysis of the training through surveying the participants, so they could not determine its effectiveness at this point.

All but one interviewee expressed satisfaction with the level of communications among stakeholders though it was noted that communication with the City of Tampa could have been better. One interviewee indicated that communication was just average, and some of the stakeholders were not aware of the progress of the pilot.

The team continued to conduct many outreach activities, including in-person presentations and webinars with the public, transportation professionals, conferences, colleges, etc. One interviewee indicated that the most effective form of outreach was the demonstrations that THEA provided. The individual explained that the team has the demonstrations “down to a science” and that they can tailor the demonstrations to the audience (e.g., more technical for a technical audience versus more high level for a non-technical audience). The individual has received extensive positive feedback about these demonstrations.

Early Deployment Issues and Challenges

A critical step—and critical challenge—is getting the CV system to scale to widescale deployment. An interviewee indicated that getting a CV system to work with 10 OBUs is one thing but scaling to 1000 OBUs caused problems. The next step is scaling to millions of OBUs. The Federal Government needs to work with original equipment manufacturers (OEMs) to develop standards for all aspects of this technology so deployment can occur at this scale. The perception at the beginning of this pilot was that at the conclusion of the pilot, the industry would be ready for widescale deployment (“we would be pushed out to sea”)—but the interviewee noted that “we are not there yet.” The OEMs need to develop the technology to get better market penetration for full deployment in the United States. At this point, local agencies are not able to deploy these systems and in turn to realize the benefits, especially considering the resources required.

Long-Term Post-deployment Interviews

This section summarizes the information captured during four telephone interviews with two deployment managers and two staff members of operating agencies conducted in July 2020.

Vision and Goals

All interviewees thought the CVPD was successful in that it showed that the concept could work and could serve as a stepping-stone to future deployments. Opinions about whether it was successful in meeting the specific goals and objectives set forth at the beginning of the pilot were more nuanced. One

person explained that it is hard to say with certainty that "on-the-ground results" have been measurably obtained—hard because of small samples and he was still waiting for objective numbers from CUTR. A second person agreed, saying that it is going to take time to know whether the pilot achieved the stated goals. Another person was less concerned about the small samples, "Know[ing] that the wrong-way entry alerted 14 drivers was enough. Not a large number over 18 months, but when you consider how catastrophic [one instance of wrong-way entry] could be, then amazingly successful." This person went on to say that overall, the CV system warned an average 10 drivers a day—the pilot showed that giving data to drivers to make better decisions can work. But this person also said that the pilot could not retrofit enough vehicles to make a profound difference on the safety of the transportation system. The person said that the only way to have a real impact is to go through the OEMs to get the technology in all vehicles; retrofitting vehicles is not enough. Likewise, the fourth interviewee believed the project was successful in *advancing* safety measures. It helped to raise and address many issues not foreseen in the beginning.

All interviewees thought their views of success had not changed. Success was still being defined as getting something up and running. The expectation was not to have this "big, beautiful project." They expected issues. The idea was to deploy the pilot so that the next time they would be a bit ahead of the game. Success was deployment of software and hardware—to create a data stream. Hardware was designed, built, installed, and working every day. The pilot surfaced challenges with the implementation of applications, which needed quite a bit of tweaking to fit the equipment and layout of the infrastructure in Tampa. This constituted success. Finally, the pilot provided insight into people's attitudes toward OBUs—retrofitting of privately owned vehicles turned out to be a bigger challenge than anticipated.

Pilot Effectiveness

Interviewees were asked: Have expectations changed about the positive impacts of the CV applications based on your experiences with deployment? The four persons interviewed had differences of thought:

- Two people indicated that their expectations related to the positive impact CV technology had on safety and mobility did not at all change.
- A third answered maybe to some extent; expectations were tempered a bit. There were challenges with fleet penetration and in making necessary tweaks to the applications. For instance, this person had an OBU in a personal vehicle, and early on there were quite a few false positives. To him, the experience really highlighted the complexity of taking multiple variables in a situation and applying a single warning to counteract those variables.
- A fourth said, yes, expectations have changed. The technology was not already proven and ready to go "off the shelf" as was expected. The person said, "So, we are still dealing with the 'how' to do a use case in some areas, as opposed to measuring the impact of the technology. That was not expected and required a much more flexible approach." This person explained the situation in Tampa as a "maximizer" versus "satisficer" approach: rather than the "maximizer" approach of making sure everything was perfect and searching for the best alternative, the Tampa CVPD Team was in the "satisficer" mode of working with what was good enough to move forward. The ability of the Tampa CVPD Team to shift into satisficer mode was what made the difference in achieving success as the team has defined it.

Respondents indicated that the following were applications they perceived went well as part of the deployment:

- FCW.
- ERDW.
- VTRFTV
- EEBL.

Other applications did not work so well. Several of the interviewees mentioned that the pedestrian applications never really got up and running. The project was also challenged by GPS accuracy issues, so the team moved to LIDAR, which also had issues; the team then moved to camera analytics, which they think has potential.

One person mentioned that WWE and IMA did not work well in some situations. Wrong-way applications recorded several false positives having to do with the dynamic nature of the segment—reversible lanes with lack of GPS accuracy. IMA fell short when it came to vertical interference, such as an overhead bridge. Warnings were received because two-dimensional velocity vectors indicated a collision when the other vehicle was on an overhead roadway—the third dimension is important.

Even with these issues, all mentioned that they were very satisfied with the pilot deployment experience. One interviewee said it created a lot of opportunity for agency collaboration and good lessons learned: "Just what you want a pilot to do." Another mentioned that the pilot created a lot of possibilities for the future once some of the constraints are removed. (Constraints were identified as strict FHWA pilot guidelines on when and how to implement). A third elaborated, "Over a 30-year transportation planning career, it is one of the top two things I've done. Starting something in the planning phase and deploying it and seeing how it works is fulfilling." All said they would be involved in another pilot if given the chance, for reasons such as to get pilots out there, try it, and see what we can do; to pursue opportunities for collaboration; to rally around something that is new; and to advance the field. All said they would recommend participating in a pilot such as the CVPD, with the caveat "provided they have the resources and capability."

Policy Challenges

All four individuals cited national policy challenges. One interviewee identified the preservation of DSRC options as being very important. This person described DSRC as a technology that will work today and in the future. This person was not convinced that other options are as effective now. Another indicated that national policy is necessary to enable the true benefits of CVs. A critical mass of OBU deployments is needed, which requires a mandate that all vehicles be manufactured with OBUs and a standard that all new traffic signals be equipped with RSUs. Likewise, a third interviewee said it was necessary to establish standard operating procedures for maintenance and servicing of RSUs at the local level. It was an issue during the pilot in that there were a lot of maintenance issues to be addressed, and the team did not have a ready response to them. A fourth interviewee said the biggest challenge would be continued funding and development of these technologies. The program cannot remain stagnant with what is already developed. The most frequently used apps were WWE and FCW. Now, there is the need to focus on something else, such as improving the accuracy of the pedestrian crossing alert.

Institutional Challenges

Prior interviews identified the following institutional issues: educating all stakeholders on the benefits of the CVPD, dealing with the aggressive schedule, and procuring the new equipment required for the pilot in a timely manner. There was consensus that institutional issues were sufficiently addressed. Many coordination meetings were held. These meetings were necessary because the team was always feeling behind the curve. One person said, “Every time we fixed a problem, there was another one right behind it. We were never really ahead of it.” The meetings were used to keep up with what was needed to do.

Several interviewees mentioned lessons learned for future deployments in terms of institutional issues. One person specifically talked about the procurement policy for experimental pilot projects that was enabled through the CVPD as being critical to implementation. Because of THEA’s flexible procurement policies, the team could sole-source to vendors and suppliers. One interviewee said, “If we had to advertise an RFP [request for proposals] every time we needed to add a partner, that would have severely limited our solving problems as they cropped up.” Another person cited planning better before the pilot starts. This person felt as though the time between applying for the pilot and the beginning of pilot activity was not sufficient. Also, explanation and understanding of roles within the partnerships could have been better. A third person talked about being ready for the learning curve and continuing education. Learning challenges remain as the Tampa CVPD Team moves from pilot to day-to-day management.

In terms of future CV deployment, a person from the lead agency said for CVs to work, the road operators in different States need to be on the same page (standardized) to deploy in a reasonable amount of time. A nationwide decision must be made on what baseline CV technology should be deployed so that everyone has the same understanding of how to implement it and can purchase that technology at a reasonable price. Related to this, another person from an operating agency said there needs to be a better understanding of what one can expect from existing and developed equipment/software prior to actual deployment.

Culture

Impacts on agency culture due to pilot experience involved innovation, collaboration, and managing expectations:

- Innovation is fundamental to future development, and the agency must stay on the edge to stay relevant. But the agency also must remember what its mission is, and that innovation is complementary to the main mission.
- The pilot forced collaboration with other stakeholders involved. Now, they must continue the collaboration after the pilot is over.
- While this was a learning experience and most projects after this will be easier, future deployments will still come across unforeseen issues. So, preparedness and managing expectations need to happen.

Collaboration

The consensus was that stakeholders were participating in the pilot program according to both their own priorities and shared priorities. As one person said, “An agency doesn’t get involved in this kind of project without having some of its own priorities. But implementation coalesced around shared priorities.” A person from the lead agency said everyone operates in his or her own best self-interest. So, the deployment manager had to create a win-win situation by understanding what was important to all stakeholders, working hard to identify common problems and building shared solutions into the project.

All mentioned that no formal agreements have been put in place for long-term relationships among stakeholders. But the stakeholders (e.g., the city, FDOT, and THEA) are still connecting to build on what was done in the pilot through informal agreements.

Financial Issues

THEA put up the local match. Commitments from the other agencies were in the form of a soft match—in-kind commitments for staff time and resources. THEA indicated there is value in having one agency that has the main stake in the project: “We put up the match and recruited others to take part. It helped to make decisions. For that to work, you have to be vested in trying to accomplish the goals of all of your partners.”

A person from the lead agency suggested that cost/benefit is different for an innovation project versus an agency project: “For our typical agency projects, the industry has done them so many times that we have good data on costs to do price estimation. In an innovation world, functionality rules over ‘value engineering.’ It will be more expensive at first, but the innovation projects have to get operational to test benefits.” Getting the CVPD operational and generating data were the most important outcomes, not a quantifiable return on investment.

Business Processes

The pilot required a commitment to continued operation beyond the pilot lifespan. This will be done by the City of Tampa. Staff indicated they will be using more of an agency approach to compliment the testing approach. All four interviewees said their work programs had money for CV initiatives.

Performance Measures

Prior interviewees identified the following impacts as important in decisions to participate in the pilot: increasing safety, improving mobility, effectively implementing these technologies, reducing the negative impact of transportation on the environment, and improving system reliability. But none of the interviewees could say which if any were successfully achieved. Interviewees were not deeply aware of performance measure findings or have not used the data yet. A full impact assessment of the safety, mobility, and environmental benefits of the deployment was planned as part of the Program but was still being performed at the time of the interviews.

Systems and Technology

The interviewees all had a different opinion about the most significant technical challenges:

- One indicated that the most significant challenge was over-the-air updates since the pilot needed to dedicate a specific number of RSUs to do only that. Trying to have the RSUs do that and BSMs at the same time was too much.
- Another person mentioned the real-time applications as the biggest technical challenge due to latency—IMA, red-light running, and end-of-ramp deceleration. How is it going to work interference wise? Will there be the potential for a fatality if the information does not get through?
- A third person identified the OBUs and the conclusion from the pilot that they cannot be retrofitted. In the pilot, the team could not retrofit enough vehicles to achieve necessary saturation rates. OBUs need to be built into a car. That is the future of connectivity.
- The fourth interviewee pointed to the lack of GPS precision that caused one of the planned pedestrian applications to not be deployed.

The general assumption was that the current CV applications are not mature enough for widespread development.

Workforce Development

A person from the lead agency said that there were not many issues/challenges that could have been avoided by available training. Issues ranged from infrastructure issues (some of the signal systems were quite old) to software development issues and maintenance of both the RSUs and OBUs. All were taken in stride as they surfaced and resolved moderately well. That said, it was thought that the current staff would be capable of sustaining the CVPD program but that there may be additional staffing needs because staff will not be dedicated to the CV program.

Outreach

Interviewees had a mix of responses to the question of public and policy maker acceptance of the CVPD: “Acceptance is somewhat tenuous”; “All was good; elected officials all positive”; and “The public thinks technology can do more than what it actually can do.”

User Experience/Satisfaction

When asked how users have reacted to the CV technology, an interviewee from the lead agency said “pretty good” since few people have withdrawn. The interviewee from the city said, “I think most are pleased. However, I have some concerns as to how many original vehicles will continue once the pilot has finished and the maintaining agency has changed.”

Ongoing Deployment Issues and Challenges

In terms of overall lessons learned, an interviewee from the lead agency identified funding and flexibility as two major attributes of this type of deployment. Agencies take a considerable risk when developing these kinds of systems. They need help to fund the system and need flexible procurement policies to support the acquisition of cutting-edge technologies. Another from an operating agency said that the biggest thing to keep in mind is that just because issues were solved during this deployment does not mean the same or similar issues would not happen in future deployments. The interviewee suggested that USDOT should not increase time and funding constraints on future pilots solely because of the current pilot deployments.

Post-deployment Survey

The objective of the post-deployment survey was to gather information from stakeholders who are important but less engaged in day-to-day operations about whether and how the Tampa CVPD achieved the vision, goals, and desired MEP impacts. These stakeholders were the fleet operators and supporting agencies, like HART and TECO Line Streetcar, Hillsborough Metropolitan Planning Organization, Hillsborough County, and Florida Highway Patrol (Tampa). This survey was conducted at the same time as the long-term post-deployment interviews. The survey was administered as an online survey, accessed through a link in a recruitment email.

Sampling of Survey Respondents

The Tampa deployment team manager was asked to identify individuals or groups of individuals from each fleet or supporting agency that were especially knowledgeable about or had history with the CVPD deployment. This qualification limited the number of potential survey respondents. Based on input from the deployment manager, email invitations with survey links were sent to three fleet operators and seven persons at supporting agencies. Reminder emails were sent twice.

Online Survey Questionnaire

The online survey questionnaire contained items requiring close-ended (with response codes) and open-ended (textual) responses. Two surveys were developed to target the questions appropriately: one for fleet managers and one for supporting agencies. The online survey questionnaires are provided in appendix A.

The survey introductions presented the purpose of the stakeholder online survey, highlighted the confidentiality of the collected information, and explained the need for IRB/human subject protection requirements. Following the introduction, the respondent began the main body of the survey.

Table 6 shows the proposed topics of the survey along with representative questions.

Table 6. Online survey topics and questions.

Topics	Sample Questions
Type of agency/ organization	In what type of agency/organization are you employed?
Safety/schedule adherence concerns	FLEET ONLY: How concerned are you about operators' traffic safety, operators' ability to adhere to schedules, and operators' conflicts with other road users?
CV knowledge	SUPPORTING ONLY: How knowledgeable are you about the Tampa CVPD?
Benefits	What benefits of the CV system were experience?
Training effectiveness	FLEET ONLY: How effective was training provided to you/your drivers on the CV system?
Concerns about CV system	• Do you have any of the following concerns about the CV system that was deployed in Tampa?
Impact on job	• What type of impact did the CV system have on how you perform your job?
Satisfaction with CVPD	• Overall, how satisfied are you with your CVPD experience?
Challenges and lessons learned	What was the biggest challenge in participating in the CVPD? Did you have any issues with the CV system? How did the CVPD affect your organization? Are there lessons learned you'd like to share?

Source: Texas A&M Transportation Institute, 2022

Survey Implementation and Schedule

Upon finalization of the sample list and online questionnaire, a recruitment email containing the survey URL was sent to the 10 respondents identified by the deployment manager in August 2020. The survey was live for a 2-week period. At the onset of week 2, a reminder email was sent requesting participation from those that had not yet taken the opportunity to complete the survey. A total of two fleet operators (one each from HART and TECO) and three persons at city/county supporting agencies completed the online surveys. Because of the limited sample size, the TTI Evaluation Team provided only a qualitative assessment of the responses.

Survey Findings

Safety/Driver Distraction Concerns

The two fleet respondents unanimously reported that they were very concerned about:

- Operators' traffic safety (i.e., that they would experience a crash).
- Traffic signal stops, which might interfere with operators' abilities to adhere to schedules.
- Operator conflicts with vehicles turning right in front of the transit vehicle.

- One respondent was also very concerned that operators might experience conflicts with pedestrians, bicyclists, and other vehicles in traffic lanes, whereas the other respondent was moderately concerned about these events.

When asked of concerns about the CV system that was deployed in Tampa, the only concern identified by the fleet operator respondent was driver distraction. The city/county supporting agencies did not voice that concern. One person identified cost, too many alerts or warnings, and lack of standards across deployments (i.e., too many different applications). Two others said they had no concerns.

CV Knowledge

Among the three respondents from city/county supporting agencies, there were mixed levels of knowledge about the Tampa CVPD. One each reported being very knowledgeable, moderately knowledgeable, and slightly knowledgeable.

Benefits

Only the city/county supporting agencies were able to report on benefits of the CV system that were experienced. Two of these respondents indicated the following: fewer traffic crashes and increased roadway safety, improved roadway safety and driver awareness, and less traffic congestion. The third respondent answered, “Not aware of any demonstrated benefits.” One of the fleet operators also answered in that manner, while the other one reported, “To answer the question, this would require analytical data of pilot vehicles, which we do not have.”

Training Effectiveness

The fleet operators reported that the training provided to both them and the drivers in their fleets on the CV systems was moderately effective.

Attitudes toward CV System and Alerts

Respondents were provided several statements about the CV system and alerts provided and asked if they agreed or disagreed with the statements. The findings are as follows:

- ***The alerts/warnings provided by the applications increased safety.*** Two of the supporting agency respondents agreed with this statement, one strongly. One did not know. A fleet operator respondent was neutral.[1]
- ***I would like to see more vehicles equipped with this type of technology.*** Two of the supporting agency respondents strongly agreed with this statement. The third one and the fleet operator respondent were neutral.

[1] One of the fleet operator respondents stopped answering questions beginning with this topic.

- ***I would like to see the applications expanded to other areas of Tampa.*** Two of the supporting agency respondents strongly agreed with this statement. The third one was neutral. The fleet operator agreed with this statement.

The next statements were only asked of and answered by one of the fleet operator respondents:

- ***The alerts/warnings provided by the applications were sufficient to allow my operators to react to unsafe situations.*** The response was neutral.
- ***I will continue to support the devices in fleet vehicles.*** The response was "agree."
- ***I would recommend the CV system to other agencies in urban areas like Tampa.*** The response was "agree."

Impact on Job

In answer to a question on the type of impact the CV system had on how they performed their jobs, one city/county supporting agency respondent said it was positive, two others said it had no impact, and the fleet operator respondent answered he or she did not know. As a rationale for the positive response, the respondent wrote, "We were able to measure the number of times drivers received specific alerts like collision warnings or pedestrian safety alerts. This allows us to assess direct impact of deployment." The rationale for the fleet operators for not knowing was, "The system really doesn't benefit the operator of the streetcar in avoiding an accident. The system's value is in alerting drivers of vehicles that the streetcar is there."

Satisfaction with Connected Vehicle Pilot Deployment

Overall, the fleet operator respondents were very satisfied with the CVPD experience. So was one of the city/county supporting agency respondents. Another one was neither satisfied nor dissatisfied, and the third was somewhat dissatisfied.

Challenges and Lessons Learned

The person who was somewhat dissatisfied with the CVPD experience expressed the following challenges in participating in the CVPD:

- The need to deploy OBUs rather than mobility apps.
- Interoperability across hardware.
- Incomplete development of the multimodal intelligent traffic signal system.

This person also identified the following lessons learned:

- Standardize SCMS across the State.
- Democratize apps that require less time/location precision using connected vehicle to everything (CV2X).
- Centralize (cloud) the CV app and data rather than depending on multiple disparate local deployment.

The fleet operator respondent identified the biggest challenge in participating in the CVPD deployment as adapting the technology to a heritage streetcar.

