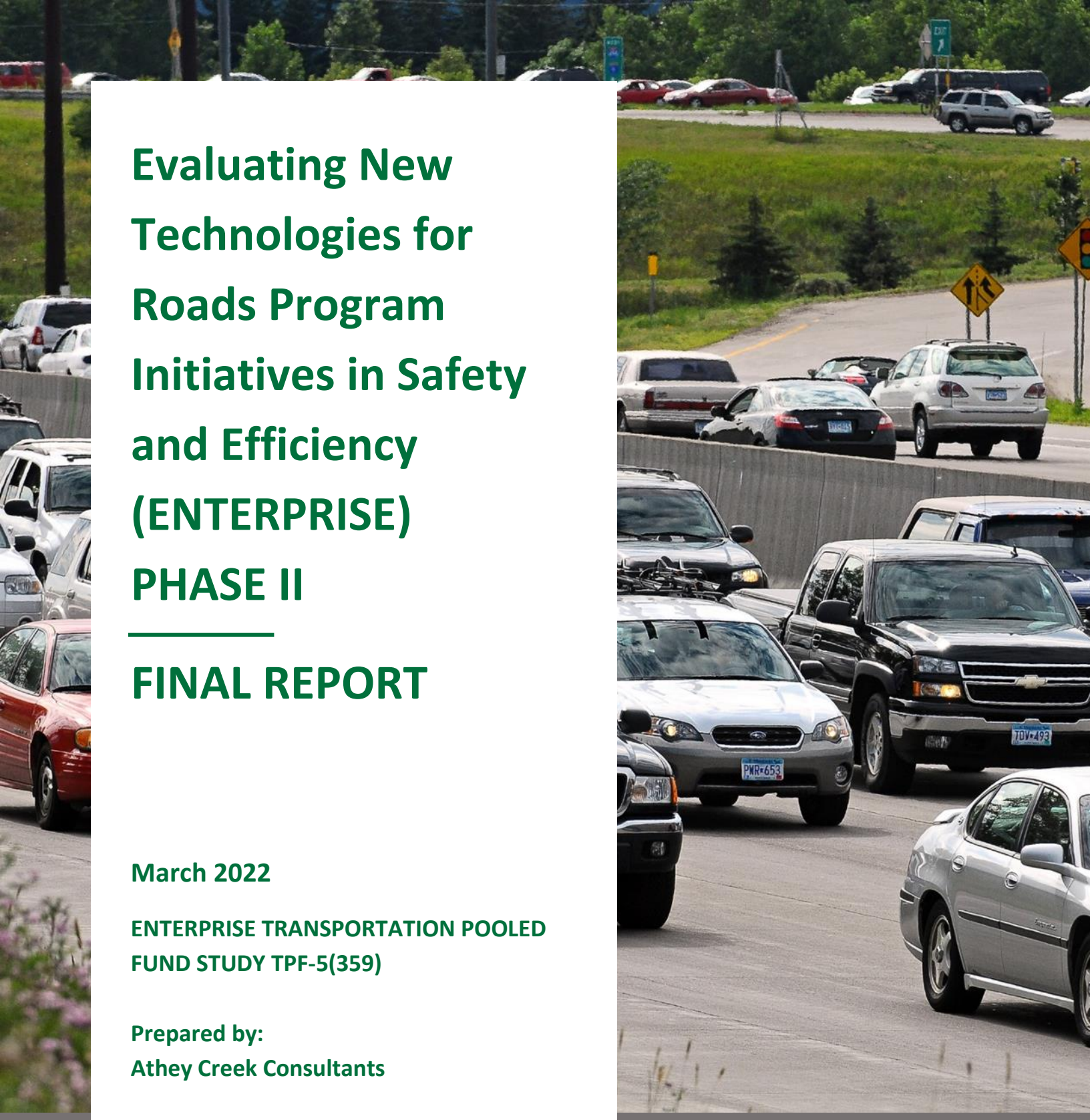

Evaluating New Technologies for Roads Program Initiatives in Safety and Efficiency (ENTERPRISE) PHASE II

FINAL REPORT

March 2022

ENTERPRISE TRANSPORTATION POOLED FUND STUDY TPF-5(359)

Prepared by:
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ENTERPRISE

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16. Abstract

Over the past thirty years, the ENTERPRISE Pooled Fund has completed research projects with one common theme – that they address specific problems to help advance the transportation technology programs in the member agencies. This final report describes the activities of ENTERPRISE Phase II technical activities, performed between 2018 and 2022. Collectively, the ENTERPRISE Phase II members identified, prioritized, and oversaw the research activities of 20 individual projects that all contributed to the objectives of the program. The 20 projects fit into three types of research activities: applied research, evaluation activities, and exploratory research.

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This final report, *ENTERPRISE Phase II*, was prepared for the ENTERPRISE Transportation Pooled Fund TPF-5(359) program (http://enterprise.prog.org/). The primary purpose of ENTERPRISE is to use the pooled resources of its members from North America and the United States federal government to develop, evaluate, and deploy Intelligent Transportation Systems (ITS).

The cover page image is courtesy of the Minnesota Department of Transportation.

Project Champion

The lead state for the current pooled fund study, TPF-5(359), is the Michigan Department of Transportation. The lead state is responsible for controlling project financing (obligating funds, tracking expenses, paying invoices, and returning unused funds to participating entities) from inception through final closeout.

ENTERPRISE Members

The ENTERPRISE Board for Phase II consisted of representatives from each of the following member entities.

- Illinois Department of Transportation
- Iowa Department of Transportation
- Kansas Department of Transportation
- Michigan Department of Transportation
- Minnesota Department of Transportation
- Ontario Ministry of Transportation
- Pennsylvania Department of Transportation
- Texas Department of Transportation
- Wisconsin Department of Transportation
- Federal Highway Administration

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This material is based upon work supported by the Federal Highway Administration under State Planning and Research (SPR) Transportation Pooled Fund (TPF)-5(359). Any opinions, findings and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the Federal Highway Administration.

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Executive Summary

Over the past thirty years, the Evaluating New Technologies for Roads Program Initiatives in Safety and Efficiency (ENTERPRISE) Transportation Pooled Fund (TPF) Study has taken on projects with one common theme – that they address specific problems to help advance the transportation technology programs in the member agencies. This final report describes the activities of ENTERPRISE Phase II technical activities, performed between 2018 and 2021. The participating members in ENTERPRISE Phase II included the following nine transportation agencies.

