



An Intelligent Human-Centric Communication System for Adverse Weather and Road Conditions

tech transfer summary

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RESEARCH PROJECT TITLE

An Intelligent Human-Centric Communication System for Adverse Weather and Road Conditions

SPONSOR

Federal Highway Administration Aurora Program Transportation Pooled Fund (TPF-5(435); Aurora Project 2023-02)

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MORE INFORMATION

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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.

Leveraging conversational AI and real-time multimodal data, CARWIS provides a next-generation, user-friendly platform for road weather information to improve safety, situational awareness, and operational efficiency for drivers and transportation agencies.

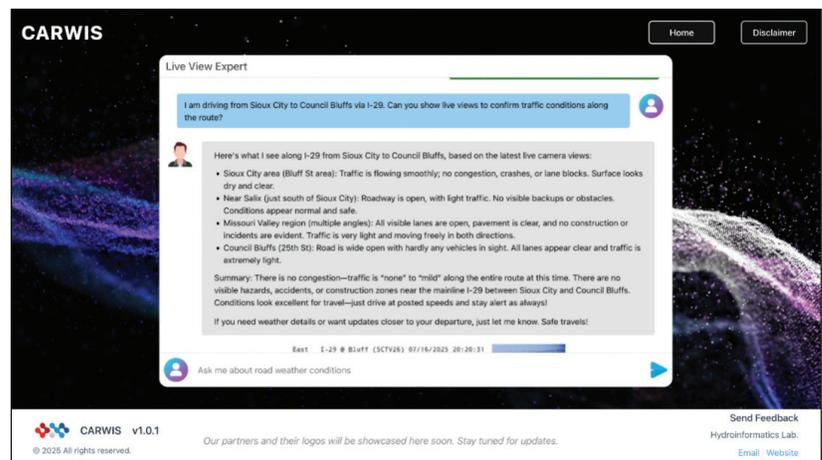
Objective

The objective this project was to develop a web-based, artificial intelligence (AI)-powered platform that delivers comprehensive, location-specific road weather information through natural conversation. The broader goal was to enhance safety and decision-making for drivers and agencies by simplifying access to real-time, actionable road, weather, and traffic data.

Background and Problem Statement

Traditional road weather information systems (RWIS) and 511 traveler information systems, while valuable, continue to face persistent challenges: (1) fragmented data sources and limited coverage; (2) unintuitive and sometimes overwhelming user interfaces; (3) a lack of real-time, actionable integration of sensor, weather, and camera data into a seamless tool; and (4) growing user expectations for conversational, multi-modal, and cross-device access to information.

These limitations suggest a need to develop a next-generation conversational AI system that (1) merges live sensor, weather, traffic, and camera data; (2) delivers tailored, context-aware insights through an intuitive conversational interface; (3) supports multiple types of stakeholders, including the general public, department of transportation (DOT) operations, and emergency planners; and (4) significantly improves both accessibility and operational value for its users.



Research Description

The project focused on the development, deployment, and evaluation of an innovative platform designed to deliver road weather information using advanced conversational AI. The resulting application is Conversational AI for Road Weather Information Systems (CARWIS).

The system consists of four specialized, role-based “experts”: Drive Assistant, Winter Expert, Live View Expert, and 511 Data Expert. Each provides tailored support for different user needs such as general trip planning, winter hazard assessment, real-time camera-based smart monitoring, and data analytics.

The system integrates multiple real-time data streams from official sources, including Iowa DOT 511 road condition feeds, roadway sensors, snowplow automated vehicle location (AVL) data, traffic and RWIS cameras, incident event feeds, and National Weather Service forecasts and alerts.

CARWIS was piloted statewide in Iowa and evaluated by DOT stakeholders.

