NCHRP Project 14-42

DETERMINING THE IMPACT OF CONNECTED AND AUTOMATED VEHICLE TECHNOLOGY ON STATE DOT MAINTENANCE PROGRAMS

Tech Brief: Implementation of Research Findings and Products

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1. Project Objectives and Summary

1.1 Background

Connected and autonomous vehicle (CAV) technologies hold the potential to produce a number of safety, mobility, and environmental benefits for the users and operators of the nation's surface transportation system. The benefits of CAVs are expected to be wide-ranging and apply not only to roadway users but also transportation agencies. These benefits include reduced crashes, improved mobility, lower emissions, and a reduced need to construct roadway infrastructure (fostered by mobility improvements).

However, even with fully autonomous capabilities, the advent of a fully integrated CAV system is not expected to come online for at least 20 years due to turnover in the existing vehicle fleet. As a result, infrastructure will need to be maintained for human drivers as well as CAVs for some time.

Additionally, uncertainty in CAV technology poses challenges. When agencies invest too early in assets for CAV technologies, and then the associated technology changes, many resources spent in acquisition, changes to maintenance practices, and workforce investments may be wasted. Uncertainty about CAV technology can make it difficult for agency managers to select and invest in assets to support CAV deployment and to determine the focus for future workforce needs.

The need for a dual system coupled with uncertainty about the future of CAV technology creates an additional maintenance burden for agencies that already have a constrained workforce and tight budgets. Compounding this is that changing maintenance needs will likely require a different set of workforce skills than is currently available in most transportation agencies.

1.2 Project Objectives

The objectives of this project were to (1) identify likely maintenance needs due to CAV technologies, (2) develop guidance on measurable standards and resource implications, and (3) assess any workforce implications.

Phase I entailed the following:

- Literature review, which summarized the known timeline for implementation of CAV technology, infrastructure elements that state and local agencies have implemented for CAVs, and any known maintenance or workforce implications (see Chapter 2);
- Survey of agencies to identify state-of-the-practice for the CAV assets that have been implemented (see Chapter 3);
- Stakeholder interviews with 10 agencies to fill in the gaps;
- Summary of available information and identification of gaps to develop performance measures in Phase II (see Chapter 2); and

- Strategies for assets to be included in Phase II (see Chapter 2).

Once Phase I commenced, it was evident agencies were not as mature in the implementation of CAV technologies as expected. During the course of the project, the projected move to fully autonomous vehicles was delayed due to technology and policy challenges as well as the COVID-19 pandemic, which altered the focus of many state agencies at least for the short term. As a result, the original objective of developing performance measures for several assets was not feasible. The focus of Phase II was gathering as much maintenance information as was available for the selected assets. Phase II then consisted of the following:

- Conduct additional interviews with agency representatives;
- Conduct interviews with maintenance contractors;
- Collect information from asset vendors;
- Summarize available information about maintenance for each selected asset; and
- Final report and implementation.

1.3 Project Summary

Connected and autonomous vehicle (CAV) technologies have the potential to produce several safety, mobility, and environmental benefits for the users and operators of the nation's surface transportation system. Due to the rate of turnover in the existing vehicle fleet, however, infrastructure will need to be maintained for both human drivers and CAVs for some time. Additionally, uncertainty regarding CAV technology can make it difficult for agency managers to select and invest in assets supporting CAV deployment and to determine future workforce needs.

This study aimed to identify likely infrastructure maintenance needs due to the implementation of CAV technologies, develop guidance on measurable maintenance standards (if feasible) and the resources required to implement those standards, and assess any implications for workforce needs. Available maintenance information for key infrastructure assets identified in Phase I of this project was collected from 39 state responses to a national survey and 18 follow-up interviews with states, municipalities, asset vendors, and maintenance contractors.

The following summarizes project activities and findings:

- The research on CAV maintenance did not find agencies with mature practices or data concerning the maintenance of CAV assets.
- The research team gathered emerging CAV information from 39 states via survey and conducted 18 follow-up interviews with states, municipalities, vendors, and maintenance contractors. The totality of this information demonstrated that within three to five years, some level of CAV maintenance history would be available from most of the responding states.
- Research identified that CAVs were likely to impact a broad array of agency assets, contributing to a system that is more actively managed, interconnected, and in need of enhanced levels of maintenance to serve CAVs.
- Research particularly focused on three major asset types that will significantly impact transportation agencies in the next decade.