- Illinois Department of Transportation (IDOT)
- Iowa Department of Transportation (Iowa DOT)
- Kansas Department of Transportation (KDOT)
- Michigan Department of Transportation (MDOT)
- Minnesota Department of Transportation (MnDOT)
- Ontario Ministry of Transportation (MTO)
- Pennsylvania Department of Transportation (PennDOT)
- Texas Department of Transportation (TxDOT)
- Wisconsin Department of Transportation (WisDOT)

Collectively, these members identified, prioritized, and oversaw the research activities of 20 individual projects that all contributed to the seven objectives of the program in some way.

- Objective #1: Investigate and promote Intelligent Transportation Systems (ITS) approaches and technologies that are compatible with other national and international ITS initiatives.
- Objective #2: Support the individual ITS program plans of ENTERPRISE participants.
- Objective #3: Provide a mechanism to support multi-state and international project cooperation and technical information interchange.
- Objective #4: Facilitate the formation of public-private partnerships for appropriate program activities.
- Objective #5: Pursue emerging ITS project opportunities in areas of interest to the group.
- Objective #6: Provide test beds in a variety of environments and locations for emerging ITS technologies.
- Objective #7: Identify common needs within the group and proceed with appropriate technical activities.

The 20 projects generally fit into three types of research activities: applied research, evaluation activities, and exploratory research. **Table 1** identifies project titles of the 20 projects and categorizes them by research type.

Table 1: ENTERPRISE Phase II projects by research type

Research Type	ENTERPRISE Projects
Applied Research	Project 1: The Evolution of ITS in Asset Management Project 2: Evolving and Phasing out Legacy ITS Devices and Systems Project 4: Roadmap for Next Generation Intersection Conflict Warning Systems (ICWS) Project 6: Emerging Practices for Communications Infrastructure Project 7: Automated Classification of Winter Road Conditions – Phase 2 Project 11: Procurement Practices for Partnering with Emerging Technology Providers Project 12: Synthesis of Probe Speed Data for Arterial Operations Project 13: Traveler Information Collaboration – Phase 1 Project 14: Establishing a Framework for Communicating DOT Map Updates to Mapping Companies Project 16 Traffic Operations Responses to the COVID-19 Pandemic Project 19: Patented and Proprietary Products Waiver Impact on ITS Procurements
Evaluation Activities	Project 3: Real-time Integration of Arrow Board Messages into Traveler Information Systems Evaluation Project 8: Use Cases and Benefits of Active Traffic Management (ATM) Strategies Project 15: State of Practice for Automated Incident Detection
Exploratory Research	Project 5: ITS Integration with Connected and Automated Vehicle (CAV) and Mobility as a Service (MaaS) Project 9: Volumes from Probe Data Project 10: Potential Approaches for Wrong-Way Driving Applications Project 17: Best Practices in Future Proofing for Emerging Technologies Project 18: Pedestrian Detection Systems for Improved Safety Project 20: Understanding Infrastructure Operations Impacts Based on Automated Vehicle (AV) Demonstrations

Benefits to Members

The members of ENTERPRISE Phase II recognized benefits through participation and collaboration with member agencies, and through the products prepared within the projects. Tangible examples of some of the implementation outcomes of research results include the following:

- Iowa DOT noted that *Project 3: Real-time Integration of Arrow Board Messages into Traveler Information Systems Evaluation* contributed to their implementation of arrow boards in construction and maintenance projects throughout the state. This project also contributed to their Work Zone Data Exchange (WZDx) approach and success in receiving a demonstration grant from the USDOT as a WZDx pilot site.
- MnDOT indicated that they used the results from *Project 5: ITS Integration with CAV and MaaS* to share with and inform the Minnesota Governor's Advisory Committee on CAV about the role of MaaS.
- *Project 10: Potential Approaches for Wrong-Way Driving Applications* was successful at reaching multiple automobile manufacturers and third-party providers of in-vehicle applications, to influence future deployments. This project also led a concept proposed to FHWA for a national data exchange for wrong-way driving reports.
- *Project 13: Traveler Information Collaboration – Phase 1* has led to the American Association of State Highway and Transportation Officials (AASHTO) initial discussion in forming a Community of Practice on Traveler Information that will fulfill the intended vision of this project.
- The industry scan developed for *Project 18: Pedestrian Detection Systems for Improved Safety* was utilized to help inform a Michigan DOT research effort that will test various detection-based pedestrian safety systems.

In addition, numerous presentations highlighting ENTERPRISE Phase II research results were made to transportation practitioners from around the country at conferences and stakeholder meetings.

1.0 Introduction

This section provides an overall background of the ENTERPRISE program, notes the duration of the research activity and members during Phase II, and provides the overall objectives of the ENTERPRISE Phase II effort.

1.1 Background

In 1991, a group of states agreed to collaborate on research to advance the use of technologies in transportation. This group organized as a TPF study with the title ENTERPRISE. Arizona DOT served as the initial program administrator. In subsequent years, the administrative activities were led by Colorado DOT, Iowa DOT, and Michigan DOT. Michigan DOT has been the lead administering state since 2009 and has overseen ENTERPRISE Phase I (TPF-5 (231) that concluded in the fall of 2017 and most recently the work summarized in this document (ENTERPRISE Phase II (TPF-5(359)).

1.1.2 Why ENTERPRISE Exists

The ENTERPRISE Program is unique compared to many other pooled fund programs. Whereas many pooled funds are focused on a specific topic (e.g., traffic management centers, maintenance decision support systems) the ENTERPRISE members unite for a much broader goal of advancing Intelligent Transportation Systems (ITS) research and deployment. Members collaborate through regular monthly webinars and bi-annual meetings. The discussions within these meetings occur at a deeper level than is typically achieved in conferences or national meetings. Members feel comradery with each other and share insightful aspects of not only their agency needs but what they have learned to benefit others. Members also collaborate by championing the research projects that make up the work plan of the program each year. The collaboration of members leads to the project ideas. Each project is the result of one or more members stating a need for research that is not fulfilled elsewhere and outlining a concept to be part of the formal voting and approval process as described in the ENTERPRISE Management Plan.

1.1.2 Benefits to Members

The members note that benefits of the program include the collaborative sharing of activities, approaches to technology deployment, lessons learned, and practices with their peers in other transportation agencies within the pooled fund. Additionally, many projects result in actionable outcomes that members use to advance their technology deployment and operations. Some examples of the benefits members have shared that resulted from ENTERPRISE Phase II include:

- Iowa DOT noted that *Project 3: Real-time Integration of Arrow Board Messages into Traveler Information Systems Evaluation* contributed to their implementation of arrow

boards in construction and maintenance projects throughout the state. This project also contributed to their Work Zone Data Exchange (WZDx) approach and success in receiving a demonstration grant from the USDOT as a WZDx pilot site.