Summary of Findings of Stakeholder Issues and Perspectives

Over the course of the post-deployment periods, stakeholder perceptions and issues have evolved, primarily as more knowledge and experience was gained through operating and maintaining the system.

Most stakeholders agreed that vision and goal of the deployment – to demonstrate the use of CV technologies to improve safety and mobility – never changed throughout the course of deployment. Reducing collision, reducing instances of wrong-way driving, and reducing the number of pedestrian-related collision was still the primary objective of the deployment. However, over time, many of the secondary goals, such as improving mobility, generating environmental benefits, became less critical as the deployment progressed. In the end, most of the stakeholder agreed that the CVPD provided the stakeholders with a good starting point from which to begin future expansion of CV technologies. Several of the stakeholder envisioned the deployment as being a good test environment to expand the level of maturity of many of the applications.

Other common critical issues that stakeholders reported throughout the deployment included the following:

- The need to continue to educate new stakeholders and decision makers on the potential benefits of the CV technologies throughout the life cycle of the deployment
- The need for flexible and realistic deployment schedules that can be adjusted as new, unforeseen circumstances developed. This was deemed critical because of the lack of experience and the level of maturity of emerging technology.
- Priorities among the stakeholders can change, especially when it takes a long time to get systems operational.
- There is often a need to involve stakeholders beyond the boundary of the systems. It was important to ensure inoperability with other CV deployments occurring elsewhere in the state and region. Road operators in different States need to be on the same page (standardized) to deploy in a reasonable amount of time. A nationwide decision must be made on what baseline CV technology should be deployed so that everyone has the same understanding of how to implement it and can purchase that technology at a reasonable price
- Financial issues, particularly those related to long-term operations and maintenance, should be addressed early on the deployment.
- One person specifically talked about the procurement policy for experimental pilot projects that was enabled through the CVPD as being critical to implementation. Because of THEA's flexible procurement policies, the team could sole-source to vendors and suppliers. There was consensus that institutional issues were sufficiently addressed.

A lesson learned mentioned by many interviewees was that there will be many unexpected "curveballs" that arise during deployments and lead to budgets being strained. They explained that there is a high cost associated with acquisition, deployment, and management of a CV system (e.g., managing the data that are developed). In an innovation world, functionality rules over 'value engineering.' The priority of the THEA CVPD Team was to get the systems and applications operating well over collecting performance measures data.

Stakeholder opinions about the level of maturity of the technology also evolved over time. At the beginning, most stakeholders felt that technologies and applications was ready to go. Over time, however, this perception changed. in the post-deployment period, most stakeholder mentioned that the

most significant technology-related challenge was the lack of maturity of the hardware (OBUs and RSUs) and the software (unstable firmware). Interviewees frequently indicated that the vendors were not able or capable of delivering technology that was “road hardened.” Many interviewees indicated that they expected that the technology they would be receiving was ready for deployment but what they received was not adequately tested and was essentially still at the prototype stage.

Multiple interviewees mentioned a challenge with the confidentiality and integrity of communication channels. More specifically, the availability of secure frequencies was an issue because of a rogue ham radio operator in the area that was authorized by the Federal Communications Commission to broadcast but whose programming was interfering with the system. Several interviewees mentioned communication issues that could have been resolved if fiber had been in place, as was assumed.

Another technological challenge encountered by the team was ensure accurate global positioning system (GPS) and survey information to generate accurate maps in the RSUs. Accurate maps were critical to ensuring that the applications did not generate false alerts.

Chapter 4. Post-Deployment Workshop

The TTI CVPD Evaluation Team held a virtual post-deployment workshop with Tampa stakeholders. The purpose of the workshop was to foster additional dialog among the deployment managers, deployment teams, and operating agencies concerning the lessons learned and major takeaways from planning and implementing the deployments. The common themes identified in the post-deployment interviews were used to frame the group discussion, which explored these and other topics in more detail. The workshop was also used to gather information needed to conduct the financial and institutional assessments, which will be documented in a separate report. The workshop was originally planned as an in-person event but was shifted to a virtual platform because of the COVID-19 pandemic.

Workshop Participants

Workshop participants represented the deployment managers, deployment team members, and operating agencies from Tampa. It was originally expected that 20–30 persons would participate in the workshops. Some but not all were to be individuals who had participated in the interviews. The TTI CVPD evaluation team coordinated with the deployment managers in identifying persons to be invited to the workshop (*4*).

Workshop Format and Schedule

Originally, it was envisioned that these workshops would be from a half day to a full day in duration. The TTI CVPD Evaluation Team developed open-ended questions designed to facilitate and guide the discussion in the workshop. When the format shifted to a virtual platform, the TTI Evaluation Team used the following half-day agenda to guide the workshops:

- Welcome, Self-Introductions, Purpose of Workshop (10 minutes)
- Key Findings from Interviews/Discussion (70 minutes)
  - Goals and Expectations
  - Technical Challenges and Solutions
  - Satisfaction and Lessons Learned
- Break
- More Key Findings from Interviews / Discussion (60 minutes)
  - Performance Measures Outcomes
  - Institutional Issues and Questions
- Sustainability and Expectation for Future Operations (30 minutes)
- Final Impressions of CVPD Experience (15 minutes)

The workshop focused on issues associated with operation and maintenance of the deployment and covered topics such as equipment and application reliability; changes in operations and maintenance

policies, practices, and procedures; changes in financial and institutional arrangements; etc. The specific topics covered in the workshop include the following:

- Roles in the CVP Pilot.
- Pilot Effectiveness.
- Deployment and stakeholder communications management.
- Technical, institutional, resource, and policy challenges.
- Outreach.

Appendix A contains the seed questions used in the workshop. The virtual workshop was held on November 23, 2020, from 12:00 p.m. to 4:00 p.m. Central.

Workshop Analysis

The following sections summarize the results of the discussion that took place during each segment of the workshop. The discussion and remarks are those shared by the workshop participants throughout the workshop and do not reflect the opinions of the TTI Evaluation Team.

Key Findings from Interviews

The following sections summarize the key findings from the workshop interviews.

Goals and Expectations (Expectations about What Constituted Success [e.g., Goals] Changed during Deployment)

The workshop facilitators asked the participants whether they had different and competing expectations for the Tampa CVPD. The general response was that the public thought that AVs would be here in 2 years, and they wanted to know why we are not there yet. Initially, the expectation was that this technology was coming very quickly, and there was also a question of whether CV and AV were the same. Additionally, media and public expectations of what the technology did were different than what its true capabilities were. This perception did not affect the pilot in terms of what was done but did change the marketing and the consistent messaging about the technology (CV, AV, etc.). Media and marketing about the pilot deployment had to change, and the deployment team had to do more education on the participant end.

For the public agencies in attendance, they wanted to work with the new technology but also use it to address problems they were facing. The most striking reality to note for this audience was the perception by the public that the CVPD was an AV project. This perception did not affect the ability to get participants to retrofit their vehicles. Additionally, the team lost participants because of delays that occurred through SCMS over 6 months.

When asked which expectations were met, one participant noted that he or she was able to put “shelf-ready” technology in a corridor, get it operational, get results (even if only in five vehicles), and get data from the vehicles. That met expectation was exciting. It was also beneficial that the participant was able to get the data into the vehicle. When considering what expectations were not met, one response was the realization about how much work it took to get the “shelf-ready” technology up and running. Other issues were noted related to versions of software and the time needed to get maps operational, both of which were a surprise.

With respect to performance management, participants acknowledged that the experimental design at the beginning of the project assumed that the technology would be fully ready, out on the road, and operational. It turned out that the technology was not fully ready as originally assumed. The deployment team had to make changes to those assumptions. With respect to the technology, the market in which the technology development was taking place was small-sized research and development businesses, some of which almost disappeared from the market. Regarding the deployment, the market around the technology was in rapid development, and there were significant growing pains associated with the technology.

One significant unmet expectation was the fact that the National Highway Traffic Safety Administration (NHTSA) ruling was imminent when the project started. The reality that the ruling did not materialize dramatically changed the dynamics of the project, including the overall direction of the project. The CVPD team found that they could test applications in the corridor and see benefits, which got them out of thinking in terms of communication. The applications were what they were testing.

The workshop facilitators asked participants what they would do differently if they were starting over. With respect to technology, they would schedule much more integration testing on-site. There were challenges that could not be seen in the lab, and they would quadruple the amount of integration and on-site testing in a future project. Participants also emphasized that site visits are very important. The Tampa CVPD Team needed to ensure that everything in the field was in proper working order and had a good assessment of preexisting field equipment. Additionally, the team needed to get out of the cellular connections and connect to fiber from the start or as soon as possible. Participants would also improve the specification for the OBUs if they were starting over. Finally, participants would not schedule an installation appointment in a vehicle until the installers were ready to go. They only want to touch the vehicle and the equipment once, and canceled appointments were the most stressful part of the deployment.

Manufacturer/Vendor Technical Challenges (

Workshop facilitators asked participants if the lack of participation by the auto manufacturers diminished the chances of success of the pilot. Participants noted that when project leaders reached out to the auto manufacturers, the manufacturers indicated that they were not interested in going down the pilot route. Rather, they would wait until the NHTSA ruling was released and then build to the specification. Participants noted that some companies got out of the hardware business and stayed in software, making it difficult to get them to support the hardware after the shift. However, some vendors were highly engaged, attending all meetings and being very responsive to queries

The facilitators asked whether the participants thought that the car manufacturers might have improved the process by exerting pressure on the participating vendors. One participant said that pressure might not be the right word to use in this scenario. One manufacturer took a very active role in phase 3 and worked with an after-market safety device (ASD) provider to develop the applications that would be interoperable as they are working toward at-scale production. The participants were also of the opinion that projects such as the CVPD must be collaborative for all of this to work. They believed that if the government mandate pushing the V2V had been issued, there would have been a lot more motion and work with the OEMs. The lack of the ruling slowed the manufacturing of the OBUs, which impacted the overall project.

Installation of Equipment and Data Technical Challenges

Other specific technical challenges and thoughts shared by workshop participants centered on the installation of equipment and data. Of note, installation of the RSUs was challenging with the initial use of providing power over ethernet. Grounding problems occurred in the event of lightning strikes, and the salt air proved to be corrosive. Separate power lines were eventually installed to mitigate these problems. Participants noted that they could have done a better job installing a complete end-to-end grounding. Additionally, the systems engineering design was such that sensors and components could easily be swapped out (including the installation of newer tech), which was included in the architecture as a physical layer that was separated from the applications. Finally, the team initially thought that it was not feasible to capture all the data streams (including BSMs) though that process went very well. In the long run, the team did not lose any data despite storms and outages.

Applications that Worked Well

The workshop attendees were asked to reflect on what applications worked well and whether they would deploy them again. Overall, participants felt that all the applications worked despite the issues that arose because of the COVID-19 pandemic. The End of Ramp Deceleration Warning application showed promising results, and the Wrong Way Entry application worked well, notwithstanding OBU firmware issues. The Forward Collision Warning and Emergency Electronic Brake Light Warning applications worked well together, and there is evidence that the participants responded. Data analysis indicates a change in behavior. The analysis of the Vehicle Turning Right in Front of Transit Vehicle application provided evidence of reducing potential exposure to conflict. IMA worked well, especially with buses and when evaluated as part of the progression use case. IMA could gain in further refinement to the operational parameters to make it more tuned with respect to a high-density urban environment in terms of the level of accuracy. Participants noted that it is important to measure the accuracy of all the applications, including false negatives, false positives, true positives, and true negatives. Also, a change in firmware would require the agency to touch base with the vendor, which is achievable but would require additional work. When asked what changes would be made if deploying these applications again, the respondents indicated they would make changes in the End of Ramp Deceleration Warning and Wrong Way Entry applications though they did not describe specific changes. The PCW application would be of interest for the intersections on non-limited-access facilities.

Applications that Did Not Work Well

Attendees were also asked to share information on what applications did not work well. An intelligent traffic signal system (I-SIG) was tested at the University of Arizona and was not capable of doing what the Tampa CVPD Team wanted it to do. Additionally, the team never got the TSP application operational. The original plan was to use 3 years of downloaded certificates and to download the TSP-required certificates every 2 weeks. The Tampa CVPD team was testing this process when the COVID-19 pandemic occurred, and the team had to stop its testing.. The team turned off securing for testing and has had intermittent success. If the download process had worked as planned, the team would have met the requirements and worked to ensure the pilot was operational and able to generate data.

For the PCW application, the team had an issue with the LIDAR-based system at the beginning. The initial technology had difficulty tracking pedestrians in the crosswalk. When the Tampa CVPD Team was able to deploy a new technology, the team could successfully track pedestrians. This technology change warranted extended time for data collection with new technology. One problem with the pedestrian handheld devices was due to differences in the devices and the way in which they provided information.

The location service varied considerably across manufacturers of Android phones, so they could not be use for the crash warning. The deployment had to use the video imaging system and push that information to the vehicles. The roadside sensor was very accurate in identifying the location of pedestrians and sending it to the vehicles several times a second. The challenge lay with sending inaccurate car information to an inaccurate phone location and using that message as a warning.

Satisfaction and Lessons Learned

The workshop facilitators asked whether the participants were satisfied with the pilot experience despite the challenges experienced during the deployment. The following are the specific responses offered:

- From one agency's perspective, it has been a positive experience. Their board of directors was happy working with USDOT and that it increased their visibility. They were also glad to be working with the chamber of commerce and other local partners. The project would be a great case study of how even small agencies should not shy away from technologies.
- Innovative deployments, like the CVPDs, are always full of technical challenges. It is easy to let all the technical challenges overwhelm progress, if a deployer tries to address them all at once. In terms of innovation projects and new development, agencies should focus on completing what they can accomplish first, and then come back and address challenges as time and resources permit. Pilot deployments such as these are different than other types of projects; sometimes you must take "good enough" and keep moving forward.
- Deployers must get to some point where they are generating data. Do the best possible at the time and come back later to see if other things can be accomplished. Any successful application is a positive.
- There is a plan to require queue-flushing technology in future projects. The stakeholder plan to install more RSUs so that as CVs become more prevalent, the region will be ready.
- One critical lesson learned was that more integration testing is needed to work through all the issues and that everyone on the team needs to be involved.
- Prior to the Tampa CVPD, one stakeholder had not dealt with the public and consumers on the installation side. It was an eye-opening experience, and the stakeholder learned a lot. It was a positive experience working with the whole team of vendors, project managers, the client, infrastructure, etc.
- Another lesson learned was that working collaboratively, meeting consistently, holding on-site meetings, etc., were the best part about the entire project. The deployment team got more done on-site and working together, and the ongoing meetings established an open channel for communication.
- There was a tremendous amount of information exchange; it is not often that an entity gets to collect longitudinal data with participants. The project was of tremendous value regardless of the constraints. The deployment stakeholders gained a vast amount of information to foster research into the future.
- It is important to learn to be responsive to the constraints and adapt the experimental design over time if necessary.

Performance Measurement

The workshop attendees were asked about any performance data received from CUTR and what they have learned in terms of the effectiveness of the applications. The participants responded that they chose

an academic institution to provide an objective perspective on the evaluation. Their evaluator had full freedom to assess and report performance outcomes as supported by the data.[2]

The workshop facilitators asked the Tampa CVPD Team to share lessons learned that they could use in developing performance metrics for their next CV deployment. The team noted that they had meetings at the beginning where they were able to convey an agency's problems, after which they identified applications that could help them. They recognized the need to measure what the technology did in the corridor. They also indicated that they have identified functional items in which a road operator would be interested, specifically that the loss of packets might not impact the use of an application at an intersection, and in crash prevention. Providing such information to CUTR was helpful.

Procurement Policies

Workshop participants were asked to reflect on the importance of flexible procurement policies to the success of the pilot. The general sentiment was that a team needs to know its procurement policies and build its schedule around them. These types of deployment projects can be done without flexible policies, but deployers are unlikely to meet their schedule. The Tampa CVPD Team could not have accomplished the project and kept to the schedule without flexibility. A tight schedule equals a need for more flexibility.

Institutional Issues and Questions

The Tampa CVPD Team was asked to describe any future plans for the CV system that was deployed in the pilot. THEA noted that anything deployed on its roadways is owned and operated by the agency, and it will continue operations. THEA has added a line item in its current capital work program. After 5 years, the line item will be removed from the capital budget and be shifted to its operations and maintenance budget. The other RSUs deployed as part of the pilot will become city-owned property and be used in conjunction with the other RSUs. The City of Tampa has an interlocal agreement with FDOT to operate those within the city, and the city will remain in the pilot for as long as it remains functional. The area partners will also continue to use DSRC if they are able. All the OBUs are DSRC, and the city is not scheduling a bulk removal of the equipment. If the city is required to remove the equipment, it will do so. The city currently does not have plans to take the equipment out because the contract with USDOT was to continue operation after the project.

Another important consideration for future deployment and moving toward a more widespread deployment of CV technologies is the involvement and integration of the OEMs. For the anticipated phase 4 of the deployment, specific OEMs will be included. The team recognizes that there will be a significant need to explain to the public that this technology can be put into vehicles. Phase 4 is incorporating the OEMs and the OBU manufacturer. Since an ecosystem is in place, this deployment will be a testbed for CV2X and DSRC. Phase 3 ended on September 30, 2020, and OEMs will be bringing their own applications for testing as part of phase 4.

[2] Note that the workshop was held prior to the results of the final performance analysis report prepared by CUTR was available for review.

Workforce Challenges

Workshop participants were asked to share experiences with the learning challenges both during the pilot and as they move to day-to-day management. The primary response was that since THEA is a small agency, it outsources most of the work associated with the ongoing operation of the system. THEA has internal project management for maintenance as well as a contract with the RSU vendor for maintenance of the RSUs. Training and education of staff are built into the scope of services for the RSU maintenance contract. THEA has an ongoing requirement to continue to upload performance data in the Secure Data Commons and evaluate the effectiveness of phase 4 deployment. To support this effort, THEA has contracted CUTR to extend its work effort beyond the end of the CVPD.

Sustainability and Expectations for Future Operations

The following sections summarize workshop questions focused on future operations for the pilot deployment.

Ongoing Operations

The workshop facilitators asked which of the applications the Tampa CVPD Team deemed beneficial for the city. The team indicated that as part of phase 4, it is participating and trying to get up to 600 users. The OEMs will be recruiting people to participate in the program as well. The team hopes to continue to provide data. The team will continue to work on TSP and I-SIG to get something out of those applications and continue to gather data for PCW. The OEMs will deploy seven applications on their units. The red-light violation warning will be in the OEM units, and they will have their own logs to gather performance data. Tampa is working on possibly sharing data from the OEMs.

RSU Operations and Maintenance

The workshop participants were asked to discuss whether Tampa personnel are fully trained to operate and maintain RSUs. Participants noted that the RSU vendor is part of phase 4, and that operation and maintenance are built into the contract with them. The contract will be ongoing for 2 years, and at that time THEA will look at structuring a new operation and maintenance contract. This vendor monitors RSU performance and sends a daily status report of the equipment. If there is any RSU with an issue, the vendor connects to it and tries to diagnose the problem. The RSU vendor has a contracting team that performs maintenance in Tampa, and the team will go into the field to determine what needs to be done (replacement, etc.). In phase 4, task 6 is interference testing. The system is being built and installed, and a separate agreement with USDOT will cover writing the testing protocol.

OBU Operations and Maintenance

The Tampa CVPD Team was asked to discuss information related to the operation and maintenance of the OBUs. The project had three OBU vendors initially, with two primary vendors remaining in the deployment. Within those two vendors are multiple firmware versions. Not all the OBUs have been updated, depending on whether they have driven through the area where the new firmware would be downloaded. Approximately 10 versions are currently operational. Each vendor has a “friends of the pilot” release that is for testing purposes only. A few of the OBUs are used for demonstrations and application testing before they are released to the public.

The workshop facilitators also asked whether the same RSU team should be responsible for OBU deployment, operations, and maintenance. The Tampa CVPD Team indicated that if users do not want to continue in the pilot, they can keep their unit and will get the messages; the OBU will continue to function. Currently, the ASD provider is contracted by THEA to maintain and support the OBUs. If users have trouble, they call the ASD provider, who works to repair and/or replace the unit. The goal is that any participants wanting to go through into phase 4 can get the unit upgrade, which is the Sirius. If they want to continue to participate in the pilot and get the additional incentive, they must swap to the new unit. The incentive is a discount on tolls: 50% discount up to $550 for the duration of the project ($550 is the 50 percent amount).

