Integration of Connected Vehicle and RWIS Technologies

tech transfer summary

Integrating connected vehicle technology into road weather information system infrastructure can significantly improve road safety by providing real-time weather information to drivers.

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The Aurora program is a partnership of highway agencies that collaborate on research, development, and deployment of road weather information to improve the efficiency, safety, and reliability of surface transportation. The program is administered by the Center for Weather Impacts on Mobility and Safety (CWIMS), which is housed under the Institute for Transportation at Iowa State University. The mission of Aurora and its members is to seek to implement advanced road weather information systems (RWIS) that fully integrate state-of-the-art roadway and weather forecasting technologies with coordinated, multi-agency weather monitoring infrastructures.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the project partners.

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Objective

This project aimed to identify the challenges involved in the integration of connected vehicle (CV) technology into road weather information system (RWIS) infrastructure and to recommend areas of future research that can address these challenges.

Background

CVs are equipped with advanced technologies that allow them to interact with other vehicles and with infrastructure and other external systems. CVs collect and transmit data about their position and performance through dedicated short-range communications (DSRC), line-of-site cellular technology, or commercial cellular network technologies. This connectivity can be used to improve traffic control and safety.

RWIS infrastructure is used by departments of transportation (DOTs) to improve safety and mobility, especially in inclement weather, by reducing drivers' exposure to dangerous weather-related road conditions, improving winter maintenance, providing interactive information to travelers, and reducing traffic congestion and delays.

Various DOTs are integrating or planning to integrate CV technology into their RWIS to enhance the detection of road surface conditions, improve road weather forecasts, and provide real-time weather information to drivers.

Problem Statement

Although CV-RWIS integration offers benefits, challenges to integration include, for example, the need to train agency staff on new technologies, policies, and procedures; a lack of standards governing data exchange formats and communication protocols; and privacy concerns. These challenges must be identified and addressed to take full advantage of CV-RWIS integration.

Research Description

To identify the challenges to CV-RWIS integration, this project reviewed the literature related to CV-RWIS integration, analyzed ongoing DOT projects related to CVs and RWIS, surveyed agencies about their RWIS investments to facilitate CV integration, and conducted follow-up interviews with selected agencies.

Based on the information gathered from these sources, the current challenges facing CV-RWIS integration were summarized and recommendations for future research to address these challenges were developed.

Key Findings and Recommendations

Data Standards to Enhance Interoperability and Interpretability

- CV-RWIS integration necessitates adherence to robust data standards. As highlighted in the literature review, survey, and targeted interviews, differences in the format, transmission frequency, and reliability of data hinder data interoperability.

- The lack of standard protocols for data exchange between CVs and RWIS reduces the usability of the available data. The development and implementation of standardized data formats and communication protocols are important for seamless CV-RWIS integration.

- Guidelines for data quality assurance and verification to ensure reliability and accuracy can help agencies implement standards and facilitate collaboration between industry stakeholders, standardization bodies, and regulatory authorities.

Deployment Configurations, Adoption Rates, and Impacts

- To determine the technology standards, minimum system requirements, and hardware or software configurations that best support CV-RWIS integration, agencies should construct testbeds to evaluate different technologies, determine best practices, assess the adoption rate of technologies, and forecast the impacts of CV-RWIS integration.

- The outcomes of these research efforts should provide agencies with detailed information about the array of technical options available and the factors involved in selecting, deploying, and operating them.

Investments in RWIS Technologies to Support CV Integration

- Efficient data handling requires robust computational capabilities for swift processing and exchange. However, the literature indicated that determining the optimal number of CVs and RWIS stations for efficient integration poses a challenge.

- Barriers to RWIS investments identified in the survey results included a lack of technical and financial support, uncertainties regarding data reliability and the longevity of specific technologies, and organizational culture. A common issue in the targeted interviews was similarly that limited resources hinder integration.

- Edge computing, a concept that brings computation closer to the point of need, can be deployed to optimize data processing and exchange but can also present difficulties, such as increased costs and issues regarding integration with existing systems.

- Research efforts should focus on developing efficient and compatible edge computing equipment and on determining the optimal number of CVs and RWIS stations for cost-effective integration.

Investments in Information Technology and Data Communication Technology

- Challenges identified in the literature included providing the computation, communication, and storage resources needed to handle enormous amounts of CV data; finding a communication method with a sufficient range and latency for CV applications; and striking a balance between data interchange and the preservation of user privacy.

- Challenges identified in the survey included a lack of financial and technical support for investments in information technology, uncertainty regarding technology, data incompatibility, a lack of standardization, and the need for workforce development. Insufficient resources was also a challenge identified in the targeted interviews.

- Addressing communication issues related to CV-RWIS integration requires a strong communication infrastructure. Investments in high-speed networks are critical for real-time data transmission between CVs and RWIS and the system's overall efficiency.

- Cybersecurity techniques such as encryption, secure authentication, and continuous monitoring are critical for data security. A comprehensive strategy for protecting the integrity and confidentiality of data exchanged between CVs and RWIS should be developed.

Maintenance Practices

- Key concerns expressed in the survey included workforce training needs, data reliability, financial and technical support, and uncertainties about technology.

- To ensure reliable, high-quality, and accurate data for road maintenance, CV and RWIS sensors must perform effectively in all weather conditions. Algorithms should be developed to minimize the impact of erroneous or inaccurate sensor data, and the dependability of sensor data should be maintained through frequent maintenance and calibration.

- Performance data are needed to develop standards or metrics for maintenance planning and programming. As technologies such as RSUs become more mature, performance standards should be developed to help agencies better scope costs and other maintenance resources.

- Technologies are changing rapidly, which can often render a given technology obsolete. This makes it difficult for agencies to make investment decisions and assess maintenance needs.

Workforce Development

- The survey and targeted interviews found that organizations recognize the importance of technical skills in supporting CV-RWIS integration and the need to train staff. Most agencies already support workforce development efforts. However, some agencies face shortages in staff that can manage CV-RWIS integration, and many struggle to retain qualified staff.

- A comprehensive approach is recommended for workforce development, including working with outside experts and investing in training infrastructure to ensure that training is current and effective. Collaborating with educational institutions and providing financial incentives for training can help agencies overcome resource constraints.

- Funding sources must be identified to support training initiatives and help create a culture of continuous learning and mentorship programs that will promote ongoing skill development.

- Nationally consistent credentials and training programs should be developed for the skills needed for CV-RWIS integration. Such programs would ensure that agencies can depend on the skills gained in a given training program and that different training programs have a consistent level of quality.

Implementation Benefits and Readiness

Integrating CV technology into RWIS infrastructure has the potential to significantly improve road safety by enhancing the detection of road surface conditions, improving road weather forecasts, and providing real-time weather information to drivers.

Before the benefits of CV-RWIS integration can be more fully and consistently realized, the challenges identified in the literature and by agencies need to be addressed. Short- and long-term recommendations for achieving a more favorable environment for CV-RWIS integration are summarized above and described in the white paper resulting from this project.