- MnDOT used the results from *Project 5: ITS Integration with CAV and MaaS* to share with and inform the Minnesota Governor's Advisory Committee on Connected and Automated Vehicles about the role of mobility as a service (MaaS).
- *Project 10: Potential Approaches for Wrong-Way Driving Applications* was successful at reaching multiple automobile manufacturers and third-party providers of in-vehicle applications, to influence future deployments. This project also led a concept proposed to FHWA for a national data exchange for wrong-way driving reports.
- *Project 13: Traveler Information Collaboration – Phase 1* has led to the American Association of State Highway and Transportation Officials (AASHTO) initial discussion in forming a traveler information community of practice, that will fulfill the intended vision of this project.
- The industry scan developed for *Project 18: Pedestrian Detection Systems for Improved Safety* was utilized to help inform a Michigan DOT research effort that will test various detection-based pedestrian safety systems.

In addition, numerous presentations conveying findings from ENTERPRISE Phase II research projects were made to transportation practitioners from around the country at national and local conferences and stakeholder meetings.

The Appendix contains a summary table with additional examples of implementation for research projects conducted under this ENTERPRISE Phase II Pooled Fund.

1.2 Duration of Research Activity and Members

This report describes the research conducted by the ENTERPRISE Phase II between November 2018 and November 2021.

The participating agencies that contributed financial resources as well as technical input and program leadership to the program during Phase II included the following:

- IDOT;
- Iowa DOT (ENTERPRISE Vice-Chair);
- KDOT;
- MDOT (ENTERPRISE Program Administrator);
- MnDOT (ENTERPRISE Chair);
- MTO
- PennDOT:
- TxDOT; and
- WisDOT.

1.3 Objectives of the Research

The objectives of the research activity were identified by consensus of the participating state and provincial DOTs that contributed funds annually. The following were the overall objectives identified for ENTERPRISE Phase II:

Objective #1: Investigate and promote ITS approaches and technologies that are compatible with other national and international ITS initiatives.

Objective #2: Support the individual ITS program plans of ENTERPRISE participants.

Objective #3: Provide a mechanism to support multi-state and international project cooperation and technical information interchange.

Objective #4: Facilitate the formation of public-private partnerships for appropriate program activities.

Objective #5: Pursue emerging ITS project opportunities in areas of interest to the group.

Objective #6: Provide test beds in a variety of environments and locations for emerging ITS technologies.

Objective #7: Identify common needs within the group and proceed with appropriate technical activities.

Each year, members contribute funds in support of projects of mutual interest and develop an annual work plan that align with one or more of the program objectives. These projects typically involve private sector partners working with designated member agencies. Over time ENTERPRISE has grown into a multi-national consortium dedicated to the advancement of ITS. Its current partners include active ITS states from across the U.S. and Canada and previously included the Netherlands. ENTERPRISE provides a focus for coordinating ITS developments and for sharing results within and outside the program.

This report includes the following sections:

- 2.0 Methodology – Summarizes the research that occurred in ENTERPRISE Phase II.
- 3.0 Findings – Provides an overview of 20 separate research projects funded in ENTERPRISE Phase II.
- 4.0 Conclusions – Provides conclusions about the value and future of the collaboration of ENTERPRISE.
- Appendix – Lists examples of implementation outcomes of ENTERPRISE Phase II research.
- Bibliography

2.0 Methodology

This section describes the three phases that were used to complete the 20 projects under ENTERPRISE Phase II.

2.1 Phases of Activities

ENTERPRISE Phase II conducted three phases of research activities:

- **Primary Phase.** These were the initial projects identified, prioritized, and approved by the ENTERPRISE Phase II Board to be the initial focus of the activities.
- **Secondary Phase.** These projects were partially scoped out by members prior to the Primary Phase and were finalized and approved near the completion of the Primary Phase projects.
- **Tertiary Phase.** These projects were added near the conclusion of the Secondary Phase based on members discussing emerging topics and challenges they are facing.

2.2 Projects Completed in the Primary Phase

A total of five projects were identified by the members to be completed in the Primary Phase to address objectives of the ENTERPRISE Phase II. Table 2 identifies each project title and maps each project to the objectives addressed by each project.

Table 2: Primary Phase projects mapped to ENTERPRISE Phase II objectives

Primary Phase Projects	Objective #1. Investigate and promote ITS	Objective #2. Support members individual ITS program plans	Objective #3. Support cooperation	Objective #4. Facilitate PPPs	Objective #5. Pursue emerging ITS	Objective #6. Provide test beds	Objective #7. Technical activities to address common needs
Project 1: The Evolution of ITS in Asset Management		✓					✓
Project 2: Evolving and Phasing out Legacy ITS Devices and Systems		✓					✓
Project 3: Real-time Integration of Arrow Board Messages into Traveler Information Systems Evaluation	✓	✓	✓	✓	✓	✓	✓
Project 4: Roadmap for Next Generation ICWS	✓	✓	✓	✓		✓	✓

Primary Phase Projects	Objective #1. Investigate and promote ITS	Objective #2. Support members individual ITS program plans	Objective #3. Support cooperation	Objective #4. Facilitate PPPs	Objective #5. Pursue emerging ITS	Objective #6. Provide test beds	Objective #7. Technical activities to address common needs
Project 5: ITS Integration with CAV and MaaS	✓	✓			✓		✓

2.3 Projects Completed in the Secondary Phase

Near the completion of the Primary Phase, the ENTERPRISE Phase II members convened and reviewed earlier concepts for the Secondary Phase projects and ultimately prioritized and selected a total of seven projects to be completed in the Secondary Phase to address objectives of the ENTERPRISE Phase II. Table 3 identifies each project title and maps each project to the objectives addressed by each project.