When asked to provide information on the people trained to do future installations or to handle maintenance and repair, the Tampa CVPD Team indicated that Hillsborough Community College (HCC) had trained installers of the OBUs in the initial project phases. Moving forward, the Tampa CVPD Team will have its own installers as well as contracted installers. The installers will be able to rent out a bay at HCC for installations, but the students are not part of the program moving forward.

The workshop participants were asked to provide information on OBU units, ownership, inventory, and updates. For the aftermarket installations, 400 OBUs must be installed, which have been ordered. There are no spare SiriusXM OBUs; all that are in inventory were ordered specifically for the project. THEA has a master technician who will train other technicians. THEA will also have a contractor that has been trained. Firmware updates are done over the air in the field though no planned firmware updates are anticipated for phase 4. The OBUs will use the latest firmware update that was functional at the end of phase 3. THEA owns the units, and the ASD provider manages the inventory. THEA would like to continue beyond phase 4 though there is no current plan at this time. THEA is being flexible, and there are possibilities to continue beyond the life of phase 4. THEA's desire is to have the deployment work indefinitely.

Network Operation

The workshop facilitators asked for information on responsibilities related to the ongoing operation of the platform. Participants noted that they are following their data management plan and standard operating procedures, which includes daily tasks, weekly tasks, and monthly tasks, as well as automated push information related to the status of RSUs. Participants undertake a complete review of the system to ensure that none of the files are filling up, which is also included in the data management plan document.

One full-time operator is responsible for operating the platform and has been since the beginning of phase 2. With respect to the need for a separate area to test new CV technologies away from the deployment area, this capability will be available to the RSU vendor in phase 4 through membership in the American Center for Mobility. Three automobile companies with road applications have access to that as well. With new firmware releases, the "friends of the pilot" test the new releases before they go out for distribution. Only the OEMs are adding the red-light violation warning to their units. It is not being added to the aftermarket units

Going Forward

Workshop facilitators asked how the deployment participants are going to leverage their investment in RSUs and OBUs in the future. Numerous conversations have taken place from the infrastructure owner operator perspective, and regional partners are interested in applications to provide better service to their customers and better operate their roadways.

Final Impressions

Workshop participants were asked to share any final observations with TTI Evaluation Team. One participant noted that it is important to look at the progress that was made, which would not have been made without USDOT initiating the entire program in the first place. Supporting the pilot program was an enormous step in getting progress and learning about these technologies. Additional advice for agencies considering the deployment of forward collision warning was that road operators can use this technology now regardless of how it communicates. Agencies can use existing technology to backfill data in the absence of CVs, and it is likely that agencies already can provide data and detection information. An agency need not be a large DOT to get involved. Managed lanes and transportation systems management and operations are the last stop since most agencies do not want to add lanes, and CV falls into that category of strategies that are used to manage the network.

Chapter 5. User Satisfaction Evaluation

The Tampa CVPD Team, like the other two individual CVPD sites, was responsible for executing user acceptance surveys as part of the evaluation. Users of the CV technology in the Tampa pilot included drivers of passenger vehicles, bus operators, and streetcar operators. Researchers at CUTR of the University of South Florida were primarily responsible for the user survey design and administration. However, as the independent evaluator, the TTI CVPD evaluation team, along with the Volpe Center, assisted CUTR in developing the survey instruments, ensuring that questions important to the independent evaluation were included, and assessing the user acceptance survey results. The Volpe National Transportation Systems Center designed the survey in coordination with TTI and provided the draft survey instruments to the Tampa CVPD Team. The Tampa CVPD Team was responsible for administering the survey to the users. This chapter documents the findings from user acceptance surveys.

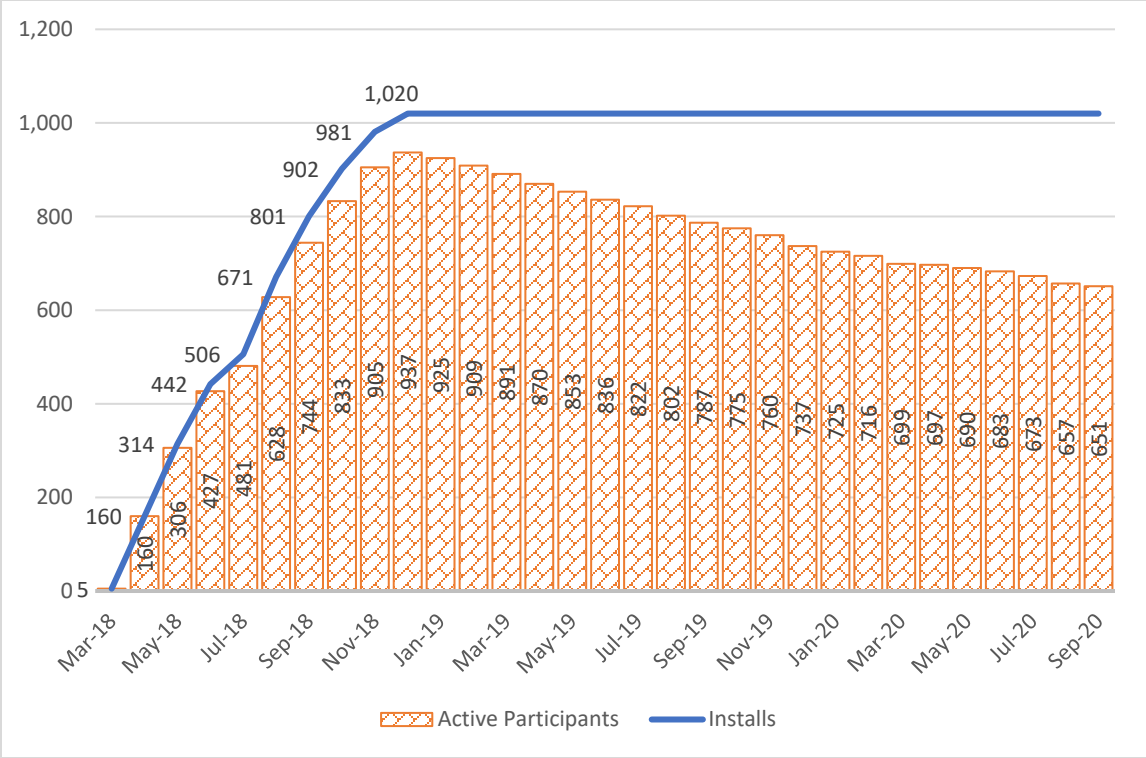
Drivers of Passenger Vehicles

Definition

A passenger vehicle participant in the Tampa CVPD was among those recruited to have CV technology installed in their personal light-duty vehicles, go through the registration and training process, and be approved to be part of the CVPD. The treatment group received warnings, and a control group did not receive warnings. The treatment group participants' vehicles used the OBU applications when they were within the study area in which the applications operated. Passenger vehicle participants who had OBUs installed in their vehicles may have received in-vehicle warnings.

Recruitment and Technology Installations

Users were recruited by emails to THEA customers that introduced them to the study and provided information on how to register as a study participant. Recruitment only happened once at the beginning of the pilot. According to email communication from CUTR, 2420 THEA customers expressed an interest in participating in the CVPD. Of these interested persons, 1058 confirmed an installation appointment, showed up, agreed to the IRB informed consent, and completed the initial survey. Of these 1058 persons, THEA installed OBUs in 1020 vehicles. Thirty-eight persons did not have OBUs installed either because the installer determined that the vehicle did not meet installation requirements, or the persons changed their minds about having the equipment installed. Figure 3 presents the installation progress and passenger vehicle participant retention from March 2018 to September 2020. During this time, active participants in the Tampa CVPD dropped from 1020 to 651 for reasons identified in chapter 3.



Source: Center for Urban Transportation Research, 2021

Figure 3. Bar chart. Tampa CVPD OBU installation and active participants.

Survey Methodology

User acceptance surveys were administered at three points in time. Methodologically, the original survey design was as a panel, in which the responses from the same respondents in all three survey waves could be tracked over time. Unfortunately, respondents IDs from the initial survey were not tracked in the two post-deployment surveys, so respondents' answers on one survey could not be linked to those of a subsequent survey. Also, some questions were not asked in the post-deployment surveys (e.g., demographics) because it was assumed that the initial survey data could be associated with a respondent's answers in subsequent surveys, which unfortunately they could not.

The first survey was administered at the installation facility when the participants brought their vehicles to have the equipment installed. This survey was administered online, and it covered attitudes and perceptions about CV technology, driving experiences in downtown Tampa, previous experience with CV applications, and general travel behavior. The number of respondents in the initial survey (1058) was more than the number of OBUs installed for the reasons cited in the preceding paragraphs.

Invitations to participate in the second and third surveys were sent via email to participants. A link was provided in the email to access the online survey questionnaire. For purposes of discussing results, the two surveys are referred to as the *after-immediate survey*, initiated in December 2019, and the *after-final survey*, initiated in summer 2020. According to CUTR, the administration of these two surveys took a few months each. The post-deployment surveys were meant to capture vehicle participants' experience with

the CV apps, their satisfaction with participating in the pilot, and other related information. Generally, the same questions were asked in the two post-deployment surveys.

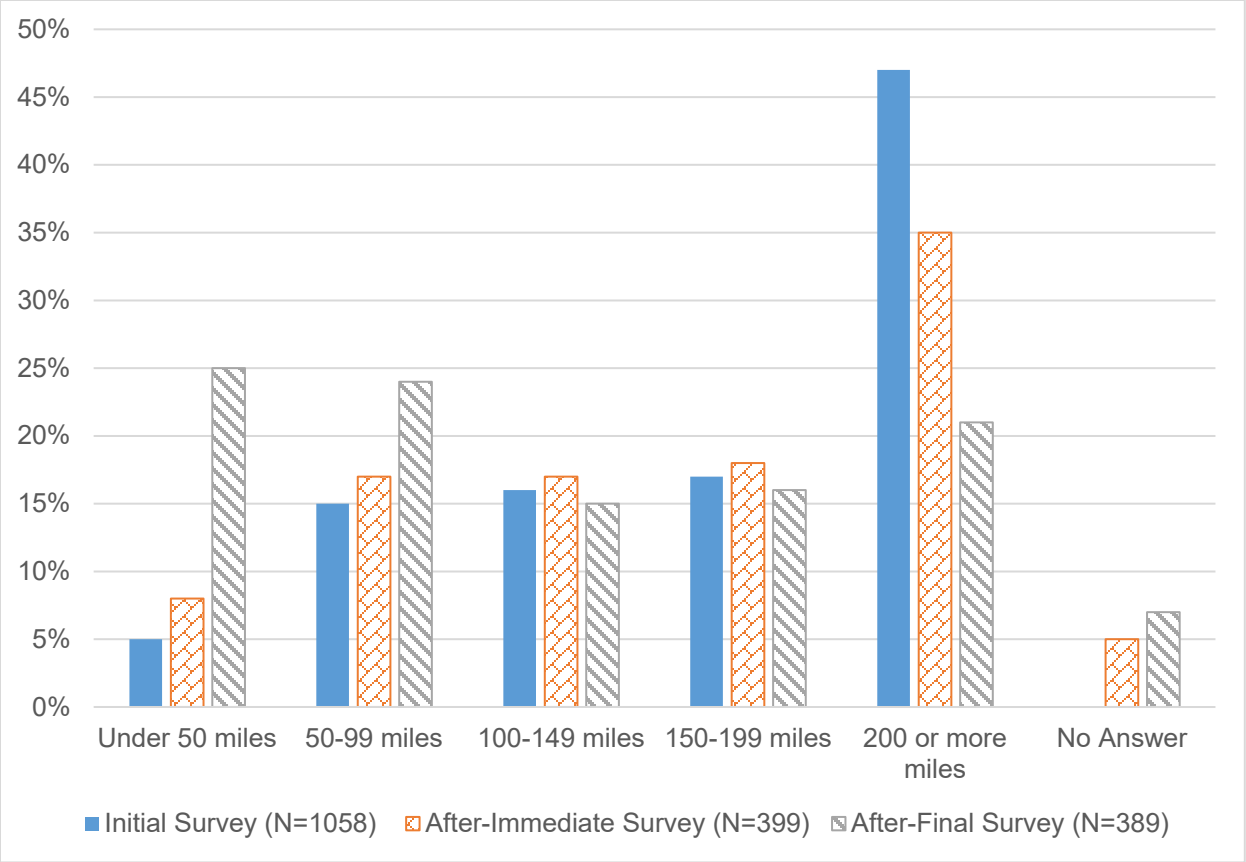
Participation rates in the three surveys varied and were calculated based on the number of active participants at the time of survey administration (see Table 7).

Table 7. Tampa CVPD user survey participation rates.

Survey Type	Approximate Dates	Active Participants	Respondents	Rate
Initial—at installation	March–Oct. 2018	1,058	1,058	100%
After-immediate	Dec. 2019	736	389	53%
After-final	Summer 2020	650	384	60%

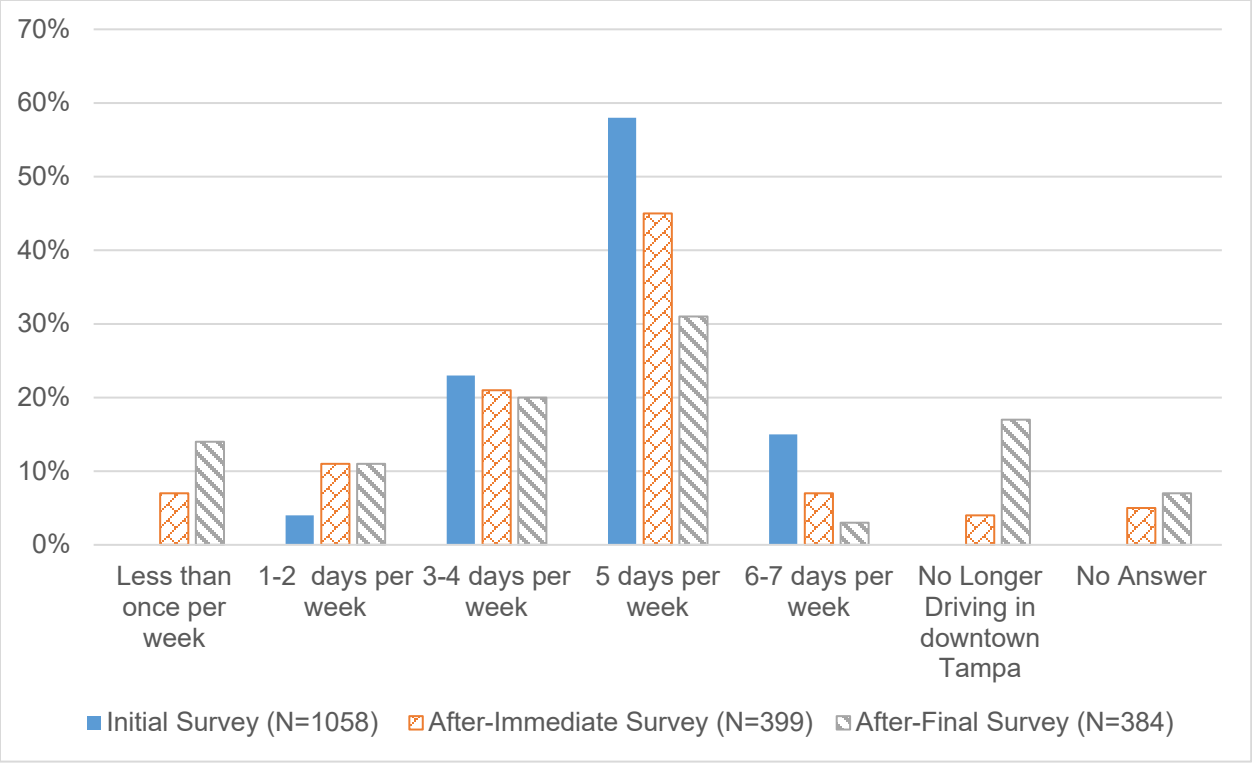
Source: Center for Urban Transportation Research, 2021

Figure 4 and Figure 5 compare the driving behavior of respondents in the initial survey with that of respondents in the two post-deployment surveys. It appears that as the deployment progressed, persons who drove 200+ miles tended to leave the sample, which increased the proportion of drivers with short trips. In addition, the proportion of more frequent drivers into downtown Tampa was higher in the initial survey than in the subsequent ones. By design, the initial survey did not include any persons who did not drive into downtown Tampa or who drove less than once a week.



Source: Texas A&M Transportation Institute, 2022

Figure 4. Bar chart. Number of miles traveled in a typical week.



Source: Texas A&M Transportation Institute, 2022

Figure 5. Bar chart. Number of days driven into downtown Tampa.

Findings from the Initial Survey

This section presents findings from key survey questions that were only asked in the initial survey.

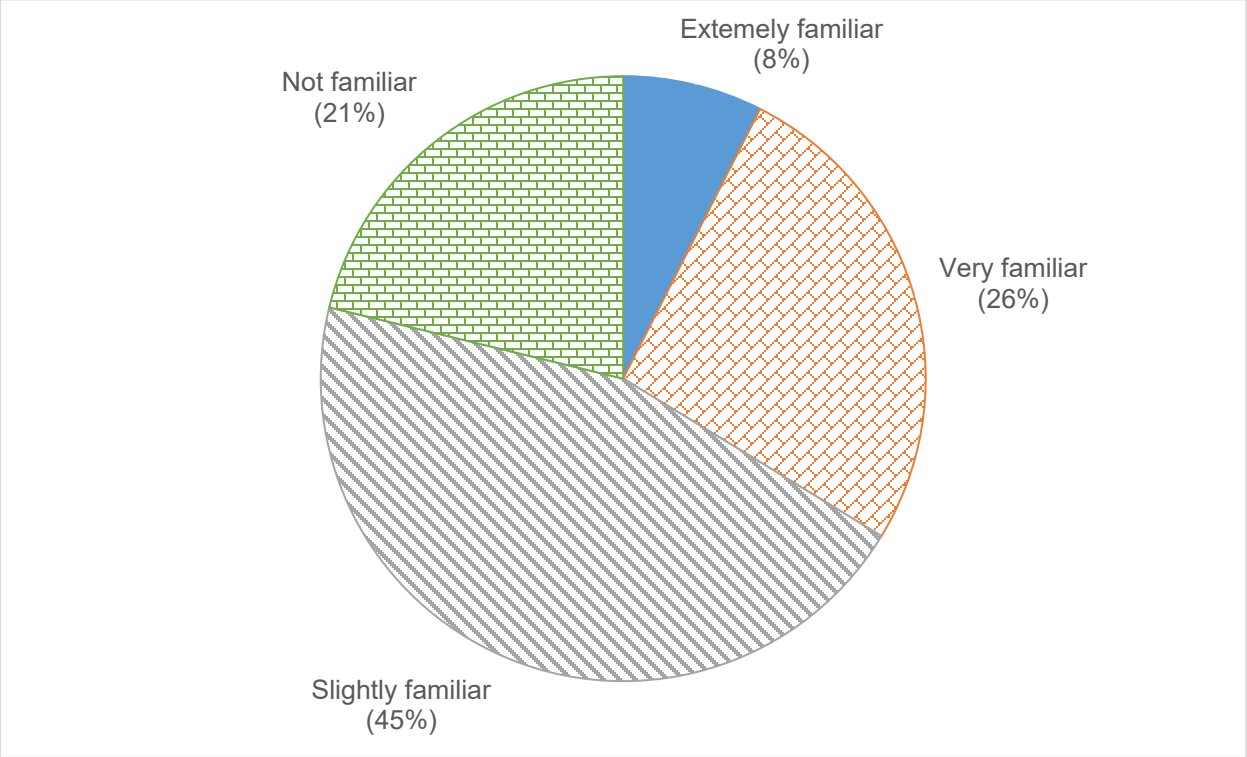
Demographics of Passenger Vehicle Participants

Of the 1058 persons surveyed initially, the majority (55 percent) were male. The total sample represented a range of ages with the most prevalent being 45–54 (29 percent), 35–44 (26 percent), and 55–65 (19 percent). Participants tended to be educated persons having a bachelor's degree (27 percent), associate degree (36 percent), or some college (17 percent). Most (87 percent) were employed full-time. Three-quarters were White (77 percent), 10 percent were Black or African American, and 16 percent were of Hispanic or Latino origin. Complete demographics tables for the initial survey respondents are presented in appendix B; demographic questions were not present in the post-deployment surveys.