Key Findings

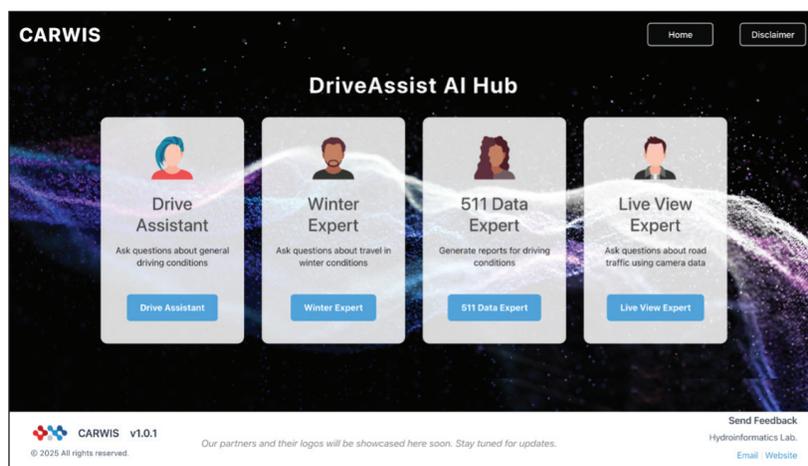
The stakeholder evaluation yielded several insights.

Usability, Relevance, and DOT Value

- 88% of respondents agreed or strongly agreed that CARWIS was easy to use.
- The Drive Assistant received unanimous positive feedback for ease of interaction and relevance. Additionally, 88% of users not only trusted the accuracy of the agent’s data but also agreed that it provided actionable insights.
- Most users saw clear value for agency workflows, with 63% agreeing or strongly agreeing that CARWIS fits well with current DOT operational processes and 88% agreeing that CARWIS provides value beyond the tools currently available to their agencies.
- There was strong support for integrating CARWIS features into state 511 systems, as 88% of participants agreed or strongly agreed this would enhance Iowa DOT’s internal operations and public communications.

Impact of Expert Modules and Scenario-Based Support

- Every respondent used the Drive Assistant, rating its scenario-based summaries and dynamic safety advice as “Very Helpful” or “Somewhat Helpful.” Follow-up Q&A was particularly valued: 75% of users found it “Very Helpful.”
- All respondents who used the Winter Expert found it easy to use and relevant, consistently reporting high trust in its winter hazard detection and pre-trip preparation guidance, even when tested during non-winter months.
- The Live View Expert achieved near-universal high marks for usability and relevance, with all users rating its live camera features as “Very Helpful.” Its route-planning and camera-based congestion assessment were also rated highly by users, demonstrating its clear operational impact for event and incident response.
- All users rated the 511 Data Expert at least “Somewhat Helpful” for use cases such as comprehensive PDF-based reporting and analytics, and several users highlighted its route and surface condition summaries as “Very Helpful” or “Extremely Helpful.”



CARWIS homepage and AI expert selection interface

Areas for Improvement

- Users identified key areas for further optimization, including (1) reducing response time, (2) offering succinct, summary-style outputs for in-vehicle or hands-free use; (3) adding visual context (like map integration); and (4) refining agent roles or implementing an adaptive, unified interface to further simplify user experience.
- Respondents expressed a strong interest in advanced features such as timestamped data, voice-activated or voice-response modes, and increased adaptivity in expert selection. These enhancements are readily actionable given the current system architecture and user analytics already collected by CARWIS.
- The surveyed operational professionals expressed their belief that CARWIS can directly reduce cognitive load, increase situational awareness, and streamline both public traveler and maintenance crew tasks if provided at scale and continuously supported.

Implementation Readiness and Benefits

CARWIS is designed as a modular software-as-a-service platform that can be easily hosted or integrated into DOT or third-party systems as a standalone tool or RESTful backend. The prototype consumes official APIs with minimal requirements for adoption.

CARWIS delivers a range of operational benefits, including enhanced safety, operational efficiency, improved public information access, scalability, and adaptability to other states and contexts.

Recommended implementation steps are summarized as follows:

- Pilot CARWIS with a broad range of users, including actual drivers, the general public, and diverse stakeholders from agency operations, winter maintenance, and emergency planning.
- Integrate CARWIS into existing 511 traveler information websites and enable interoperability with third-party communication channels such as Apple CarPlay, Android Auto, messaging applications, and smart watches.
- Continue customizing expert roles, interfaces, and reporting features to align with agency-specific operational workflows, unique data sources, and evolving regional needs.
- Establish sustained maintenance and technical support for ongoing platform operations, regular system and AI model updates, and responsive adaptations based on user analytics, seasonal feedback, and emerging data requirements.
- Pursue collaborative partnerships to expand CARWIS into a fully operational, nationwide system with cross-state data integration.