Table 3: Secondary Phase projects mapped to ENTERPRISE Phase II objectives

Secondary Phase Projects	Objective #1. Investigate and promote ITS	Objective #2. Support members individual ITS program plans	Objective #3. Support cooperation	Objective #4. Facilitate PPPs	Objective #5. Pursue emerging ITS	Objective #6. Provide test beds	Objective #7. Technical activities to address common needs
Project 6: Emerging Practices for Communications Infrastructure	✓	✓		✓		✓	✓
Project 7: Automated Classification of Winter Road Conditions – Phase 2	✓	✓				✓	✓
Project 8: Use Cases and Benefits of ATM Strategies	✓	✓	✓				✓
Project 9: Volumes from Probe Data	✓	✓	✓		✓	✓	✓
Project 10: Potential Approaches for Wrong-Way Driving Applications	✓	✓	✓			✓	✓
Project 11: Procurement Practices for Partnering with Emerging Technology Providers		✓		✓		✓	✓

Secondary Phase Projects	Objective #1. Investigate and promote ITS	Objective #2. Support members individual ITS program plans	Objective #3. Support cooperation	Objective #4. Facilitate PPPs	Objective #5. Pursue emerging ITS	Objective #6. Provide test beds	Objective #7. Technical activities to address common needs
Project 12: Synthesis of Probe Speed Data for Arterial Operations	✓	✓		✓			✓

2.4 Projects Completed in the Tertiary Phase

After nearly completing the Secondary Phase, the ENTERPRISE Phase II members convened and discussed activities and needs in their member organizations and ultimately agreed on eight additional projects be completed in the Tertiary Phase to address objectives of the ENTERPRISE Phase II. Table 4 identifies each project title and maps each project to the objectives addressed by each project.

Table 4: Tertiary Phase projects mapped to ENTERPRISE Phase II objectives

Tertiary Phase Projects	Objective #1. Investigate and promote ITS	Objective #2. Support members individual ITS program plans	Objective #3. Support cooperation	Objective #4. Facilitate PPPs	Objective #5. Pursue emerging ITS	Objective #6. Provide test beds	Objective #7. Technical activities to address common needs
Project 13: Traveler Information Collaboration – Phase 1		✓	✓				✓
Project 14: Establishing a Framework for Communicating DOT Map Updates to Mapping Companies	✓		✓	✓	✓		✓
Project 15: State of Practice for Automated Incident Detection	✓		✓			✓	✓
Project 16: Traffic Operations Responses to the COVID-19 Pandemic	✓	✓	✓				
Project 17: Best Practices in Future Proofing for Emerging Technologies	✓	✓					✓

Tertiary Phase Projects	Objective #1. Investigate and promote ITS	Objective #2. Support members individual ITS program plans	Objective #3. Support cooperation	Objective #4. Facilitate PPPs	Objective #5. Pursue emerging ITS	Objective #6. Provide test beds	Objective #7. Technical activities to address common needs
Project 18: Pedestrian Detection Systems for Improved Safety	✓				✓		✓
Project 19: Patented and Proprietary Products Waiver Impact on ITS Procurements		✓	✓	✓			✓
Project 20: Understanding Infrastructure Operations Impacts Based on AV Demonstrations	✓				✓		✓

2.5 Oversight and Conduct of Research Activities

Prior to authorization of each individual research project, one or more ENTERPRISE members agreed to perform the role of Project Champion for each project. The Project Champion served as the primary liaison to the contractor team performing the research and engaged other members for input throughout each project.

The Program Support contractor (CTC & Associates) provided overall program support, organizing meetings, and supporting communications to and from members. The Program Support contractor also supported the member agencies in creating and refining the project ideas into detailed scopes of work.

The Technical Consultant (Athey Creek Consultants) conducted the research to complete each individual project, working closely with the Project Champion and also providing updates to and seeking input from other members. Prior to conducting the projects, a series of tasks were defined and agreed with the members. These tasks varied by project, sometimes including in-person or virtual workshops, project teams, peer exchanges, interactive webinars, surveys, industry polls, demonstrations, interviews, and/or detailed data analyses. For each project, the Technical Consultant developed a draft report that was appropriate for the project. The draft was circulated to the Project Champion, members, and project team as appropriate for input and reactions before being finalized and posted to the ENTERPRISE website.

The ENTERPRISE members agree that a strength of the program is that multiple states participate together in the research projects. ENTERPRISE members regularly invite others from their

organization to collaborate around a project (or portion of a project). Non-ENTERPRISE members are also contacted, as appropriate, to enhance information gathering for projects. This provides very tangible input to the contractor team performing the research. Examples of collaborative workshops, peer exchanges, interactive webinars, surveys, demonstrations, and interviews that were conducted and the specific projects they relate to are summarized in **Error! Reference s ource not found.**.

Table 5: Interviews, surveys, demonstrations, peer exchanges, workshops, and interactive webinars supporting research efforts

ENTERPRISE Phase II Project	Interviews	Survey	Demonstration	Peer Exchange	Workshop	Interactive Webinar	Brief Summary
Project 1: The Evolution of ITS in Asset Management	✓						• Phone interviews gathered current ITS asset management practices. ○ 8 members (IDOT, Iowa DOT, KDOT, MDOT, MnDOT, MTO, PennDOT, WisDOT)
Project 2: Evolving and Phasing out Legacy ITS Devices and Systems	✓						• Phone interviews or email correspondence produced 60 case studies describing how agencies are evolving and phasing out ITS devices and systems. ○ 7 members (IDOT, Iowa DOT, MDOT, MnDOT, MTO, PennDOT, WisDOT) ○ 7 non-members (Alaska DOT&PF, California DOT, Delaware DOT, Maryland DOT State Highway Administration (SHA), Massachusetts DOT, Missouri DOT, Ohio DOT)
Project 3: Real-time Integration of Arrow Board Messages into Traveler Information Systems Evaluation	✓						• Participation from the following. ○ 2 members (Iowa DOT, MnDOT) ○ 1 university (Iowa State University Center for Transportation Research and Education) ○ 1 non-member (Regional Transportation Commission (RTC) of Southern Nevada) ○ 4 companies (iCone, Street Smart Rentals, Traffic Technologies, Castle Rock) • Input was gathered through interviews with all participants to document deployments at MnDOT, Iowa DOT, and the RTC and then evaluate the ENTERPRISE member agency deployments in MnDOT and Iowa DOT.
Project 4: Roadmap for Next Generation ICWS						✓	• Two interactive webinars were conducted. The first webinar discussed ICWS issues, current practices, and approaches to address issues. The second presented the draft roadmap and prioritized next steps with input from attendees. ○ 5 members (IDOT, Iowa DOT, MDOT, MnDOT, WisDOT)