Familiarity with Advanced Vehicle Technologies

In the initial survey, participants were presented with a definition of CV technology and descriptions of the applications and then asked about their familiarity with them. Seventy-nine percent of the respondents indicated that they were slightly, very, or extremely familiar the CV technologies. Twenty-one percent said they were not familiar with CV technology, that is, had not heard of CVs before this study and had no information about the applications; whereas 34 percent said they were extremely or very familiar with the

technology, that is, had heard of the applications and understood how they work (see Figure 6). This question was only asked in the initial survey.

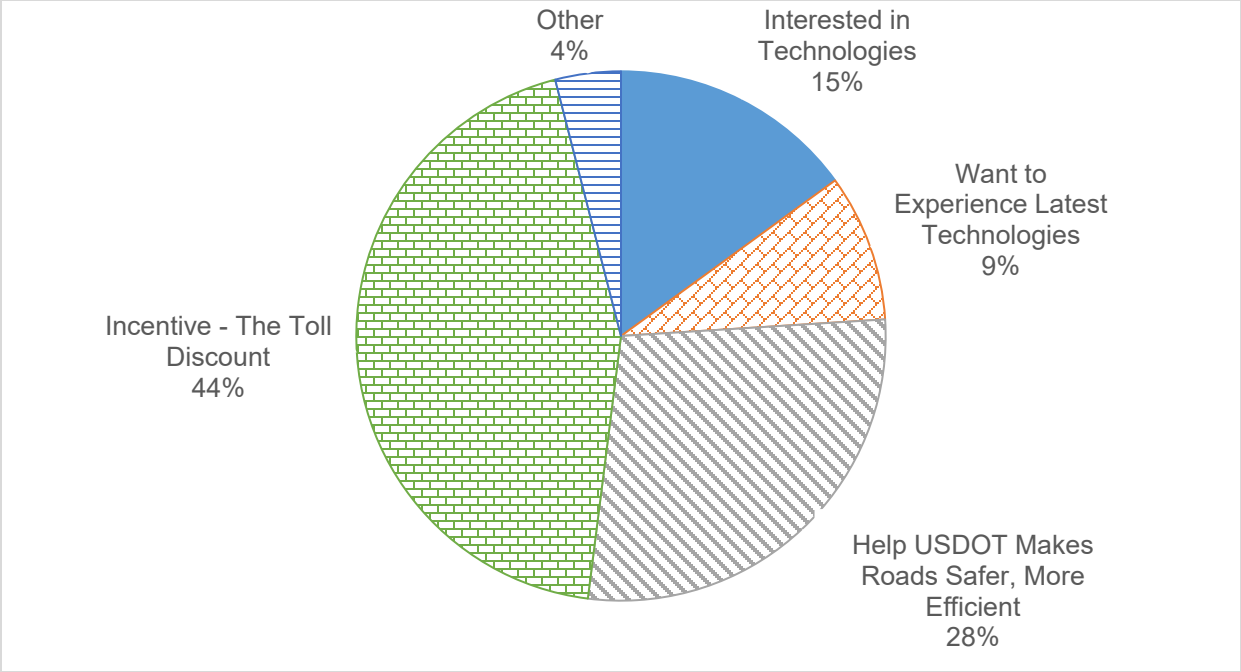


Source: Texas A&M Transportation Institute, 2022

Figure 6. Pie chart. Percentage familiar with CV technology (N=1058).

Motivation to Participate in Study

Participants had varying reasons for their willingness to have OBUs installed in their vehicles (see Figure 7). For most (44 percent) the incentive (i.e., toll discount) was most compelling. But for a sizeable percent (28 percent), it was the desire to help USDOT makes roads safer and more efficient. It would have been informative to ascertain which type of motivation was most effective in maintaining active participants throughout the deployment; however, participant ID numbers were not tracked across the surveys, so researchers do not know who might have dropped out and who might have continued after the initial survey.



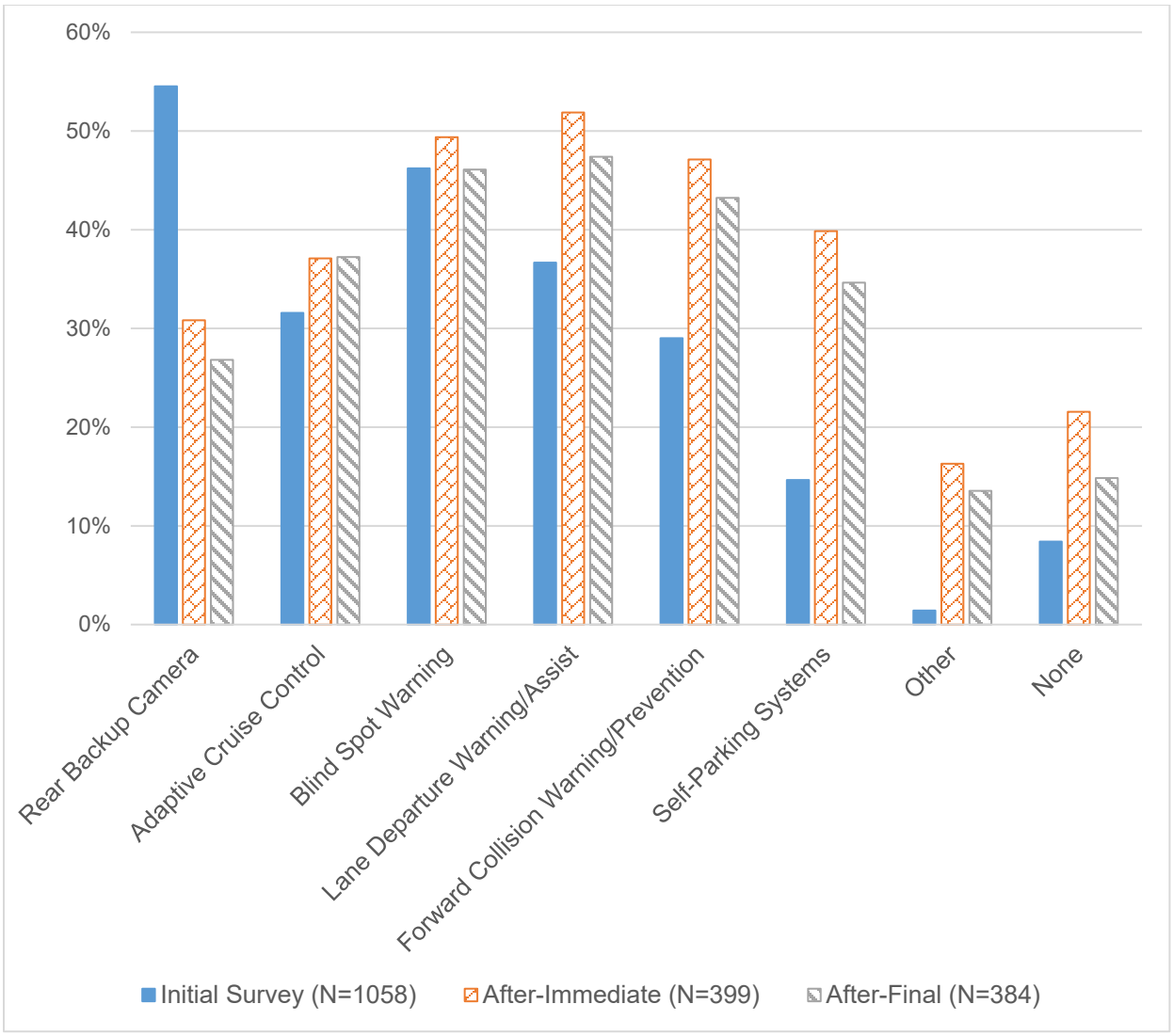
Source: Texas A&M Transportation Institute, 2022

Figure 7. Pie chart. Motivation for participating in deployment (N=1058).

Comparative Findings from Initial, After-Immediate, and After-Final Surveys

Prior Experience with Advanced Vehicle Technologies

The level of familiarity with technology often positively influences attitudes and perceptions of technology. Except for rear backup cameras, the respondents in the initial survey had less familiarity with advanced technologies on vehicles than did those participants that remained to respond to the later surveys (see Figure 8).

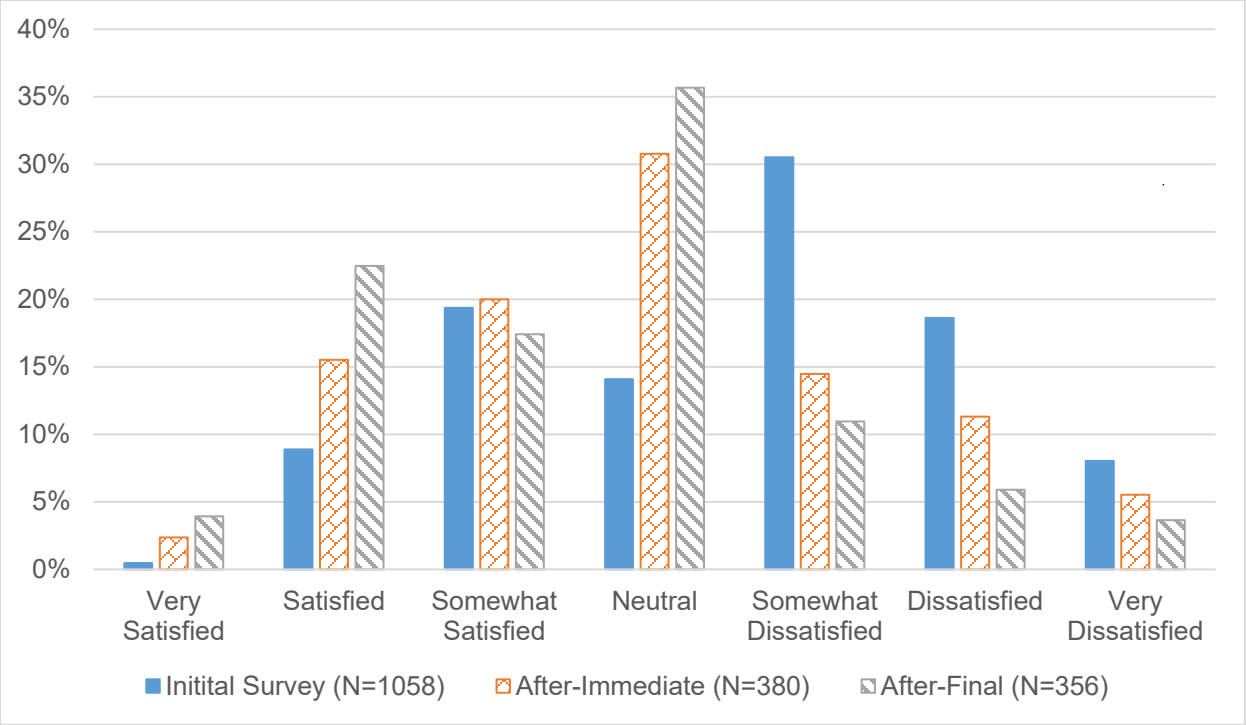


Source: Texas A&M Transportation Institute, 2022

Figure 8. Bar chart. Percentage of users with experience with advanced technologies on any vehicle.

Satisfaction with Aspects of Driving in Downtown Tampa

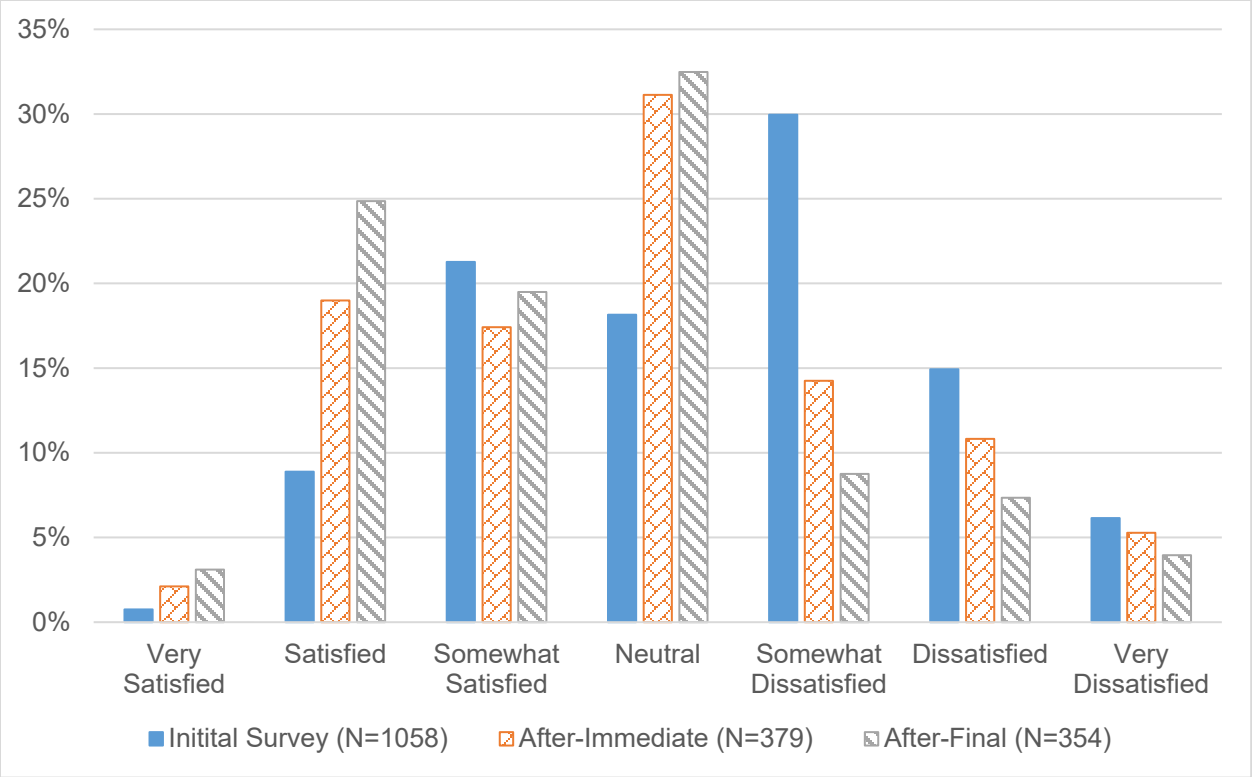
Respondents in the post-deployment surveys indicated being satisfied or very satisfied with overall travel time driving in downtown Tampa to a significantly greater degree than respondents in the initial survey (see Figure 9). Eighteen percent of after-immediate survey respondents and 26 percent of after-final survey respondents were satisfied or very satisfied, compared to 9 percent of those in the initial survey. Levels of dissatisfaction were higher among initial survey respondents as well, while significant proportions of the post-deployment survey respondents were neutral (neither satisfied nor dissatisfied).



Source: Texas A&M Transportation Institute, 2022

Figure 9. Bar chart. Satisfaction levels with overall travel time driving in downtown Tampa.

Like satisfaction levels noted previously, respondents in the post-deployment surveys indicated being satisfied or very satisfied with the overall driving experience in downtown Tampa to a greater degree than did those in the initial survey (see Figure 10). Levels of dissatisfaction were higher among initial survey respondents as well, while significant proportions of the post-deployment survey respondents were neutral (neither satisfied nor dissatisfied).

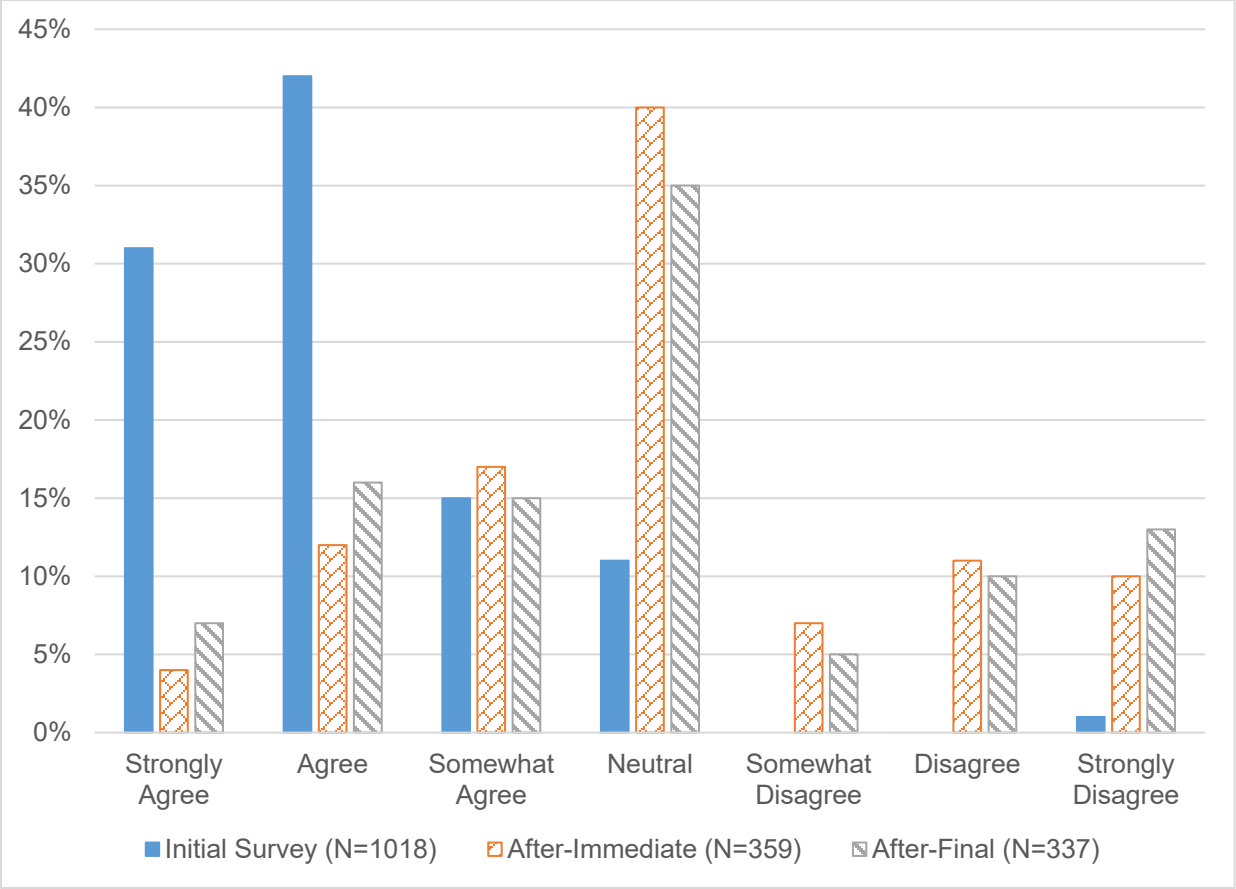


Source: Texas A&M Transportation Institute, 2022

Figure 10. Bar chart. Satisfaction levels with overall driving experience in downtown Tampa.