    - Pavement marking national standards were changing through proposed updates to the MUTCD that benefit both human driver safety and image processing at the heart of CAVs. The increased standards for lane marking widths to 6 in. will affect states at different levels based on their current practices but, on the whole, were expected to increase maintenance costs.
    - Opportunities like the U.S. DOT-sponsored Smart City Challenge and CV Pilot Program, along with federal grants like the Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD), had enabled agencies to invest reduced capital funding into more emerging asset types such as RSUs and vehicle-based OBUs. Out of these deployments, agencies were gaining value in the need for staff advancement into electrical maintenance, computer programming, and information technology skills. The pilot deployments cataloged were mostly short in duration and filled temporary skill gaps with support from third parties, like universities, vendors, consultants, and maintenance contractors.
- The research team conceptualized from all information gathered that the growth in CAV technology assets represents a natural extension of current ITS and TSMO programs in the relationship between field staff needs and activities and the staff operating the system in the back office or in a TMC.
    - CAV assets—like ITS and TSMO assets—best achieve user and agency benefits when applied through the systems engineering process. The research team describes the FHWA guidance documents that support systems engineering for CAVs and ancillary plans for early CAV pilot testing. The outcome of systems engineering is typically a traceable plan for validation and verification that the implemented system serves all users in a measurable way.
    - CAV assets—like ITS and TSMO assets—may require a strong business case to agency management to elicit upfront and continued investment support. Several tools exist to begin to demonstrate the return on investment of CAV pilots, but the research team noted that some of the agency interviews highlighted intangible returns like greater agency awareness that may not easily translate into economic analysis.
    - CAV assets—like ITS and TSMO assets—may struggle from a lack of operations and maintenance funding even though these assets may be safety-critical to travelers. A proven remedy to limited operations and maintenance funding is procurement requirements that enable vendor-led maintenance and training of agency maintenance staff through the early deployment period.
    - Finally, CAV assets—like ITS and TSMO assets—represent a high risk of sudden failure to agencies that frequently invest in pavement and bridges. Failures may be temporary or may be mitigated, but they require a different response mindset than traditional schedule- or proactive-based maintenance.
- Ultimately, the research team captured that instability in national technology and communication standards during the course of the project led to functional obsolescence of some of the CAV assets studied, which is cautionary for state agencies as they consider their future investments in CAV assets. While even short-life deployments can help agencies start to adopt early changes for CAV readiness, the potential growth to agency workforce knowledge, skills, and abilities must be balanced with the risk of technology deployment costs with limited public benefit.

2. Strategies for Implementation

The initial goal of this project was to identify maintenance needs for infrastructure assets for CAVs. However, agencies were in earlier stages of implementation than expected. As a result, none of the agencies or maintenance contractors had much experience with the maintenance of CAV assets. As a result, only limited information about maintenance practices was available, and standards and best practices could not be developed. As a result, several additional implementation activities are proposed.

2.1 Implementation Activities

Further activities could include the following:

- Identify several states or agencies that have had one or more of the assets that were a focus of this project (e.g., pavement markings, RSUs). This would include agencies that have conducted widespread implementation of the asset(s), several years of experience with the asset(s), and willingness to participate. Databases could be developed with a structure that will allow gathering additional data to track performance (historical information if available and an additional two years of data). Using this information, initial performance estimates could be developed, along with cost estimates.
- Conduct focus groups with asset vendors to develop initial performance estimates. Many agencies indicated that they were using initial vendor contractors for maintenance due to the newness and uncertainty of the technologies. The research team obtained some limited information from vendors. However, contacting vendors was not within the scope of the original work since it was initially felt that agencies would be more mature in the implementation of the assets.

Among the most significant findings of the research were direct agency interviews and survey responses validating that states are acting in anticipation of CAVs but with significant limitations in workforce knowledge, skills, and abilities. The agencies addressed that gap temporarily by contracting work to third parties in the form of universities, vendors, consultants, and contractors. Public-Private Partnerships (PPP) also represented an effective method to pilot emerging technology, but long-term adverse outcomes could result if agency planning for the technology project does not retain the deployment knowledge.

2.2 Likely Champions

The main champions who are likely to take leadership in deploying the research products are relevant state and national organizations/committees such as the National Uniform Traffic Control Device Connected Automated Vehicle Task Force, AASHTO Maintenance Committee, Transportation Research Board Asset Management Committee, maintenance staff, and vendors.