ENTERPRISE Phase II Project	Interviews	Survey	Demonstration	Peer Exchange	Workshop	Interactive Webinar	Brief Summary
							○ 16 non-members (Delaware DOT, Florida DOT, Georgia DOT, Indiana DOT, Kentucky Transportation Cabinet, Louisiana DOT and Development, Maryland DOT SHA, Minnesota St. Louis County, Mississippi DOT, Missouri DOT, New Hampshire DOT, New Mexico DOT, North Carolina DOT, Ohio DOT, South Dakota DOT, Utah DOT)
Project 5: ITS Integration with CAV and MaaS					✓		• Two workshops were conducted, one with MnDOT and one with MTO to engage broader stakeholder groups within their agencies beyond the ENTERPRISE Board members and include their input on how ITS will integrate with CAVs and mobility services.
Project 6: Emerging Practices for Communications Infrastructure	✓						• Phone interviews documented long-distance data communications practices. ○ 4 members (MDOT, MnDOT, MTO, WisDOT) ○ 5 non-members (California DOT, Florida DOT, Georgia DOT, New Hampshire DOT, North Dakota DOT, Utah DOT) ○ 2 commercial cellular service carriers (AT&T, Verizon)
Project 7: Automated Classification of Winter Road Conditions – Phase 2				✓			• The following project team provided input throughout the project and share agency experiences with data to automate the reporting of winter road conditions. ○ 4 members (Iowa DOT, MDOT, MnDOT, WisDOT)
Project 8: Use Cases and Benefits of ATM Strategies	✓						• Phone interviews documented different experiences with ATM deployments. ○ 1 member (WisDOT) ○ 5 non-members (Central Florida Expressway, Indiana DOT, Nevada DOT, Ohio DOT, South Dakota DOT)

ENTERPRISE Phase II Project	Interviews	Survey	Demonstration	Peer Exchange	Workshop	Interactive Webinar	Brief Summary

Project 9: Volumes from Probe Data	✓					✓	• Three interactive webinars (traffic operations, work zone planning and monitoring, transportation planning) engaged participants to discuss potential use cases for probe volume data.
							  ○ 8 members (Iowa DOT, KDOT, MDOT, MnDOT, MTO, PennDOT, TxDOT, WisDOT)
							• Interviews discussed how their agency could potentially use probe data and enhance the use cases.
							  ○ 3 non-members (Colorado DOT, Maryland DOT SHA, North Carolina DOT)
							• Other project participation included:
							  ○ 2 companies (INRIX, TomTom)
							  ○ 1 coalition (Eastern Transportation Coalition)
							  ○ 1 university (University of Maryland Center for Advanced Transportation Technology Laboratory (CATT Lab))
							  ○ 1 research laboratory (National Renewable Energy Laboratory (NREL))

Project 10: Potential Approaches for Wrong-Way Driving Applications	✓					✓	• A total of two SAE International World Congress (WCX) Digital Summit presentations were shared with the industry. • A total of four industry exchanges (3 meetings and one email exchange) were conducted where the concept was described and there was very positive feedback from the industry representatives, indicating they understood the vision of the concept and would explore creation of products within their organization.
Project 11: Procurement Practices for Partnering with Emerging Technology Providers	✓			✓			• ENTERPRISE members identified prominent challenges they were facing in efforts to partner with emerging technology providers. • 8 case studies produced from correspondence with several agencies. ○ 2 members (MnDOT, PennDOT)

ENTERPRISE Phase II Project	Interviews	Survey	Demonstration	Peer Exchange	Workshop	Interactive Webinar	Brief Summary
							○ 3 non-members (FDOT, New York City DOT, Automated Bus Consortium)
Project 12: Synthesis of Probe Speed Data for Arterial Operations	✓						• Interviews conducted to document arterial probe speed data use. ○ 2 members (PennDOT, WisDOT) ○ 6 non-members (Georgia DOT, Indiana DOT, New Jersey DOT, North Carolina DOT, Ohio DOT, RTC of Southern Nevada) ○ 3 third-party probe data providers (HERE Technologies, INRIX, TomTom)
Project 13: Traveler Information Collaboration – Phase 1						✓	• A webinar was conducted with the AASHTO Committee on Transportation System Operations (CTSO) where there was positive reactions to the initiative and willingness to advance traveler information collaboration through a new AASHTO Community of Practice titled "Traveler Information".
Project 14: Establishing a Framework for Communicating DOT Map Updates to Mapping Companies	✓	✓				✓	• Interviews to document the process third-party mapping providers use to incorporate DOT map changes. ○ 3 companies (HERE Technologies, TomTom, Waze) • Survey distributed to MTO and all 50 states and DOT mapping/traveler information contacts. • Interactive webinar conducted with survey participants to gather input on draft guidance. ○ 4 members (Iowa DOT, KDOT, MTO, TxDOT) ○ 19 non-members (Alabama DOT, Alaska DOT&PF, Georgia DOT, Idaho Transportation Department, Maryland DOT SHA, Missouri DOT, Nevada DOT, New Hampshire DOT, North Carolina DOT, North Dakota DOT, Ohio DOT, Oklahoma DOT, Oregon DOT, Rhode Island DOT, South Carolina DOT, Tennessee DOT, Utah DOT, Washington State DOT, West Virginia DOT)

ENTERPRISE Phase II Project	Interviews	Survey	Demonstration	Peer Exchange	Workshop	Interactive Webinar	Brief Summary
Project 15: State of Practice for Automated Incident Detection			✓	✓		✓	• Interactive webinar with ENTERPRISE agency TMC operators and managers, to develop common user needs for automated incident detection systems. • Webinar demonstrations to ENTERPRISE Phase II members and operations staff of automated incident detection products and capabilities. ○ 1 member (PennDOT) ○ 1 non-member (Colorado DOT) ○ 7 companies (FLIR, Bosch, Citilog, OptaSense, Navtech Radar, Waycare, TrafficVision) • Peer exchange webinar for states to share experiences with automated incident detection products. ○ 4 members (Iowa DOT, MnDOT, MTO, KDOT) ○ 3 non-members (Georgia DOT, Maryland DOT SHA, Virginia DOT)
Project 16: Traffic Operations Responses to the COVID-19 Pandemic	✓			✓			• Interviews conducted with ENTERPRISE members to document COVID-19 operational responses. ○ 8 members (Iowa DOT, Kansas DOT, MnDOT, MTO, WisDOT, MDOT, PennDOT, TxDOT) • Peer exchange webinar to highlight 3 TMC operational experiences (PennDOT Virtual TMC, MDOT Hybrid TMC, and MnDOT remaining physically in the building), and MnDOT winter maintenance planning during COVID-19. The webinar also provided discussion on overall COVID-19 experiences through a round robin format.
Project 17: Best Practices in Future Proofing for Emerging Technologies						✓	• Two webinar workshops were conducted to allow ENTEPRISE Phase II members to brainstorm and share collective input to the business model and concept for integrating the future proofing of ITS assets into the DOT business model.