Opinions about CV Technology

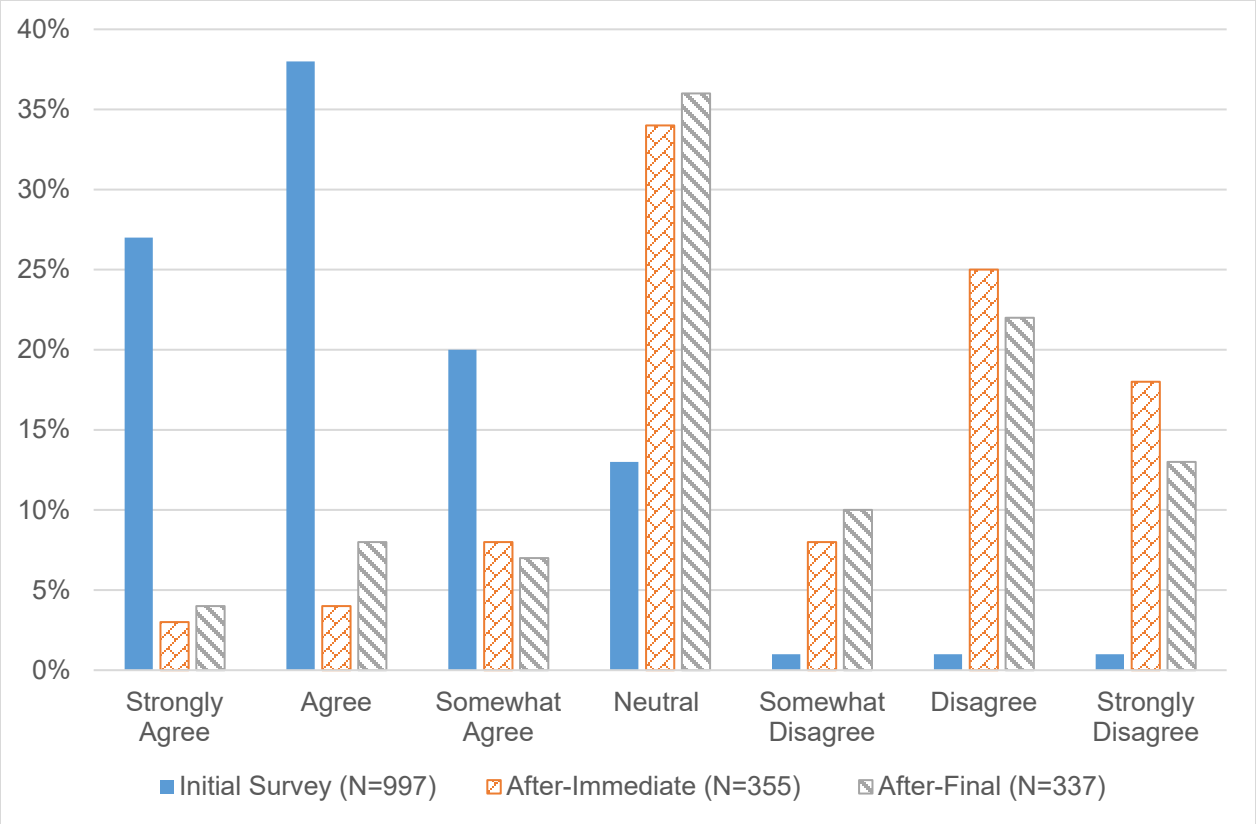
Prior to using the CV technology, participants in the initial survey had extremely positive perceptions of its utility; however, as reflected in the post deployment surveys, those who may have experienced the technology had fewer positive perceptions. Almost three-fourths (74 percent) of initial survey respondents agreed or strongly agreed that CV technologies will improve their safety, compared to only 16 percent in the after-immediate and 23 percent after-final surveys that thought the CV technologies had improved their safety (see Figure 11). Regarding the opinions of initial survey respondents, while they thought CVs could improve safety, a minority (34 percent) were extremely or very concerned about roadway safety when driving in downtown Tampa. Most (38 percent) were moderately concerned, and 28 percent were slightly or not concerned at all.



Source: Texas A&M Transportation Institute, 2022

Figure 11. Bar chart. Opinions about whether CV technology will improve safety.

The majority (63 percent) of the initial respondents agreed or strongly agreed that CV technologies would reduce time spent in congested conditions. However, in the post deployment surveys, only 7 percent in the after-immediate survey and 12 percent in the after-final survey thought the CV technologies had reduced their time spent in congested conditions (see Figure 12).

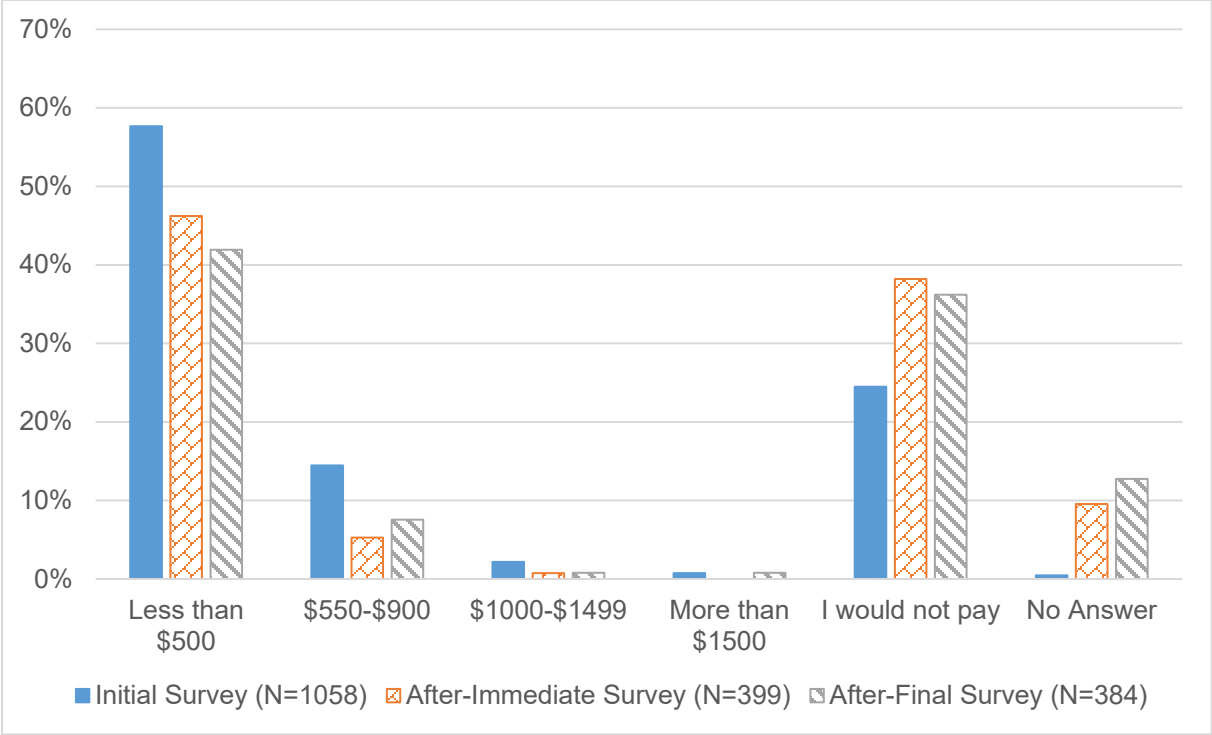


Source: Texas A&M Transportation Institute, 2022

Figure 12. Bar chart. Opinions about whether CV technology will reduce time spent in congested conditions.

Willingness to Pay for CV Technologies

Participants in the initial survey (before actually having experienced the installed OBUs) were generally more willing to pay to retrofit their vehicles with the CV technologies than participants in the later surveys (see Figure 13). Fifty-eight percent of the initial survey respondents would be willing to pay less than $500 compared to 46 percent of respondents in the after-immediate survey and 42 percent of those in the after-final survey. Very few respondents in any of the survey iterations would be willing to pay more than $500. A fourth (24 percent) of respondents in the initial survey would not be willing to pay anything to retrofit the vehicle with the CV technologies. Even larger percentages in the subsequent surveys expressed zero willingness to pay, 38 percent in the after-immediate survey and 36 percent in the after-final survey.



Source: Texas A&M Transportation Institute, 2022

Figure 13. Bar chart. Willingness to pay.

Concerns and Benefits Relating to CV Technologies

A significant percent (46 percent) of respondents indicated that they were concerned about privacy at the time the OBUs were installed in their vehicles. The percentage remained relatively unchanged (44 percent) at the time of the final survey. However, privacy concerns were eclipsed by other concerns among after-final survey respondents such as false alerts (58 percent), cost (53 percent), and trust in the technology (48 percent) (see Table 8). It is significant that the concern about "too many warnings" increased from 5 percent in the initial survey to 23 percent in the final survey. Likewise, concerns about trust in the technology increased from 30% in the initial survey to 48% in the final survey.

In terms of perceived benefits, the most prevalent opinion was that fewer crashes and increased roadway safety would result from use of CV technologies (see Table 9). This was especially true among participants in the final survey. There was generally a more positive perception that the CV technology would result in less stressful driving among respondents to the initial survey than among those who were surveyed post-deployment. A significant percentage of respondents in the final survey identified lower car insurance rates as a benefit when compared with respondents in the prior two surveys. Also, the percentage of persons who responded that they did not know enough about the technology to identify benefits increased from 8 percent in the initial survey to 26 percent in the final survey.

Table 8. Concerns about connected vehicle technologies.

Concern	Initial Survey (N=1058)	After-Immediate (N=399)	After-Final (N=384)
Privacy	46%	32%	44%
False alerts	45%	42%	58%
Trust in technology	30%	40%	48%
Cost	16%	24%	53%
Safety	8%	11%	9%
Too many warnings	5%	12%	23%
No concerns	18%	16%	19%
Do not know enough about the technology	11%	10%	14%

Source: Texas A&M Transportation Institute, 2022

Table 9. Benefits of connected vehicle technologies

Benefits	Initial Survey (N=1058)	After-Immediate (N=399)	After-Final (N=384)
Fewer traffic crashes and increased roadway safety	67%	52%	80%
Less traffic congestion	55%	32%	49%
Less stressful driving experience	55%	31%	44%
Lower car insurance rates	34%	33%	46%
Increased fuel efficiency	29%	18%	24%
Lower vehicle emissions	21%	11%	18%
Do not know enough about the technology	8%	18%	26%
No benefits	Not applicable	15%	19%

Source: Texas A&M Transportation Institute, 2022

Findings from After-Immediate and After-Final Surveys about CV Warnings Experienced

Respondents were asked at two points in time (i.e., after-immediate and after-final) if they had experienced any of the CV application warnings. As might be expected, the numbers of drivers experiencing warnings was generally small. Table 10 shows these results. The most frequently received warnings were end-of-ramp deceleration and wrong-way entry.

In the immediate after and the final after surveys, participants were asked questions about their perceptions as to the helpfulness, clarity, and timeliness of the alert produced by different applications. The following figures are based on the answers from participants assigned to the treatment group who had the HMI turned on and were able to see and hear the application warnings.

Table 10. Drivers of passenger vehicles experiencing warnings in the Tampa CVPD.

CV Application Warning	After-Immediate Survey (N=389)	After-Final Survey (N=384)
End-of-ramp deceleration	113 (29%)	130 (34%)
Wrong-way entry	84 (22%)	77 (20%)
Wrong-way driver	53 (14%)	44 (11%)
Forward collision	39 (10%)	41 (11%)
Pedestrian collision	25 (6%)	23 (6%)
Vehicle turning right in front of a transit vehicle	19 (5%)	35 (9%)
Intersection movement assist	14 (4%)	10 (3%)
Emergency brake light	13 (3%)	23 (6%)

Source: Texas A&M Transportation Institute, 2022

Perceptions about End-of-Ramp Deceleration Warning

The end-of-ramp deceleration warning (ERDW) was the most frequently experienced. Among those Tampa CVPD participants who experienced it, most thought it was clear why the warning was being received and found the warning to be helpful (see Table 11). A little less than half in both surveys received unnecessary warnings, and most respondents who received the unnecessary warnings thought they were distracting.

Table 11. Experiences in terms of clarity, helpfulness, and distraction for the ERDW

Experiences	After-Immediate Survey (N=113)	After-Final Survey (N=130)
Generally clear why receiving warning—yes	94 (80%)	110 (85%)
Help to adjust for appropriate speed for curve—yes	85 (75%)	103 (79%)
Receive unnecessary warning—yes or sometimes	49 (43%)	63 (48%)
Unnecessary warnings distracting—yes or sometimes (bases for percentages are 49 and 63, respectively)	36 (73%)	50 (79%)

Source: Texas A&M Transportation Institute, 2022

For most persons experiencing the ERD warning, the timing and auditory alerts were just right. This was true in the after-immediate survey—79 percent and 61 percent, respectively—and in the after-final survey—74 percent and 67 percent, respectively (see Table 12). There was an increase between the two surveys from 12 percent to 20 percent in the percentage of people who thought the timing was too late, which could present a safety issue. Sizeable percentages in both surveys (35 percent and 25 percent) thought the auditory alert was too loud, which could be annoying (see Table 13). In terms of visual interface, most respondents in the after-immediate survey had a negative assessment of it (see Table 14). Most thought the icon disappeared too fast (65 percent), and some thought it was too bright (30 percent). None thought it was just right. On the other hand, most in the final survey thought the interface was just right (62 percent) though some thought it was too fast (32 percent).

Table 12. Assessments of the timing for the ERDW

Assessments	After-Immediate Survey (N=107)	After-Final Survey (N=126)
Just right	85 (79%)	93 (74%)
Too late	13 (12%)	25 (20%)
Too early	9 (8%)	8 (6%)

Source: Texas A&M Transportation Institute, 2022

Table 13. Assessments of the auditory alert for the ERDW

Assessments	After-Immediate Survey (N=108)	After-Final Survey (N=130)
Just right	65 (61%)	87 (67%)
Too loud	38 (35%)	33 (25 %)
Too quiet	5 (4%)	10 (8%)

Source: Texas A&M Transportation Institute, 2022

Table 14. Assessments of the visual interface for the ERDW

Assessments	After-Immediate Survey (N=57)	After-Final Survey (N=113)
Just right	0 (0%)	70 (62%)
Too fast	37 (65%)	37 (32%)
Too bright	17 (30%)	3 (3%)
Too dim	3 (5%)	3 (3%)

Source: Texas A&M Transportation Institute, 2022

Perceptions about Wrong-Way Entry Warning

The wrong-way entry (WWE) warning was the second most frequently experienced warning, and peoples' experiences with it were not as positive as those with the ERD warning. Few in either the after-immediate or after-final surveys thought that the WWE application helped to avoid entering the REL the wrong way—13 percent and 10 percent, respectively (see Table 15). Nearly nine of ten people in both surveys received unnecessary warnings, and virtually all of them found the unnecessary warnings distracting.

Table 15. Experiences in terms of clarity, helpfulness, and distraction for the WWE warning

Experiences	After-Immediate Survey (N=85)	After-Final Survey (N=76)
Generally clear why receiving warning—yes	49 (47%)	46 (54%)
Help to avoid entering the REL wrong way—yes	11 (13%)	8 (10%)
Receive unnecessary warning—yes or sometimes	75 (88%)	68 (89%)
Unnecessary warnings distracting—yes or sometimes (bases for percentages are 75 and 68, respectively)	70 (93%)	65 (96%)

Source: Texas A&M Transportation Institute, 2022

For most persons experiencing the WWE warning, the timing and auditory alerts were just right. This was true in the after-immediate survey—64 percent and 59 percent, respectively—and in the after-final survey—57 percent and 63 percent, respectively (see Table 16). Like the ERDW, sizeable percentages in both surveys (37 percent and 30 percent) thought the auditory alert was too loud (see Table 17). Like with the other two warnings discussed previously, no after-immediate survey respondents thought that the visual interface was just right; instead, nearly two-thirds indicated it was too fast (63 percent) and nearly one-third thought it was too bright (30 percent). In the after-final survey, however, a large majority - 71 percent thought it was just right. (See Table 18).

Table 16. Assessments of the timing for the WWE.

Assessments	After-Immediate Survey (N=74)	After-Final Survey (N=75)
Just right	47 (64%)	43 (57%)
Too late	18 (24%)	22 (29%)
Too early	9 (12%)	10 (13%)

Source: Texas A&M Transportation Institute, 2022

Table 17 Assessments of the auditory alert for the WWE warning.

Assessments	After-Immediate Survey (N=81)	After-Final Survey (N=73)
Just right	48 (51%)	46 (63%)
Too loud	30 (37%)	22 (30%)
Too quiet	3 (4%)	5 (7%)

Source: Texas A&M Transportation Institute, 2022

Table 18. Assessments of the visual interface for the WWE warning.

Assessments	After-Immediate Survey (N=57)	After-Final Survey (N=68)
Just right	0 (0%)	38 (56%)
Too fast	35 (61%)	26 (38%)
Too bright	20 (35%)	1 (1%)
Too dim	2 (4%)	3 (4%)

Source: Texas A&M Transportation Institute, 2022

Perceptions about Wrong-Way Driver Warning

The wrong-way driver warning (WWDW) was the third most frequently experienced warning, and peoples' experiences with it were slightly more positive than with the WWE warning. It was generally clear to most respondents in both post-deployment surveys why they were receiving the warning (see Table 19). About one in five of those experiencing the warning said it helped to avoid driving the wrong way on the reversible lane (REL). A lot of people received unnecessary warning: about 90 percent in both surveys, and many of those persons found the unnecessary warnings distracting.

Table 19. Experiences in terms of clarity, helpfulness, and distraction for the WWDW.

Experiences	After-Immediate Survey (N=53)	After-Final Survey (N=44)
Generally clear why receiving warning—yes	30 (56%)	22 (50%)
Help to avoid driving wrong way on REL—yes	11 (21%)	9 (20%)
Receive unnecessary warning—yes or sometimes	47 (87%)	39 (89%)
Unnecessary warnings distracting—yes or sometimes (bases for percentages are 47 and 39, respectively)	39 (83%)	33 (85%)

Source: Texas A&M Transportation Institute, 2022

Similar percentages thought the timing of the warning was just right in the two surveys—68 percent and 65 percent, respectively (see Table 20). A larger percentage of persons in the after-final survey thought that the auditory alert was just right (70 percent) than in the after-immediate survey (52 percent). In that latter survey, a large percentage (40 percent) thought that the alert was too loud (see Table 21). Like with the other two warnings discussed previously, no after-immediate survey respondents thought that the visual interface was just right, whereas 71 percent of those in the after-final survey thought it was just right. Most respondents in the after-immediate survey thought it was too fast (see Table 22).

Table 20. Assessments of the timing for the WWDW.

Assessments	After-Immediate Survey (N=44)	After-Final Survey (N=40)
Just right	30 (68%)	26 (65%)
Too late	9 (20%)	5 (13%)

Assessments	After-Immediate Survey (N=44)	After-Final Survey (N=40)
Too early	5 (12%)	9 (22%)

Source: Texas A&M Transportation Institute, 2022

Table 21. Assessments of the auditory alert for the WWDW.

Assessments	After-Immediate Survey (N=52)	After-Final Survey (N=43)
Just right	27 (52%	30 (70%)
Too loud	21 (40%)	11 (26%)
Too quiet	4 (8%)	2 (4%)

Source: Texas A&M Transportation Institute, 2022

Table 22. Assessments of the visual interface for the WWDW.

Assessments	After-Immediate Survey (N=30)	After-Final Survey (N=38)
Just right	0 (0%)	27 (71%)
Too fast	19 (63%)	10 (26%)
Too bright	9 (30%)	0 (0%)
Too dim	2 (7%)	1 (3%)

Source: Texas A&M Transportation Institute, 2022

Perceptions about Forward Collision Warning

The sample of people who experienced this warning was small, 39 after-immediate respondents and 41 after-final respondents. The data are presented in Table 23, but interpretation of them should be done cautiously. Most respondents in both surveys thought that it was generally clear why they were receiving an FCW. Many thought that the warning helped them avoid a collision. A definite majority of those in both surveys received unnecessary warnings and found them to be distracting.

Table 23. Experiences in terms of clarity, helpfulness, and distraction for the FCW.

Experiences	After-Immediate Survey (N=39)	After-Final Survey (N=41)
Generally clear why receiving warning—yes	26 (66%)	27 (66%)
Help to avoid a collision—yes	19 (49%)	16 (39%)
Receive unnecessary warning—yes or sometimes	28 (71%)	25 (61%)
Unnecessary warnings distracting—yes or sometimes (bases for percentages are 28 and 25, respectively)	21 (75%)	21 (84%)

Source: Texas A&M Transportation Institute, 2022

There was more diversity of opinion about the timing of the FCW among after-immediate survey respondents than among after-final survey respondents (see Table 24). While a majority of respondents in the after-immediate survey felt that the timing of the warning was just right, about one in five persons thought it came too early, and nearly as many thought it came too late. For the vast majority of after-final survey respondents, the timing was generally just right, and about one in five thought it came too early. Most respondents in both surveys thought the auditory alert was just right, and similar lesser numbers thought that it was too loud (see Table 25). As with the previous warnings discussed, none of the respondents in the after-immediate survey thought the visual interface was just right (in fact, a substantial majority (70 percent) felt that the icon disappeared too fast. However,-in the after-final survey, the majority thought that the visual interface was just right (70 percent). (See Table 26). The majority felt that the icon disappeared too fast.