ENTERPRISE Phase II Project	Interviews	Survey	Demonstration	Peer Exchange	Workshop	Interactive Webinar	Brief Summary
Project 18: Pedestrian Detection Systems for Improved Safety	✓						• Interviews documented different pedestrian detection systems and related research efforts. ○ 3 members (TxDOT, MDOT, MnDOT) ○ 1 non-member (City of Bellevue, WA) ○ 1 university research center (Texas A&M Transportation Institute)
Project 19: Patented and Proprietary Products Waiver Impact on ITS Procurements	✓						• Interviews and a project questionnaire were used to document how agencies have modified their practices per an FHWA rulemaking that waived the requirement for State DOTs to obtain prior approval from FHWA for use of patented or proprietary products in Federal-aid projects. ○ 3 members (MnDOT, MDOT, PennDOT) ○ 2 non-members (Montana DOT, Washington State DOT)
Project 20: Understanding Infrastructure Operations Impacts Based on AV Demonstrations	✓						• Phone interviews to document infrastructure impacts resulting from AV shuttle deployments. ○ 2 members (MDOT, MnDOT) ○ 10 non-members (City of Arlington, Texas; City of Frisco, Texas; City of Ottawa, Ontario, Canada; Delaware Transit Corporation; Maryland DOT; Maryland Transportation Authority; Metropolitan Transit Authority of Harris County; North Central Texas Council of Governments; Ohio DOT; and Virginia DOT) ○ 1 university (University of Alberta) ○ 1 company (Southland)

3.0 Findings

This chapter presents a summary of the findings of the research activities performed in ENTERPRISE Phase II. Each of the 20 research activities are summarized below to provide readers with a high-level summary of the findings and links to additional details in the individual final project reports.

3.1 Project 1: The Evolution of ITS in Transportation Asset Management

ITS provides cost-effective solutions for agencies to achieve their mobility objectives. Both agencies and travelers are dependent upon the availability and reliability of advanced technologies. As a result, the use of technology is increasing and agencies' investments in ITS assets are increasing along with the effort required to plan, procure, manage, and operate them.

The final report for this project summarizes the current state of ITS asset management, both in the ENTERPRISE member agencies and across North America, and describes the attributes and criteria being used to effectively support ITS asset management. State and local DOTs can implement this research by considering the attributes identified in this research for inclusion into their own asset management plans.

The final report is available on the ENTERPRISE The Evolution of ITS in Transportation Asset Management project web page.

3.2 Project 2: Evolving and Phasing Out Legacy ITS Devices and Systems

Transportation agencies across the country have deployed numerous ITS devices and systems, some of which have been in place for more than 25 years. As technology changes, it is important to evaluate these "legacy" devices and systems to determine if needs have changed; whether these devices and systems should be replaced, reused, or evolved in other ways; or whether it is beneficial to continue their operation. This project documented nearly 60 case studies, including decision factors, criteria, approaches, and tools agencies use to help guide decision-making when evolving and phasing out ITS devices and systems. Based on the case studies, a set of criteria and applicable tools was developed for ten common ITS devices and systems. In addition, multiple overarching tools used by agencies to guide decisions for managing ITS devices and systems were documented. State and local DOTs can implement this research by using the criteria defined in the report and tools identified to assist with identifying and navigating through multiple considerations while assessing ITS devices and systems to determine potential evolutions or eliminations.

The final report is available on the ENTERPRISE Evolving and Phasing Out Legacy ITS Devices and Systems project web page.

3.3 Project 3: Real-time Integration of Arrow Board Messages into Traveler Information Systems Evaluation

The ENTERPRISE Pooled Fund Study has completed two previous efforts supporting transportation agencies integrating arrow board status information from the field into traveler information systems to alert traffic management center (TMC) operators and travelers in real-time, for example, of a lane closure. Per direction from the ENTERPRISE Board, Phase 1 and Phase 2 were completed in 2017 in order to properly assess needs and potential solutions before deployment and evaluation of a real-time arrow board system at one or more ENTERPRISE agency sites.

In 2018, MnDOT conducted a one-year pilot project through a contract with a vendor (Street Smart) that installed a monitoring device on 20 arrow boards that provided arrow board status information (e.g., right arrow on, left arrow on) to the vendor's server. The arrow board status information from the server was then integrated with MnDOT's Advanced Traffic Management System (ATMS) and then their Road Condition Reporting System (RCRS). In 2019, the Iowa DOT had access to five equipped arrow boards with reporting capabilities (Street Smart, iCone, Ver-Mac) to provide real-time arrow board status information to the vendor's server. This project evaluated the deployments of the arrow board concept in these two ENTERPRISE member states (Minnesota and Iowa). In addition, an overview of the RTC of Southern Nevada real-time arrow board reporting system deployment is included as another perspective. Overall, the data analysis for MnDOT and the information gathered from interviews from MnDOT and Iowa DOT indicate a benefit to the traveling public and TMC operators with additional information on the overall network with the location of lane closures provided by arrow board reporting systems. State and local DOTs can implement this research by considering similar deployments of real-time arrow board functionality in future construction and maintenance activities.

The final report is available on the ENTERPRISE Real-time Integration of Arrow Board Messages into Traveler Information Systems Evaluation project web page.

3.4 Project 4: Roadmap for Next Generation Intersection Conflict Warning Systems (ICWS)

ICWS are used to warn drivers on the mainline road of the presence of traffic at stop-controlled intersections and/or warn drivers at stop-controlled approaches of the presence of traffic on mainline roads. ICWS deployments are still relatively new with few deployments prior to 2010, however the number of deployments has increased in the past several years nationwide. The ENTERPRISE Pooled Fund Study has completed several ICWS related projects from 2011 – 2015 including design and guidance for ICWS, system engineering documents for ICWS, and overall coordination and outreach with national standards groups, industry associations, and other

pooled fund programs. Building off these previous efforts, ENTERPRISE conducted this project to identify and document issues related to the development and deployment of next-generation approaches to ICWS. This information was utilized to develop a roadmap of prioritized next steps to help guide future ICWS deployment efforts. State and local DOTs can implement this research by using the roadmap as a resource if they plan future deployments of ICWS systems.

The final report is available on the ENTERPRISE Roadmap for Next Generation Intersection Conflict Warning Systems (ICWS) project web page.

3.5 Project 5: ITS Integration with CAV and MaaS

The approach used for this project began with secondary research to identify what kind of outcomes are anticipated from CAVs and MaaS. This was intended to provide some baseline information and context for each topic, independent of ITS and traffic operations. That information was then summarized and used in two workshops with ENTERPRISE members from MnDOT and MTO. Staff from traffic operations, ITS and planning participated in the workshops to share their thoughts of how CAV and MaaS may impact their work. Information from those workshops was then combined and used in a third workshop with the ENTERPRISE Board members to further discuss potential impacts and agency actions in the near and long-term. The final report presents research highlights on anticipated outcomes from CAV and MaaS; a summary of potential impacts on ITS/traffic operations; and suggested agency actions to stay engaged as CAV and MaaS continue to evolve. State and local DOTs can implement this research by sharing the anticipated outcomes and potential impacts identified in the report with their planning and traffic operations staff for their consideration when forecasting future activities.

The final report is available on the ENTERPRISE ITS Infrastructure Integration with CAV and MaaS project web page.

3.6 Project 6: Emerging Practices for Communications Infrastructure

Transportation agencies that operate ITS field devices and systems continually adapt their communications infrastructure to meet emerging needs, improve efficiency, increase coverage, and improve operations. As agencies begin to implement CAV systems, they are seeking backbone communications options that can serve multiple purposes. This research utilized a "customer-centric" (agency-focused) approach to document emerging practices for ITS communications infrastructure. This report explores agencies' long-distance data communications needs and options for related infrastructure, with focus on emerging technologies, including: considerations for selecting communications infrastructure; costs, benefits, and performance; options for ownership, leasing, and security; and developments in edge computing and cloud computing. The report also documents long-term management

practices for long-distance data communications infrastructure assets including broadband access to agency owned right-of-way and sharing options; fiber tracking; managing leases and licenses; physical security of ITS devices and communications infrastructure; and cybersecurity practices. State and local DOTs can implement this research by considering the options for communications presented in the report (and needs driving each option) to identify candidate communications solutions for ITS deployments.

The final report is available on the ENTERPRISE Emerging Practices for Communications Infrastructure project web page.

3.7 Project 7: Automated Classification of Winter Road Conditions – Phase 2

The process of gathering information about road conditions during a winter storm typically involves plow operators, enforcement or other traffic operations staff reporting on conditions that they observe while on the road. ENTERPRISE sponsored this effort to research what transportation agencies are doing to leverage technology and automate or assist with winter road condition reporting. Phase 1 of the effort focused on gathering information about how agencies were approaching automated and assisted classification of road conditions. Efforts in ENTERPRISE Phase II concluded the initial activities by exploring specific attributes of data that can be used to automate road condition reporting with the intent of increasing agencies' understanding and evaluation of this data. This was achieved by establishing a list of available data sources, providing an overview of the types of data available from each source, describing common characteristics for various types of data, and gathering information about agency experiences with data to automate the reporting of winter road conditions. State and local DOTs can implement this research when their traveler information and/or roadway maintenance groups consider automated classifications of winter road conditions. The research findings should assist agencies in understanding the potential approaches and early examples of use.

The final report is available on the ENTERPRISE Automated Classification of Winter Road Conditions – Phase 2 project web page.

3.8 Project 8: Use Cases and Benefits of Active Traffic Management (ATM) Strategies

ATM encompasses a suite of strategies that give agencies the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing and predicted traffic conditions. ATM approaches focus on influencing travel behavior with respect to lane/facility choices and operations. ATM deployments are still relatively new in the United States with few deployments prior to 2010, however the number of deployments has increased in the past decade nationwide. ENTERPRISE conducted this project to identify resources and document lessons learned related

to the development and deployment of ATM strategies, with an emphasis on deployments in urban areas that include multiple applications (e.g., Variable Speed Limits (VSLs), dynamic queue warning, part-time shoulder running). State and local DOTs can implement this research by considering the various materials and summaries prepared whenever they evaluate or consider active traffic management deployments. The material will provide deeper content than is typically available through conference presentations or vendor outreach material.

The final report is available on the ENTERPRISE Use Cases and Benefits of Active Traffic Management (ATM) Strategies project web page.

3.9 Project 9: Volumes from Probe Data

ENTERPRISE members' use of third-party probe-based traffic data is becoming increasingly widespread. Meanwhile, third-party probe data is emerging as a source for traffic volumes. To help ENTERPRISE agencies prepare for probe volume data being more widely available, this project documented 22 potential agency use cases for probe volume data and four business cases outlining benefits and implementation considerations. Traffic operations uses include real-time traffic management (e.g., events, evacuation routes, road closures), operational systems and automated functions (e.g., dynamic shoulder operations, incident detection), and performance management. Work zone use cases range from real-time monitoring to post-analysis and planning future work zones. Transportation planning uses include calibrating and validating travel demand models, estimating traffic impacts to plan for similar future events, and congestion performance reporting. Benefits cited for use of probe volume data include significantly increased coverage of traffic volumes, less field detection devices, reduced or eliminated need for temporary short-duration volume counts, improved data insights, better situational awareness, more proactive congestion management, increased deployment of traffic management systems, improved accuracy of travel demand models, and more immediate access to traffic volumes for post-event analysis. State and local DOTs can implement this research by considering the uses and benefits described to plan for and implement probe volume data across several agency functions and user groups.

The final report is available on the ENTERPRISE Volumes from Probe Data project web page.