Table 24 Assessments of the timing for the FCW.

Assessments	After-Immediate Survey (N=38)	After-Final Survey (N=38)
Just right	25 (66%)	28 (74%)
Too late	6 (16%)	2 (5%)
Too early	7 (18%)	8 (21%)

Source: Texas A&M Transportation Institute, 2022

Table 25. Assessments of the auditory alert for the FCW.

Assessments	After-Immediate Survey (N=39)	After-Final Survey (N=40)
Just right	26 (67%)	26 (65%)
Too loud	13 (33%)	13 (33%)
Too quiet	0 (0%)	1 (2%)

Source: Texas A&M Transportation Institute, 2022

Table 26. Assessments of the visual interface for the FCW

Assessments	After-Immediate Survey (N=26)	After-Final Survey (N=33)
Just right	0 (0%)	23 (70%)
Too fast	18 (70%)	7 (21%)
Too bright	8 (30%)	2 (6%)
Too dim	0 (0%)	1 (3%)

Source: Texas A&M Transportation Institute, 2022

Perceptions about Vehicle Turning Right in Front of a Transit Vehicle Warning

The sample of people who experienced the warning was quite small—19 after-immediate respondents and 35 after-final respondents. The data are presented in the tables below, but interpretation of them should be done cautiously. Most respondents in both surveys thought that it was generally clear why they

were receiving an VTRFTV warning (see Table 27). Many thought that the warning helped them avoid a collision. About a third of after-immediate respondents received unnecessary warnings, and only a small percentage thought they were distracting. about a third of the after-final survey respondents also found this to be distracting.

Table 27. Experiences in terms of clarity, helpfulness, and distraction for the VTRFTV warning.

Experiences	After-Immediate Survey (N=19)	After-Final Survey (N=35)
Generally clear why receiving warning—yes	16 (84%)	28 (80%)
Help to avoid a collision—yes	14 (74%)	21 (60%)
Receive unnecessary warning—yes or sometimes	6 (32%)	14 (40%)
Unnecessary warnings distracting—yes or sometimes (bases for percentages are 6 and 14, respectively)	2 (11%)	11 (31%)

Source: Texas A&M Transportation Institute, 2022

A strong majority of respondents in both surveys thought the timing of the warning was just right (see Table 28). The same was true for the sound level of the auditory alert (see Table 29). Among the extremely small sample of after-immediate respondents, most thought the icon disappeared too fast. Among the larger sample of after-survey respondents, two-thirds thought the visual interface was just right (see Table 30).

Table 28. Assessments of the timing for the VTRFTV warning.

Assessments	After-Immediate Survey (N=18)	After-Final Survey (N=32)
Just right	14 (78%)	29 (91%)
Too late	4 (22%)	1 (3%)
Too early	0 (0%)	2 (6%)

Source: Texas A&M Transportation Institute, 2022

Table 29. Assessments of the auditory alert for the VTRFTV warning.

Assessments	After-Immediate Survey (N=18)	After-Final Survey (N=34)
Just right	12 (67%)	23 (68%)
Too loud	6 (33%)	10 (29%)
Too quiet	0 (0%)	1 (3%)

Source: Texas A&M Transportation Institute, 2022

Table 30. Assessments of the visual interface for the VTRFTV warning.

Assessments	After-Immediate Survey (N=8)	After-Final Survey (N=29)
Just right	0 (0%)	18 (62%)

Assessments	After-Immediate Survey (N=8)	After-Final Survey (N=29)
Too fast	6 (75%)	9 (31%)
Too bright	2 (25%)	2 (7%)
Too dim	0 (0%)	0 (0%)

Source: Texas A&M Transportation Institute, 2022

Perceptions about Remaining Three CV Applications

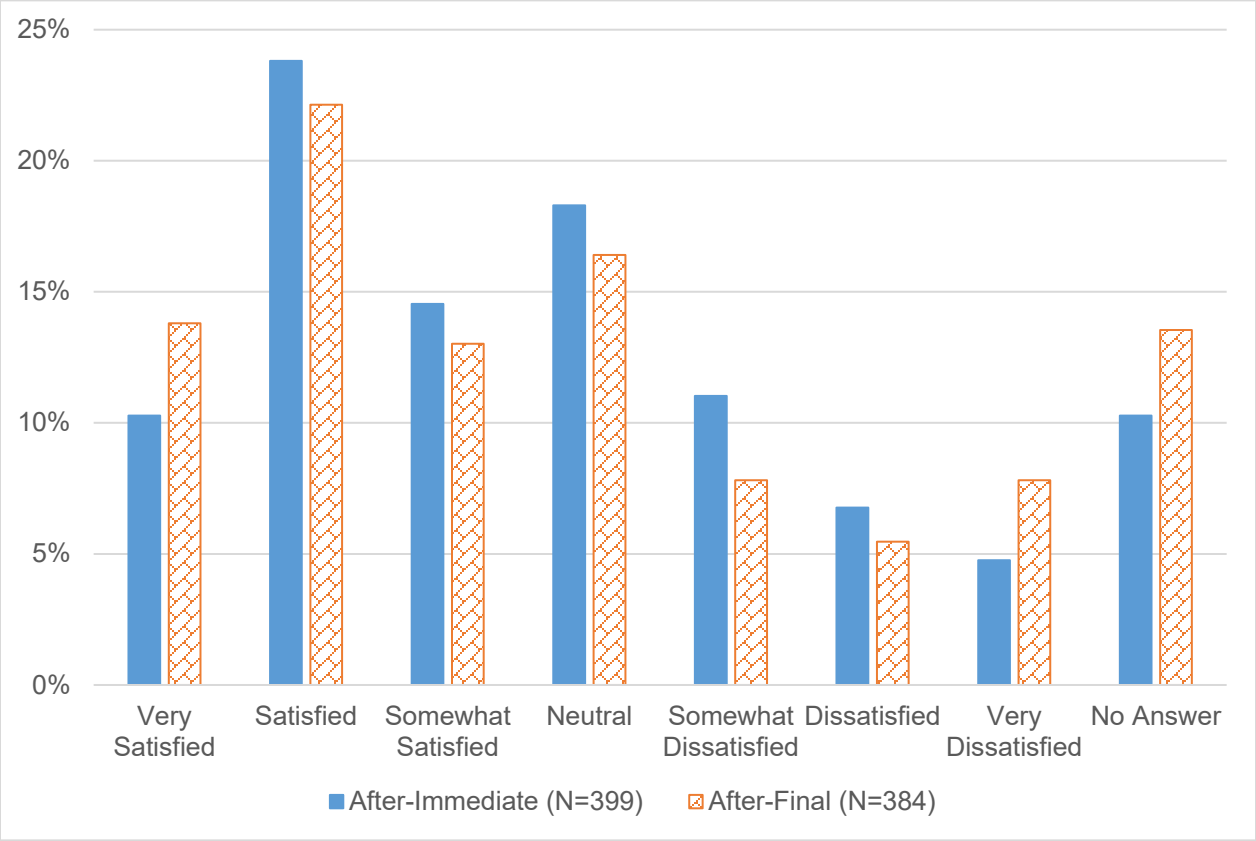
Data pertaining to the remaining three CV applications are based on extremely small samples of respondents—25 or fewer persons in both the after-immediate and after-final surveys. So, findings are presented in qualitative terms for the following applications:

- **Pedestrian Collision Warning**—After-immediate had 25 respondents; after-final had 23 respondents.
    - Most respondents in the after-immediate survey said that the warning helped avoid a pedestrian in the crosswalk at the courthouse on Twiggs Street, and about half of those in the after-final survey thought so.
    - About half in both surveys received unnecessary warnings, and nearly everyone who did found them distracting.
    - The reason for receiving the warning was clear to most respondents in both surveys, and most thought the warning came at the right time. A few respondents thought it came too late.
    - Slightly more than half of the respondents in both surveys thought the sound level for the auditory alert was just right, and the remaining others thought it was too loud.
    - Most respondents in the after-final survey thought the visual interface was just right, whereas most of those in the after-immediate survey thought the icon disappeared too fast.
- **Emergency Electronic Brake Light Warning**—After-immediate had 13 respondents; after-final had 23 respondents.
    - About half of respondents in both surveys thought the warning helped them avoid a collision with a vehicle stopping in front.
    - Most in both surveys did not receive unnecessary warnings, and nearly all thought it was clear why they were receiving the warning and it came at just the right time.
    - Respondents in the after-immediate survey were less comfortable with the auditory alert (thinking it too loud) and the visual interface (thinking it disappeared too fast). On the other hand, those in the after-final survey tended to think the sound level was just right, as was the visual interface.
- **Intersection Movement Assist**—After-immediate had 14 respondents; after-final had 10 respondents.
    - Most respondents in both surveys did not think the warning helped avoid a collision at an intersection, and half in each survey received unnecessary warnings.
    - All respondents in the after-immediate survey thought the warning came at just the right time; most thought the sound level was just right but that the icon disappeared too fast or was too bright.

- Perceptions among after-final survey respondents was varied on timing, with a majority answering at just the right time. The sample was split on whether the sound level was just right or too loud. Most felt the visual interface was just right, while a few thought it was too fast.

Satisfaction with Participation in the Connected Vehicle Pilot Deployment

The two post-deployment surveys had a question on satisfaction with participation in the pilot. Nearly half of participants in both the after-immediate (49 percent) and after-final (49 percent) surveys were satisfied with their experience of participating in the pilot (see figure 14). About one-fourth in both surveys were dissatisfied. Eighteen percent and 16 percent in the after-immediate and after-final surveys, respectively, were neutral about the experience, expressing neither satisfaction nor dissatisfaction.



Source: Texas A&M Transportation Institute, 2022

Figure 14. Bar chart. Satisfaction with participation in the Tampa CVPD among participants.

The post-deployment surveys also included a question that asked respondents to assess how effective the CV technology was in delivering warnings. The results are difficult to interpret. In all, 42 percent of respondents did not provide a response to the effectiveness question in the after-immediate survey, and 89 percent did not provide an answer in the after-final survey (see Table 31).

Table 31. Perceptions of effectiveness of CV technology in delivering warnings among post-deployment survey respondents.

Perception of Effectiveness	After-Immediate Survey	After-Final Survey
Extremely effective	12	1
Very effective	29	2
Moderately effective	46	4
Slightly effective	54	3
Not effective	89	7
Did not receive warnings	0	27
No answer	167	340
Total	397	384

Source: Texas A&M Transportation Institute, 2022

Bus Operators

Bus operators are the bus drivers on the HART buses selected for use in the CVPD. HART trained these bus operators on how to interact with the OBUs installed on the buses. The bus applications were used while the bus was traversing the selected downtown streets where RSUs were installed and operating the transit application. The plan was to install OBUs in 10 buses. For a variety of reasons, this was not done, and so the user surveys, while designed, were not implemented.

Streetcar Operators

Streetcar participants are the streetcar operators who operate the TECO streetcars selected for use in the CVPD. HART provided training to the streetcar operators on how to interface with the OBUs installed on the streetcar. The streetcar applications were used at two locations along the Channelside route. The plan was to outfit 10 streetcars. For a variety of reasons, this was not done, and so the user surveys, while designed, were not implemented.

Chapter 6. Summary of Results

Stakeholder Acceptance

The TTI CVPD Evaluation Team conducted pre- and post-deployment interviews with deployment managers, deployment team members, operating agency staff, and policy makers that were involved in the Tampa CVPD. The objectives of the pre-deployment interviews were to gather in-depth baseline information on vision, goals, and desired impacts; anticipated or potential challenges; and desired outcomes. The post-deployment interviews were used to assess whether the pilots achieved their vision, goals, and desired impacts as well as to derive lessons learned for future CVPDs. The post-deployment interviews were conducted at two points in time: shortly after deployment to get initial feedback (i.e., near term) and toward the end of deployment to gather comprehensive information (i.e., long term). Table 32 summarizes the key finding from these stakeholder interviews.

The TTI CVPD Evaluation Team also conducted a stakeholder workshop toward the end of the deployment. The purpose of this workshop was to get final thoughts on the experiences and lessons learned through the deployment. The following lists the key findings from this workshop:

- Generally, the deployment was a positive experience; however, many of the applications were not necessarily deployment ready. A considerable amount of integration work, fine-tuning, and troubleshooting were required to get the applications ready for deployment.
- A considerable gap exists between the public's expectation of what the technology can do versus what the technology can actually do. The public tends to think of CV technology and autonomous vehicle operations as synonymous. A considerable effort is needed to manage public expectations.
- Delays in getting the application operations caused participants to lose interest in the project. Agencies should not schedule equipment installations in the vehicle until the system has been fully deployed and tested.
- It is a significant leap in complexity to go from a small research and development project to a full-scale deployment. Challenges exist that cannot be identified in the laboratory.
- Policy changes at the national level caused a substantial shift in the market. Some companies got out of the hardware business and stayed in the business of producing applications. This market shift made it difficult for the stakeholder to get vendors to support their hardware after the market shift.
- Significant technical challenges associated with the installation of equipment and the data had to be overcome. Examples of issues that had to be overcome include the use of power over ethernet, grounding, and the corrosive effects of salt in the air.

Table 32. Summary of findings from stakeholder interviews.

Topic Area	Pre-deployment	Immediate Post-deployment	Final Post-deployment
Vision and goal	• Primary goal was increasing safety for end users by reducing collisions, instances of wrong-way driving, and pedestrian-related fatalities • Secondary benefits included improving mobility and system capacity, preparing city for next phase of smart infrastructure development, assessing environmental benefits, and acting as laboratory of future testing	• Expectation adjusted due to technical challenge	• Deployment proved CV concepts worked and served as stepping-stone to future deployment • Measurable benefits difficult to detect because of small sample sizes • Some alerts, like WWE, should be considered successful because they prevented catastrophic events
Effectiveness	• Project benefited from progressive and tech-friendly attitude from State and local decision makers • Managing public perceptions and expectation consistent with capabilities of technology • Maintaining open architecture • Spectrum sharing with non-transportation entities	• Expectations about positive impact of deployment increased due to social media posts by users • Sparse penetration of OBUs, hampering ability to evaluate whether deployment was meeting goals and objectives • Dealing with new technologies created delays in performance data collection • Stakeholders generated many lessons learned on how to overcome unforeseen challenges	• Challenges with market penetration; some applications require extensive fine-tuning • Technology was not already proven and ready to go “off the shelf”; still dealing with how to do use case as opposed to measuring impact of technology • Created much opportunity for agency collaboration and good lessons learned

Topic Area	Pre-deployment	Immediate Post-deployment	Final Post-deployment
Institutional challenges	• Educating all stakeholders on potential benefits • Maintaining aggressive deployment schedule and coordination with other projects • Project management styles between infrastructure and software developers	• Unable to get agreement between stakeholders to upgrade traffic signal control equipment • Acquiring permits to install equipment in infrastructure took longer than expected • Geographic diversity impeded rapid troubleshooting of technical challenges	• Institutional issues sufficiently addressed • Flexible procurement policies critical to success • Better planning before starting pilot • Being ready for learning curve and continuing education
Culture	• No change in culture needed	Not applicable	• Innovation is fundamental to future development, and agency must stay on the edge to stay relevant, but agency also must remember what its mission is—that innovation is complementary to main mission • Pilot forced collaboration with other stakeholders involved; now, they must continue collaboration after pilot is over • While this was learning experience and most projects after this will be easier, future deployments will still come across unforeseen issues; preparedness and managing expectations need to happen

Topic Area	Pre-deployment	Immediate Post-deployment	Final Post-deployment
Collaboration	• All stakeholders focused on primary goal • Regularly scheduled meeting and phone calls between stakeholders critical to success • Used cooperative, top-down process with all stakeholders having equal voice • Formalized plan and operating agreements in place between agencies to ensure continued operations after evaluation study	• Lead agency must be able to respond to changes, requests, and needs rapidly	• Stakeholders participated in pilot program according to both their own priorities and shared priorities
Financial issues	• Shared commitment to successful execution of CVPD • Some stakeholders had perception that governmental entities had access to unlimited resources	• Many unexpected “curveballs” that led to budgets being strained • High costs associated with acquiring, deploying, maintaining, and operating devices; small, reasonable costs per device become large when large number of devices are needed • Consider using cost-sharing agreement or data use agreements that spread costs over multiple entities or deployment stages	• There is value in having one agency that has main stake in project • Cost/benefit is different for innovation project versus agency project

Topic Area	Pre-deployment	Immediate Post-deployment	Final Post-deployment
Systems and technologies	• Lack of maturity of CV hardware and software was significant challenge • Stakeholders expected technology would be deployment ready • Interoperability issues existed between CV technologies from different vendors • Challenges with confidentiality and integrity of communication channels due to other licensed operators in spectrum • Need to develop mechanism for providing over-the-air updates of software and licenses • Need for good GPS and survey precisions to generate accurate positioning and maps • Could deployment implement a sustainable communication scheme with DSRC or with cellular • SCMS software not ready at outset of deployment; once delivered, software was not stable; deployment had to switch to private provider	• Technology is not mature enough to be deployed in real transportation environment • Interoperability issues existed between CV technologies from different vendors • Over-the-air updates of OBU firmware and software difficult because RSU reception changes as vehicle moves through network • GPS technology not permitting high-precision locating • Some RSUs not working due to electrical storms and lightning strikes • Privacy requirements limited ability to live-monitor OBU performance; OBU software issues remained undetected	Most significant challenge was over-the-air updates since pilot needed to dedicate specific number of RSUs to do only that; trying to have RSUs do that and BSMs at same time was too much Latency is big technical challenge associated with some real-time applications—IMA, red-light running, and end-of-ramp deceleration OBUs should not be retrofitted but built into car, future of connectivity Lack of GPS precision caused one planned pedestrian application not to be deployed
Business processes	• No changes to existing governmental business practices needed • Funding for maintenance of deployed CV technologies would be incorporated into normal agency operating budget	• Monitor dashboard was critical in determining where devices were not performing well	Will be using more of an agency approach to compliment testing approach in future deployment

Topic Area	Pre-deployment	Immediate Post-deployment	Final Post-deployment
Workforce development	• Lack of sufficient training available; unsure of what entities are best suited to coordinated training efforts in future; combination of in-house and external training used • Staffing will continue to be challenging due to very specialized skills needed; may be difficult to convince executive levels to offer competitive pay scales	• Institute performance monitoring team to monitor OBU and RSU functionality; this team aided in rapid detection of RSU and OBU operational issues	• Not many issues/challenges that could have been avoided by available training • Current staff would be capable of sustaining CVPD program

Source: Texas A&M Transportation Institute, 2022

Stakeholders were asked to reflect on which applications performed well and which applications would require additional refinement. The following summarizes their responses:

- Overall, the stakeholders felt that all the applications worked despite the issues that arose because of the COVID-19 pandemic.
- The ERD warning showed promising results, and the WWE application worked well, notwithstanding OBU firmware issues.
- The Forward Collision Warning and Emergency Electronic Brake Light Warning applications worked well together, and there is evidence to support that these applications influenced driver behavior.
- IMA could gain in further refinement to the operational parameters to make it more tuned with respect to a high-density urban environment in terms of the level of accuracy.
- THEA was unsuccessful at getting the TSP and I-SIG applications fully operational during the deployment evaluation period.
- The original LIDAR-based detection system for the PCW application had difficulty tracking pedestrians in the crosswalk. Changing the detection technologies required extending the time for data collection with new technology,

The stakeholders noted the importance of measuring the accuracy of all the applications, including false negatives, false positives, true positives, and true negatives. Furthermore, issues associated with GPS accuracies and digital maps may have caused some high false alarm rates in some applications.

User Satisfaction and Perceptions

THEA collected user perception data at the time the equipment was installed in participants' vehicles, immediately after beginning to receive alerts, and then again toward the end of the post-deployment period. The purpose of collecting these data in this way was to examine how user perceptions changed after gaining some experience with the applications. The following summarizes the findings from the user satisfaction surveys.:

In terms of perceived benefits, most respondents thought deploying the technology would result in fewer crashes and increased road safety. There was generally a more positive perception that CV technologies would produce a less stressful driving environment in the pre-deployment period compared to perceptions in the post-deployment period. Although many of the respondents thought deploying the technology would result in fewer crashes and increased road safety, most participants were neutral about whether the actual deployment improved safety (see Figure 11). Likewise, most participants were neutral about whether the deployment reduced their time spent in congestion (see Figure 12).

Most of the study participants cited the toll discount incentives as their reason for wanting to participate in the deployment, but a sizeable percentage indicated the desire to help USDOT make the roads safer and more efficient as a factor influencing their decision to participate.

There was generally a more positive perception that CV technologies would produce a less stressful driving environment in the pre-deployment period compared to perceptions in the post-deployment period. The level of familiarity with technology was cited as having a positive influence on attitudes and perceptions of using advanced technologies. Concerns about privacy remained high between the pre- and post-deployment periods; however, concerns about false alerts, costs, and trust in technology all eclipsed privacy as a concern in the post-deployment responses.

In terms of prior experience with advanced vehicle technologies, the respondents in the initial survey indicated that they were less familiar with advanced technologies on vehicles than did those participants that remained to respond to the later surveys. The level of familiarity with technology was cited as having a positive influence on attitudes and perceptions of using advanced technologies

Nearly half of participants in both the after surveys were satisfied with their experience of participating in the pilot. Respondents in the post-deployment surveys indicated being satisfied or very satisfied with the overall driving experience in downtown Tampa to a greater degree than did those in the initial survey. Respondents in the post-deployment surveys indicated being satisfied or very satisfied with overall travel time driving in downtown Tampa to a significantly greater degree than respondents in the initial survey

In terms of user satisfaction related to the specific applications, the user surveys found the following:

- Most participants agreed that the ERDW had a positive impact on their approach speed on the REL. Most agreed that the ERDW alerts were timely and had an appropriate audible tone. Most thought the icon disappeared too fast (65 percent), and some thought it was too bright (30 percent).
- Most of the participants did not report positives experiences with the WWE and the WWD applications. A high number of participants reported receiving unnecessary warnings and virtually every participant found the unnecessary warnings to be distracting.
- The sample size of individuals receiving a FCW was relatively small. Most respondents in both surveys thought that it was generally clear why they were receiving an FCW. Many thought that the warning helped them avoid a collision. A definite majority of those in both surveys received unnecessary warnings and found them to be distracting.
- For both the PCW and the EEBL alerts, about half the respondents thought the warning were helpful in avoiding collisions.
- Most of the survey respondents indicated that they did not think the IMA alerts helped avoid collision at intersections.

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Appendix A. Tampa Stakeholder Survey/Interview Guide

Survey/Interview Guide Overview

The TTI CVPD Evaluation Team plans to conduct three types of interviews:

- **Pre-deployment interviews**—These interviews will elicit vision, goals, and expectations and gather information on financial and institutional preparedness. The TTI CVPD Evaluation Team plans to execute these interviews just before activation of the test CV applications.
- **Near-term post-deployment interviews**—These interviews will capture early deployment experiences, challenges, and solutions. The TTI CVPD Evaluation Team plans to conduct these 1–3 months after activation of the deployment.
- **Long-term post-deployment interviews**—These interviews will gather opinions about whether the deployments achieved the desired vision, goals, and MEP impacts. The TTI CVPD Evaluation Team also plans to collect observations and experiences about challenges (e.g., technical, institutional, and financial), adopted solutions, and lessons learned. The TTI CVPD Evaluation Team will also use these interviews to measure stakeholder levels of satisfaction with pilot outputs/outcomes and the long-term sustainability of the CVPD. The team will conduct these interviews about 9–12 months after activation of the applications.

The target stakeholders for the qualitative interviews are deployment managers, deployment team members, operating agencies, and policy makers. The TTI CVPD Evaluation Team will interview at least one but not more than three individuals from each of the entities within a stakeholder group:

- The TTI CVPD Evaluation Team defines **deployment managers** as the lead deployment agency and decision makers for each CVPD. TTI plans to conduct interviews with individuals from these agencies in the pre-, near-term post-, and long-term post-deployment time periods. Respondents will be executive management or project managers.
- The TTI CVPD Evaluation Team defines deployment **team members** as those individual/agencies responsible for the planning, development, and implementation of the applications and technologies. The CVPD evaluation team plans to interview these individuals in the pre-deployment and near-term post-deployment time periods. Respondents will be project managers and key technical leads (operations, development, engineering, and IT) from these team member entities.
- The TTI CVPD Evaluation Team defines **operating agencies** as those individuals involved in the pre-deployment planning and development activities as well as the day-to-day operations of the pilots once started. The TTI CVPD evaluation team plans to interview these individuals in the pre-deployment and long-term post-deployment time periods. Respondents will be the key technical leads from these agencies.
- The TTI CVPD Evaluation Team defines **policy makers** as those individuals in a position to influence the selection of the pilot site or to make decisions about the deployment in the future. The TTI CVPD evaluation team will interview policy makers in the pre-deployment and long-term post-deployment time periods. The respondents will be the champion for the CVPD within the policy-making entity.

The TTI CVPD Evaluation Team will select interview respondents using a purposeful sampling methodology. This methodology involves selecting individuals or groups of individuals from stakeholder groups that have specific knowledge about or a history with the CVPD. Once identified, these individuals will receive an email inviting them to participate in the interviews. The emails will contain the informed consent document as an attachment. To the extent possible, the team will interview the same persons from an organization across all relevant interview types. If this is not possible, the team will substitute an

individual from the same organization who is both knowledgeable and experienced with the CVPD to participate in the post-deployment interviews. If such an individual is not available, then no substitute will be used.

All three types of interviews will have a rolling pilot in which the first five interviews for each pilot site will contain questions to elicit feedback from respondents on the clarity and efficacy of the interview questions. The TTI CVPD Evaluation Team will ask the interviewees these evaluative questions after they have completed the interview. Example questions include the following:

- How relevant were these questions?
- Were the questions clear and understandable?
- Were there any biased questions?
- What questions should I have asked (i.e., possibly missed questions)?

Pre-deployment Interview Guide

This section contains questions that the TTI CVPD Evaluation Team will use when conducting pre-deployment interviews. The projected length of the interview is 45–60 minutes depending on the number of questions asked. The interviewer will send the questions to interviewees in advance to facilitate discussion. Probes in the interview guides will be removed prior to sharing with the interviewees. Individuals performing the interviews will be knowledgeable about the deployment and receive proper training through Texas A&M University's IRB.

TTI will assign questions to stakeholder groups based upon assumptions of their knowledge and interest levels. It may be necessary to tweak some words based on who is being interviewed.

Preamble

Good morning [afternoon] and thank you for participating in this interview. I am [name], a member of the CV Pilot Deployment Independent Evaluation Team. Our job is to assess the mobility, environmental, and public agency efficiencies associated with the CV Pilot Deployments. The USDOT ITS Joint Program Office is sponsoring this evaluation. The purpose of this interview is to gather information on the vision, goals, and expectations of the CV Pilot Deployment and to gather information on financial and institutional preparedness before the deployment activation. We are conducting this interview under the human subjects' protection requirements of Texas A&M University's Institutional Review Board. The information that you provide in this interview is confidential, and we will not attribute responses to any specific individuals. As part of this interview, I will be asking a series of questions that pertain specifically to your perceptions and experiences regarding the planning, development, and upcoming implementation of the CV Pilot Deployment applications.

Interview Questions

Role, Vision, and Goals

Questions to be asked of deployment managers, deployment team members, operating agencies, and policy makers:

1. What is your agency's role in the CV Pilot Deployment?
2. What is your role in the Tampa CV Pilot Deployment?
    - Probe if not addressed: In what stage are you most involved? (planning, development, implementation, or all)
    - Probe if not addressed: In what specific activities are you most involved?
3. To the best of your knowledge, what are your agency's goals/reasons for participating in the CV Pilot Deployment?
4. In your opinion, what constitutes success for your Pilot Deployment?
    - Probe: What are the positive outcomes that your agency is hoping will result from the CV Pilot Deployment?

Policy Challenges

Questions to be asked of deployment managers, deployment team members, operating agencies, and policy makers:

5. Are there specific policies or political issues that had to be addressed to deploy the CV applications?
    - Probe: How were they addressed? [note issue by issue]
6. Are there any policy issues that your agency still needs to address in the future regarding deployment of this type of technology?

Institutional Challenges

Questions to be asked of deployment managers, deployment team members, operating agencies, and policy makers:

7. Are there any specific institutional issues that surfaced during the planning for implementation?
    - Probe: What solutions were put forth to address these challenges? [note challenge by challenge] [do not ask policy maker]

Culture

Questions to be asked of deployment managers, deployment team members, operating agencies, and policy makers:

8. Does your organization as a whole support the CV Pilot Deployment?
    - If yes: In what way has this benefitted the deployment?
    - If no: What kinds of issues/concerns has this created for the deployment?

Collaboration

Questions to be asked of deployment managers, deployment team members, and operating agencies:

9. In your opinion, does consensus exist among the various stakeholders regarding CV goals, expectations, and priorities, or is each stakeholder participating in the pilot program according to its priorities?

10. To your knowledge, what types of formal processes have been put in place to facilitate collaborative planning/programming among CV Pilot Deployment stakeholders?
11. How do key stakeholders participate in the decision process for CV system operations and management?
12. Moving into implementation, what kind of business processes and procedures have you enacted to facilitate your operational decision making?

Financial Issues

Questions asked of deployment managers, deployment team members, and operating agencies:

13. In your opinion, is there a shared commitment among stakeholders as to the financial stability of the CV Pilot Deployment and how to achieve it?
    - If yes: What are the shared commitments (including cash contributions) from the various stakeholders? How were these shared commitments achieved?
    - If no: Discuss why not.
14. Are you familiar with the long-term plan for funding/financing the CV Pilot Deployment?
    - If yes: Please describe.
15. Are you aware of the existence of a business plan or business planning process for the CV Pilot Deployment?
    - If yes: Please describe.
16. Have projections for future market participation, revenue, and cost associated with the CV Pilot Deployment been developed?
    - If yes: Can you provide detail on that process? Outcomes?
    - If no: Are there plans to do this in the future?

Business Processes

Questions asked of deployment managers, deployment team members, and operating agencies:

17. In a typical DOT-centric manner, the pilots would be organized such that the public sector is expected to assume responsibility for the infrastructure aspects of the system and the private sector the installation of vehicle equipment. Was this general structure followed?
    - If no: What structure was used?
18. Has the CV Pilot Deployment program been reflected in the overall multimodal transportation and business plans of all participating public agencies?
    - Probe: Have multiyear budgets been developed for pilot implementation?
    - Probe: Is there a plan for ongoing operation of the CV Pilot Deployment including actions defined and business models for expansion of the existing pilot and transition to support long-term deployment?
19. To what extent are your business processes changing as a result of deploying the pilot? Can you provide an example?

Performance Measures

Questions to be asked of deployment managers, deployment team members, operating agencies, and policy makers:

20. What impacts do you foresee when you (your agency) decided to participate in the CV Pilot Deployment?
    - Probe: Specifically, on individual mobility, environmental, and efficiency impacts.

Questions to be asked of deployment managers:

21. Your agency identified a number of performance measures for monitoring performance of the deployment. How will these data be used during the pilot deployment?
    - Probe: Directly for after-action debriefings and improvements, displayed in dashboards, or only after the fact for overall evaluation purposes.
22. During the deployment, will these performance measures be reported internally to the deployment team only or externally as well?
23. In what way will performance measures be related to financial stability measures? In other words, used to support business decisions related to future CV Pilot Deployment activities?

Systems and Technology

Questions to be asked of deployment managers, deployment team members, and operating agencies:

24. What do you think are the most significant technical or technology-related challenges related to the CV Pilot Deployment?
    - Probe: How has your agency coped with the challenges? What kind of solutions has your agency put forth? [note challenge by challenge]
    - Probe: What kind of issues/challenges did you encounter with standards and specifications?
    - Probe: Do you feel the applications are mature enough for deployment?
    - Probe: If no, what needs to be done to solidify the applications?
25. What kinds of security challenges did you face in planning and implementing your deployment?
    - Probe: Does your system design address hacking and privacy concerns? Please explain.
    - If yes: Does the CV program include adequate infrastructure to ensure timely issuance of security certificates to participants?

Questions asked of deployment managers and deployment team members:

26. Does the system design incorporate maintenance monitoring for both vehicles and field equipment that permits rapid identification of system degradations or failures?
    - If yes: Is emphasis placed on seamless monitoring across jurisdictional boundaries?
    - If yes: How will you deal with maintenance issues of equipment installed on vehicles?
    - Probe: Who will maintain the field equipment?
    - Probe: Has your agency developed a maintenance management system that captures maintenance actions, cost, inputs, and outputs for both field equipment and vehicles?

Workforce Development

Questions asked of deployment managers and operating agencies:

27. Are sufficient people trained to manage, operate, and maintain the CV system through both in-housework and outsourcing?
    - Probe on any challenges encountered.
28. For the in-house staff, were these individuals added on to units with an existing structure and staffing, or was a CV-specific operational unit developed?
    - Probe: If added to an existing structure, do you foresee CV responsibilities being consolidated into an operational unit with a manager and defined budget?
29. How do you see staffing evolving to meet the demands of future technologies and a mix of modes?

Outreach

Questions asked of deployment managers and operating agencies:

30. What outreach activities, if any, has your agency planned to engage other stakeholders, policy makers, or the public in the CV deployment?

Final Question

31. Do you have any additional thoughts or concerns to share that may not have come up during the interview?

Near-Term Post-deployment Interview Guide

This section contains questions that the TTI CVPD Evaluation Team will use when conducting the near-term post-deployment interview. The TTI CVPD Evaluation Team will conduct these interviews 2–3 months after the initial activation of the applications. This interview serves as a quick check-in with deployment managers and deployment team members shortly after activation of the CV applications and should be no longer than about 30 minutes in length. The TTI CVPD Evaluation Team will interview the same individuals from the stakeholder entities interviewed previously. Questions that are identical to the pre-deployment instrument are identified with the code (I), and those that are a follow-up to a question asked in the pre-deployment interview are identified with the code (F). Questions will be sent to interviewees in advance of the interviews to facilitate discussion. Probes in the interview guides will be removed prior to sharing with the interviewees.

TTI will assign questions to stakeholder groups based upon assumptions of their knowledge and interest levels. It may be necessary to tweak some words based on who is being interviewed.

Preamble

Good morning [afternoon] and thank you for participating in another [this] interview. I am [name], a member of the CV Pilot Deployment Independent Evaluation Team. Our job is to assess the mobility, environmental, and public agency efficiencies associated with the CV Pilot Deployments. The sponsor of this evaluation is USDOT's ITS Joint Program Office. The purpose of this interview is to gather initial perceptions and experiences relating to the activation of the CV applications. The interview is being

conducted under the human subjects' protection requirements of Texas A&M University's Institutional Review Board. The information that you provide in this interview is confidential, and responses will not be attributed to any specific individual.

Interview Questions

Role, Vision, and Goals

1. IF PREVIOUSLY INTERVIEWED: Can you confirm that your role in the CV Pilot Deployment was [from the pre-deployment interview]? (F) IF NOT PREVIOUSLY INTERVIEWED: What was your role in the pre-deployment stage?
2. Has your role in the CV Pilot Deployment changed in any way from the pre-deployment stage? (F)
    - If yes: What specific activities are you most involved in now?
3. Have expectations about the positive impacts of the CV applications changed at all during the early activation period? (F)
    - If yes: What has changed and why?

Pilot Effectiveness

4. In a pre-deployment interview, you stated that your agency's objectives in participating in the pilot were [list]? How well is your experience thus far meeting those stated goals? (F)
5. You also mentioned that [list] would constitute success? Has the early experience in the activation of the applications altered your view of what would constitute success? (F)

Institutional Challenges

6. What types of institutional agreement and arrangement were implemented as part of the deployment?
    - Probe: Between whom?
    - Probe: What did they include?
    - Probe: How effective were those agreements?
7. Were there any unforeseen institutional issues that needed to be addressed during initial implementation?
    - Probe: What solutions to these challenges were identified? Have they been implemented yet? [note challenge by challenge]
    - Probe: Are there any lessons learned so far?

Financial Issues

8. How has the experience thus far with activation of the CV applications influenced your perceptions of whether or not your agency has the resources to deploy and manage the V2X applications?

9. What are the cost categories that you would include in a benefit cost analysis of the pilot deployment?

Performance Measures

10. A number of performance measures have been developed for your site [have list]. Are you using these data during the pilot deployment? (F)
    - If yes: How are you or your agency using these performance metrics?
    - Probe: Are these performance measures reported internally to the deployment team only or externally as well?
    - Probe: Are the performance measures being used to assess financial stability measures—in other words, are data being compiled or analyzed to support business decisions related to future CV Pilot Deployment activities?

Systems and Technology

11. What have been the most significant technical or technology-related challenges since the pilot deployment started [number of months since start] months ago?
    - Probe: Are there solutions to these challenges that have been put forth? [note challenge by challenge]
    - Probe: Are there any lessons learned so far?
12. In your opinion, have appropriate levels of cyber security been incorporated into system design?
    - Probe: Does system design address hacking and privacy concerns? (I)
    - If yes: Are security certificates being issued to participants in a timely manner? (F)
13. Is the system operating as expected with regard to maintenance monitoring for both vehicles and field equipment to permit rapid identification of system degradations or failures? (I)
    - Probe: What is working well? What needs some tweaking? Are there any lessons learned so far?

Deployment and Communications Management

14. In general, how satisfied are you with the pilot rollout so far (i.e., activation of the CV applications)?
    - Probe: What is working well? What needs some tweaking?
    - Probe: Are there any lessons learned so far?
15. From your perspective on the deployment team, how effective is the training for drivers who are users of the CV applications?
    - Probe: What is working well? What needs some tweaking? Are there lessons learned so far?
16. How would you describe the communications among stakeholders implementing the pilot?
    - Probe: What is working well in terms of communication among stakeholders? What needs to be improved?

17. What outreach activities, if any, is your agency conducting with policy makers, the public, or other stakeholders to facilitate a successful pilot deployment? (I)

Final Question

18. Do you have any additional thoughts or concerns to share that may not have come up during the interview? (I)

Long-Term Post Deployment Interview Guide

This section contains questions that the TTI CVPD Evaluation Team will use when conducting the long-term post-deployment interview. The TTI CVPD Evaluation Team will conduct these interviews 9–12 months after activation of the applications. This interview will gather information on stakeholder perceptions about whether and how the pilot deployments achieved their goals and objectives. Using qualitative methods of data collection will provide insight into unintended consequences and lessons learned. The interview respondents are deployment managers, operating agencies, and policy makers. The same individuals from the stakeholder entities should be interviewed as were in previous interviews. Interview lengths should range between 45 minutes for policy makers to 90 minutes for the other two stakeholder groups.

Questions have been assigned to stakeholder groups based upon assumptions of their knowledge and interest levels. It may be necessary to adjust some words based on who is being interviewed. Questions that are identical to the pre-deployment instrument are identified with the code (I), and those that are a follow-up to a question asked in the pre-deployment interview are identified with the code (F).

The questions will be shared with interviewees prior to the interview. Probes in the interview guides will be removed prior to sharing with the interviewees.

Preamble

Good morning [afternoon] and thank you for participating in another [this] interview. I am [name], a member of the CV Pilot Deployment Independent Evaluation Team. Our job is to assess the mobility, environmental, and public agency efficiencies associated with the CV Pilot Deployments. The USDOT ITS Joint Program Office is sponsoring this evaluation. The purpose of this interview is to gather information on your perceptions of the outcomes of the CV Pilot Deployments. The interview is being conducted under the human subjects' protection requirements of Texas A&M University's Institutional Review Board. The information that you provide in this interview is confidential, and responses will not be attributed to specific individuals.

Interview Questions

Role, Vision, and Goals

Questions to be asked of deployment managers, operating agencies, and policy makers:

1. Has your role in the CV Pilot Deployment changed in any way over the past 6 months? (F)
    - If yes: What specific activities are you most involved in now?
2. What activities were you most involved in prior to the past 6 months?

3. Have expectations about the positive impacts of the CV applications changed at all based on your experiences during the early activation period? (F)
    - If yes: What has changed and why?

Pilot Effectiveness

Questions to be asked of deployment managers, operating agencies, and policy makers:

4. In your opinion, how successful was your deployment at achieving the goals and objectives initially defined for your deployment, which were [list] based on information collected in previous interviews? (F)
5. You also mentioned that [list] would constitute success? Have your experiences with the applications altered your view of what would constitute success? (F)

Questions to be asked of deployment managers, and operating agencies:

6. Your deployment included a number of CV applications [list applications]. Which of those applications achieved the desired outcomes and how? Which fell short and why?
7. How satisfied are you with your pilot deployment experience?
8. Would you do this again given the opportunity?
9. Would you recommend it to other agencies?

Policy Challenges

Questions to be asked of deployment managers, operating agencies, and policy makers:

10. Were there any lingering policy issues that created challenges during the pilot deployment?
11. What policy challenges, if any, will influence the long-term sustainability of the CV program?

Institutional Challenges

Questions to be asked of deployment managers, operating agencies, and policy makers:

12. Previously, you identified some institutional issues that needed to be addressed during implementation [list]. Were these issues addressed and how?
13. Were there unforeseen institutional issues that needed to be addressed during implementation?
    - If yes: What were these issues, and how were they addressed?
    - If yes: What are lessons learned for future deployments?
14. Were deployment plans sufficient to manage the implementation efficiently?
    - If no: What necessary modifications did you encounter?
15. Thinking about future CV application deployment, what if any institutional issues need to be considered to ensure successful implementation?

Culture

Questions to be asked of deployment managers and operating agencies:

16. Does your organization as a whole support the CV Pilot Deployment? (I)

17. Has your organizational culture changed as a result of your experiences with the deployment?
    - If yes: Please explain.
18. Has senior management solidified a CV business case?
    - Probe: Is this being communicated to policy makers and the public?

Collaboration

Questions to be asked of deployment managers and operating agencies:

19. Was consensus reached among the various stakeholders in terms of CV goals, expectations, and priorities, or was each stakeholder participating in the pilot program according to its own priorities? (F)
20. Was the pilot deployment implemented through a formal process for collaborative planning/programming among CV Pilot Deployment stakeholders? (F)
21. Has a formal agreement been put in place for long-term relationships among stakeholders?
    - Probe: Address funding responsibilities, business models, future CV system operation, expansion, and replication.

Financial Issues

Questions asked of deployment managers, and operating agencies:

22. In your opinion, was there a shared commitment among stakeholders as to the financial stability of the CV Pilot Deployment and how to achieve it?
    - If yes: Discuss what the shared commitments are (including cash contributions) from various stakeholders and how the shared responsibility was achieved.
    - If no: Discuss why not.
23. What were the lessons learned in terms of equipment costs (vehicle and field) to inform future deployments?
24. Previously you identified [list] as the cost categories that you would include in a benefit cost analysis of the pilot deployment. Would you now add any others?
25. Do you have the data to provide cost estimates for these categories?

Business Processes

Questions to be asked of deployment managers and operating agencies:

26. Is there a plan among stakeholders for ongoing operation of the CV deployment?
    - Probe: Is there a business model for expansion and a transition plan?
27. To the best of your knowledge, has CV been included as a formal, visible, sustainable line item in your agency's budget?
    - If no: What are the hurdles in doing so?
28. To what extent have your business processes changed as a result of deploying the pilot? Can you provide an example of how they changed?

- If any changes: Were these developed by a single agency, or were they done in an integrated way across various agencies? Have these been shared with other stakeholders?
- If no changes: Why not?

Performance Measures

Questions to be asked of deployment managers, operating agencies, and policy makers:

29. Previously, you mentioned the following mobility, environment, and public agency efficiency impacts [list] as important in your agency's decision to participate in the pilot. To your knowledge, which were successfully achieved? (F)
    - Probe: Specific probes for safety, mobility, environmental and public agency efficiency (SMEP) impacts if interviewee does not mention them when responding to question 3.

Questions to be asked of deployment managers:

30. A number of performance measures have been developed for your site [have list]. What was the most efficient use of these data during the pilot deployment?
    - Probe: Specifics using information gathered in the pre-deployment interview.
31. Have outcome MEP measures been monetized for benefit cost analysis and to inform financial sustainability? [placeholder until financial evaluation plan is finalized]

Systems and Technology

Questions to be asked of deployment managers, operating agencies, and policy makers:

32. What were the most significant technical or technology-related challenges related to the CV Pilot Deployment?
    - Probe: What are the lessons learned from addressing these challenges?
33. Do you think that the current CV applications are mature enough for widespread development?
    - Probe: Are you considering or prefer alternatives to CV?

Questions asked of deployment managers and operating agencies:

34. Was the regional concept of operations developed for CV system implementation followed as designed, or were adjustments to the concept of operations made as needed?
    - Probe: Can you describe those adjustments and why made?
35. In your opinion, were appropriate levels of cyber security incorporated into system design? (F)
36. Did any hacking and privacy incidents occur? (F)
    - If yes: How were these handled?
37. Did the CV program include adequate infrastructure to ensure timely issuance of security certificates to participants? (I)
    - If no: Why not? What was the work-around?
38. Did the system design adequately incorporate maintenance monitoring for both vehicles and field equipment to permit rapid identification of system degradations or failures? (I)

- If no: Why not? What adverse outcomes, if any, resulted from not having a maintenance monitoring system?
- If yes: What lessons were learned for future applications?
- If yes: Was vehicle maintenance performed on an as-needed basis (firefighting), or was it performed by technicians in the vicinity of the CV applications? Were OEM dealerships or service centers involved in vehicle maintenance?
- Probe: Who maintained the field equipment?
- Probe: Was a maintenance management system developed that captures maintenance actions, cost, inputs, and outputs for both field equipment and vehicles?

Workforce Development

Questions asked of deployment managers and operating agencies:

39. In hindsight, were sufficient people trained to manage, operate, and maintain the CV system through both in-house work and outsourcing? (I)
    - Probe: Were any challenges encountered?
40. Have position descriptions for CV responsibilities been institutionalized to support activities going forward?
41. Are sufficient people trained to manage, operate, and maintain the CV system going forward? (F)
42. Do you foresee CV responsibilities being consolidated into an operational unit with a manager and defined budget? (F)
43. Is staffing capable of evolving to meet the demands of future technologies and a mix of modes?

Outreach

Questions asked of deployment managers and operating agencies:

44. What outreach activities, if any, did your agency use to engage other stakeholders, policy makers, or the public in the CV deployment? (I)
    - Probe: Which was most effective?
45. How would you characterize current public and policy maker acceptance of a CV program?

User Experience/Satisfaction

46. How have users responded to the CV applications?
    - Probe: What feedback have you received from the surveys?
47. Have you received other feedback from users (e.g., emails and informal comments)?

Conclusion

48. Are there other things you feel USDOT, or other agencies should be aware of when considering a similar deployment?

Online Survey Questionnaire

This section contains the draft questions that will comprise the online surveys. These surveys will be administered to fleet operators and support agencies 9–12 months after activation to gather their perceptions of the outcomes of the pilot deployments:

- **Fleet operators** are those agencies that will be installing and operating CV technologies in multiple vehicles. The TTI CVPD Evaluation Team expects the respondents to be the fleet managers.
- **Supporting agencies** include those agencies that may interact with the pilot deployments or whose operations may be impacted by the pilot deployments. These agencies include law enforcement, State and local government, relevant associations, and special interest groups. Respondents will be persons from these entities that were active in implementation activities or meetings.

The TTI CVPD Evaluation Team has developed separate questionnaires to reflect the distinct knowledge and interests of fleet operators versus supporting agencies. The team also anticipates that respondents will require 10–15 minutes to complete the questionnaire. The TTI CVPD Evaluation Team will refine the survey questions in a later stage through a review of the pre-deployment qualitative interviews.

A purposeful sampling strategy will be used to identify survey respondents. This sampling strategy involves working with deployment managers to identify up to 10 individuals that are knowledgeable about or have experience with the CVPD from each stakeholder group. This list of individuals will serve as the sampling frame for the survey. An email will be used to invite individuals to participate in the survey. The email will contain a link to the survey questionnaire. The email will also have the informed consent document as an attachment. The survey will have a rolling pilot in which the evaluative questions will be added to the end of the questionnaire for an initial 10 individuals from each pilot site to elicit feedback on the clarity and efficacy of the survey questions.

The following represents the design of the online survey instruments that will be used to collect input from the fleet operator and support agency stakeholders. There are separate instruments for fleet operators and support agency stakeholders. Respondents are managers in these organizations.

Welcome to the Tampa Connected Vehicle Pilot Deployment Evaluation Survey. The goal of this survey is to collect information on perceptions and experiences of stakeholders involved in or interacting with the pilot deployments. The survey findings will be used to draw conclusions about the outcomes of the pilot and to draw insights for future deployments. Your participation in this survey is much appreciated. This survey is being conducted under the human subjects' protection requirements of Texas A&M University's Institutional Review Board. The information that you provide in this survey is confidential, and responses will not be attributed to specific individuals. This survey should take about 10 minutes to complete.

Fleet Operators Questions

Question	Bus	Streetcar	Other
1. In what type of operating agency are you employed?	☐	☐	☐

Question	Very Concerned	Moderately Concerned	Slightly Concerned	Not at all Concerned
2. How concerned are you about your operators' traffic safety (i.e., that they would experience a crash)?	☐	☐	☐	☐
3. How concerned are you that traffic signal stops might interfere with your operators' abilities to adhere to schedules?	☐	☐	☐	☐
4. How concerned are you about conflicts your operators might experience with:				
• Pedestrians	☐	☐	☐	☐
• Bicyclist	☐	☐	☐	☐
• Other vehicles in traffic lanes	☐	☐	☐	☐
• [streetcar only] Vehicles turning right in front of your transit vehicle	☐	☐	☐	☐

Question
5. What benefits of the CV system were experienced? (check all that apply) ☐ Fewer traffic crashes and increased roadway safety ☐ Less traffic congestion ☐ Less stressful driving ☐ Reduced travel time ☐ Improved travel time reliability ☐ Other (specify)_____ ☐ Not aware of any demonstrated benefits

Question	Extremely Effective	Moderately Effective	Slightly Effective	Not at all Effective	Don't Know
6. In your opinion, how effective was the training provided to you on the CV system?	☐	☐	☐	☐	☐
7. How effective was the training provided to drivers in your fleet on the CV system?	☐	☐	☐	☐	☐

Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
9. Based on your knowledge, to what extent do you agree or disagree with the following statements?	☐	☐	☐	☐	☐	☐
• The alerts/warning provided by the applications increased safety.	☐	☐	☐	☐	☐	☐
• The alerts/warning provided by the applications were sufficient to allow my operators to react to unsafe situations.	☐	☐	☐	☐	☐	☐
• My expectations were completely met as a result of this deployment.	☐	☐	☐	☐	☐	☐
• I would like to see more of my fleet vehicles equipped with this type of technology.	☐	☐	☐	☐	☐	☐
• I would like to see the applications expanded to other areas in Tampa.	☐	☐	☐	☐	☐	☐
• I will continue to support the devices in fleet vehicles.	☐	☐	☐	☐	☐	☐
• I would recommend the CV system to other agencies in urban areas like Tampa.	☐	☐	☐	☐	☐	☐

Question
8. Do you have any of the following concerns about the CV system that was deployed in Tampa? (check all that apply) ☐ Cost ☐ Safety ☐ Privacy ☐ Trust in technology ☐ Too many alerts or warnings ☐ False alerts or warnings ☐ Driver distraction ☐ Other (specify)_____ ☐ No concerns ☐ Don't know enough about the technology

Question	Positive	Negative	No Impact	Don't Know
10. What type of impact did the CV system have on how you perform your job?	☐	☐	☐	☐

Question	Response Space
11. Please explain:	[Text response—limited 200 characters]

Question	Very Dissatisfied	Somewhat Dissatisfied	Neither	Somewhat Satisfied	Very Satisfied
12. Overall, how satisfied are you with your CV Pilot Deployment experience?	☐	☐	☐	☐	☐

Question	Response Space
13. What was the biggest challenge in participating in the CV Pilot Deployment?	[Text response—limited to 200 characters]
14. Did you or your drivers have any issues with the CV system that you would like to report?	[Text response—limited to 200 characters]
15. Are there any lessons learned that you would like to share?	[Text response—limited to 200 characters]
16. Do you have any other comments/feedback you would like for us to consider?	[Text response—limited to 200 characters]

Thank you for your participation and comments!

Supporting Agency Questions

Question	City/County Public Agency	Law Enforcement Agency	Port
1. For what type of organization do you work?	☐	☐	☐

Question	Very	Moderately	Slightly	Not at all
2. How knowledgeable are you about the CV Pilot Deployment in Tampa? If not at all knowledgeable: Skip to question 12.	☐	☐	☐	☐

Question
3. What benefits of the CV system were experienced? (check all that apply) ☐ Fewer traffic crashes and increased roadway safety ☐ Less traffic congestion ☐ Less stressful driving ☐ Reduced travel time ☐ Improved travel time reliability ☐ Improved pedestrian safety ☐ Other (specify)_____ ☐ Not aware of any demonstrated benefits

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
4. Based on your knowledge, to what extent do you agree or disagree with the following statements?	☐	☐	☐	☐	☐	☐
• The alerts/warning provided by the applications increased safety.						
• I would like to see more vehicles equipped with this type of technology.	☐	☐	☐	☐	☐	☐
• I would like to see the applications expanded to other areas in Tampa.	☐	☐	☐	☐	☐	☐

Question
5. Do you have any of the following concerns about the CV system that was deployed in Tampa? (check all that apply) ☐ Cost ☐ Safety ☐ Privacy ☐ Trust in technology ☐ Too many alerts or warnings ☐ False alerts or warnings ☐ Driver distraction ☐ Other (specify)_____ ☐ No concerns ☐ Don't know enough about the technology

Question	Positive	Negative	No Impact	Don't Know
6. What type of impact did the CV system have on how you perform your job?	☐	☐	☐	☐

Question	Response Space
7. Please explain:	[Text response–limited 200 characters]

Question	Very Dissatisfied	Somewhat Dissatisfied	Neither Satisfied nor Dissatisfied	Somewhat Satisfied	Very Satisfied
8. Overall, how satisfied are you with your CV Pilot Deployment experience?	☐	☐	☐	☐	☐

Question	Response Space
9. What was the biggest challenge in participating in the CV Pilot Deployment?	[Text response—limited to 200 characters]
10. How did the CV Pilot Deployment affect your organization if at all?	[Text response—limited to 200 characters]
11. Are there any lessons learned that you would like to share?	[Text response—limited to 200 characters]
12. Do you have any other comments/feedback for us to consider?	[Text response—limited to 200 characters]

Thank you for your participation and comments!

Workshop Guide

The TTI CVPD Evaluation Team will conduct a workshop in each site at the conclusion of the deployment period. the purpose of the workshop is to foster additional dialogue among the deployment managers, deployment teams, and operating agencies concerning the lessons learned and major takeaways from planning and implementing the deployments. The TTI CVPD Evaluation Team will use the common themes identified in the post-deployment interviews to frame the group discussion, which will explore these and other topics in more detail. The TTI CVPD Evaluation Team will also use the workshop to gather information needed to conduct the financial and institutional assessments (see the task C scope of work).

Workshop participants will represent the deployment managers, deployment team members, and operating agencies from each site. The TTI CVPD evaluation team expects that 15–20 persons will participate in the workshop. Some but not all will be individuals who have participated in the interviews. The TTI CVPD evaluation team will coordinate with the deployment managers in identifying persons to be invited to the workshop.

Workshop Format

The following presents the proposed format for the workshop. Core members of the TTI CVPD Evaluation Team will lead the workshop in person. Other TTI CVPD evaluation team members will participate via web conference.

Workshop Questions

Without knowing the information that will result from the post-deployment interviews, the following are types of questions that will be used in the workshop.

Participant Introductions

1. Name, affiliation, and role in pilot (specific activities)

Expectations and Satisfaction

2. What is your agency's objective(s) in participating in the pilot?
3. How well did the CV Pilot Deployment meet the stated objectives?
4. When initially implemented, how did the pilot meet the stated objectives?
5. How well did the pilot implementation match what was initially proposed?
6. Were there unanticipated changes to scope, cost, schedule, or safety?
7. How were these managed? How well were you or others in your organization involved in the risk identification and mitigation planning?
8. What is your overall assessment of the success of this pilot?

9. Has your view of what constitutes success changed during the deployment and operation of the various projects? If so, in what way and why?
10. In what ways are you satisfied with the outcomes? Any ways in which you are not satisfied?
11. Would you do it again?
12. Would you recommend the pilot to other agencies?

Technical Challenges

13. What do you think were the three biggest technical or technology-related challenges in pilot implementation?
14. Were these challenges effectively addressed?
15. How were they addressed?
16. What lessons learned can be drawn from these challenges and solutions?

Institutional Arrangements

17. In what ways have the capabilities of your organization (related to CV applications) matured because of the pilot?
18. What were the two biggest institutional challenges?
19. Were these challenges effectively addressed?
20. How were they addressed?
21. What lessons learned can be drawn from these challenges and solutions?
22. With what other stakeholders did your organization most collaborate during the pilot?
23. Do you expect continued collaboration with these organizations? For what purposes?

Financial Arrangements

24. What were the biggest financial or cost-related challenges for your organization during deployment? How were these addressed?
25. In what ways has the experience with the CV applications influenced your perceptions of whether or not your agency has the resources to deploy and manage the V2X applications?
26. Have you begun any type of benefit cost analysis of the pilot deployment? Describe the cost and benefit categories.
27. What are your preliminary assessments?
28. In your opinion, is there a shared commitment among stakeholders to the financial sustainability of the CV Pilot Deployment and how to achieve it?

Lessons Learned

29. What are the three most important lessons learned? List and compare/contrast.

Sustainability

30. Has your organization developed a strategy for sustainability that you are willing to share here?
31. Do you foresee CV as a formal, visible, sustainable line item in your agency's budget?

Expectations for Future Operations

32. Are sufficient people trained to manage, operate, and maintain the CV system going forward?
33. Do you foresee CV responsibilities being consolidated into an operational unit with a manager and defined budget?
34. Is staffing capable of evolving to meet the demands of future technologies and a mix of modes?
35. Has senior management solidified a CV business case? Is this being communicated to policy makers and the public?
36. What is the level of acceptance of a CV program among policy makers and the public?

Appendix B. Tampa User Survey Demographics

Please indicate your gender.

Response	Number	Percent
Male	586	55%
Female	465	44%
No response provided	7	1%
Total	**1,058**	**100%**

In which of the following categories is your age?

Response	Number	Percent
18 to 24	23	2%
25 to 34	197	19%
35 to 44	274	26%
45 to 54	312	29%
55 to 64	202	19%
65 to 74	41	4%
75 or older	2	0%
No response provided	7	1%
Total	**1,058**	**100%**

Please indicate the highest level of education.

Response	Number	Percent
Less than high school	1	0%
High school/GED	49	5%
Vocational or technical school certificate	29	3%
Some college (no degree)	182	17%
Associate degree	384	36%
Bachelor's degree	286	27%
Graduate or professional degree	120	11%
No response provided	7	1%
Total	**1,058**	**100%**

Are you Hispanic or Latino?

Response	Number	Percent
Yes	167	16%
No	881	83%
No response provided	10	1%
Total	**1,058**	**100%**

What is your race? (check all that apply)

Response	Number	Percent
American Indian or Alaska Native	4	0%
Asian	45	4%
Black or African American	105	10%
White	812	77%
Native Hawaiian or other Pacific Islander	4	0%
Other	44	4%
More than one race (mixed)	33	3%
No response provided	11	1%
Total	**1,058**	**100%**

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