3.10 Project 10: Potential Approaches for Wrong-Way Driving Applications

Wrong-way driving is a growing concern on roadways, especially because resulting crashes tend to be severe and often result in fatalities and serious injuries. Transportation agencies are deploying on-road countermeasures at select locations; however, these can only go so far to reduce wrong-way crashes. In-vehicle navigation systems and mobile applications hold significant potential to reduce wrong-way crashes. These interventions could reach many more drivers than

on-road countermeasures alone, by always providing alerts at all locations while the application is being used. The ENTERPRISE Pooled Fund conducted outreach to automobile manufacturers and mobile app developers to explore the potential for in-vehicle navigation systems and mobile apps to provide wrong-way driving alerts. As a result of these outreach efforts, positive feedback was received that the private sector agencies will consider these in their future deployments. The outreach activities successfully completed are summarized as follows:

- A project overview document was prepared and posted to the Potential Approaches for Wrong-Way Driving Applications project web page. This document was also used during outreach activities.
- SAE International World Congress (WCX) Digital Summit 2020. Original plans were to conduct an in-person presentation at the SAE WCX in Detroit, Michigan, however the WCX was conducted virtually. This allowed the recording of a presentation video by the Project Champion (Will Sorenson, Iowa DOT). The video was viewed by multiple attendees of the digital summit and comments were received.
- SAE International WCX Digital Summit 2021. The wrong-way driving concept was presented with updated information during the 2021 WCX Digital Summit. Once again, the original intent was an in-person presentation, but as the summit transitioned to all digital, it was conducted remotely by recording the presentation.
- Cooperative Automated Transportation (CAT) Coalition Infrastructure Owner Operator/Original Equipment Manufacturer (IOO/OEM) Forum Connected Automation Working Group Meeting. The IOO/OEM working group includes approximately seven automobile manufacturers and the project champion presented to them, with feedback offered on the webinar.
- A total of three industry meetings were conducted (two with transportation application providers operating in-vehicle applications, and one with an automobile manufacturer). In each industry meeting, the concept was described and there was very positive feedback from the industry representatives, indicating they understood the vision of the concept and would explore creation of products within their organization.
- An email exchange was conducted (with no formal meeting) with an additional automobile manufacturer, with positive reactions to the concept paper shared and overall concept.
- An email exchange was conducted with a tier-1 supplier of automobile equipment and systems to automobile manufacturers, with positive reactions to the concept paper and concept.

In addition to the outreach activities to encourage private companies to consider developing wrong-way driving applications, a concept was proposed for a national data exchange framework for wrong-way driving reports. If developed, this national communication standard for wrong-way driving would enable data from 911 call sources to become available through a data feed for

in-vehicle applications to access the data and provide alerts to errant drivers and oncoming traffic. A concept overview describing a proposed national wrong-way driving data exchange framework was prepared for distribution to FHWA.

State and local DOTs may benefit from this research if one or more private automobile manufacturers or navigation system providers implements wrong-way driving applications. Other implementations of this research may occur if a national data exchange for wrong-way driving is initiated, allowing state and local DOTs to upload and consume data on wrong-way driving vehicles.

Because the outreach activities were the desired outcome of this project, there was no additional final report prepared.

3.11 Project 11: Procurement Practices for Partnering with Emerging Technology Providers

This ENTERPRISE project researched recent applications of new procurement practices, or traditional procurement practices applied in new ways, to partner with emerging technology providers. Research identified information that may be useful to project managers as they carry out individual projects, to program managers exploring ways to proactively engage industry, and to contracting and procurement staff wanting information about new and innovative practices. The case studies and resources highlighted in this project were selected for how they addressed recent procurement challenges identified by ENTERPRISE members. The resources provide guidance on process, specialized information for specific technologies, and examples of procurement training. They represent a cross-section of general procurement and technology-specific procurement to help articulate agency needs, identify prospective partners, determine contracting processes, and guide projects through procurement when partnering with emerging technology providers. Case studies are presented in terms of the challenges that they address, and key procurement practices are also highlighted. They include a variety of innovative contracting approaches and project specific applications of different procurement processes. State and local DOTs can implement this research by sharing the project outcomes with project managers and procurement staff for their consideration in future procurements of ITS solutions.

The final report is available on the ENTERPRISE Procurement Practices for Partnering with Emerging Technology Providers project web page.

3.12 Project 12: Synthesis of Probe Speed Data for Arterial Operations

Several third-party data providers offer traffic data for a variety of transportation purposes. Many agencies use third-party probe data for freeway operations and some agencies also use this data on arterials to assist in overall operations. For this effort, ENTERPRISE members were interested

in understanding the uses and suitability of probe speed data on arterials to support deploying or expanding operational uses. The purpose of this research was to assist ENTERPRISE members in understanding the overall status and key uses of arterial probe speed data for operations (real-time or post analyses) from a select number of agencies. This project focused on vehicle probe speed data without the need for deploying and maintaining equipment in the right-of-way. It excluded probe speed data that requires additional roadside infrastructure (e.g., Bluetooth, nonintrusive detectors). State and local DOTs interested in solutions for arterial traffic speeds can implement this research by considering the key uses of current state of the practice arterial probe data and considering this when scoping projects and/or procuring data.

The final report is available on the ENTERPRISE Synthesis of Probe Speed Data for Arterial Operations project web page.

3.13 Project 13: Traveler Information Collaboration – Phase 1

Traveler information has long been a management and operations strategy for transportation agencies. Used to inform travelers of events that may impact their trips, traveler information services have evolved considerably since the national designation of 511 in 2000. ENTERPRISE initiated this project to review the current state of traveler information practice for reporting road weather events and to explore the possibility of creating a community of practice and providing guidance on future practices. This project polled the traveler information coordinators in all the states to help understand their need for collaboration in traveler information. Based on the survey, a concept was developed for a Traveler Information Community of Practice. After sharing the concept paper with national agencies, AASHTO has agreed to initiate and run a Traveler Information Community of Practice within the Committee on Transportation System Operations (CTSO), accomplishing the primary intent of this project. ENTERPRISE members can implement this research by participating in the AASHTO Traveler Information Community of Practice without need for ongoing ENTERPRISE activities.

The final report is available on the ENTERPRISE Traveler Information Collaboration – Phase 1 project web page.

3.14 Project 14: Establishing a Framework for Communicating DOT Map Updates to Mapping Companies

Many transportation agencies would like to provide map updates (e.g., road change alignment, road closure, detour route) to mapping/navigation companies (e.g., Waze, Google, Apple, TomTom, HERE Technologies), however the process for communicating this information is not consistent between the companies and often unknown to DOTs. This ENTERPRISE project worked with State DOTs and with private third-party information providers that use mapping products

to disseminate information or provide route guidance. This collaboration and research led to the development of a consistent communication approach for providing transportation agency map updates to mapping companies that utilize DOT generated data for various applications such as route guidance. Transportation agencies can implement this research by using the framework developed in this report to communicate future map updates to help improve the accuracy of information disseminated through traveler information mechanisms such as mobile applications.

The final report is available on the ENTERPRISE Establishing a Framework for Communicating DOT Map Updates to Mapping Companies project web page.

3.15 Project 15: State of Practice for Automated Traffic Incident Detection

TMC operators need to be alerted of incidents in a timely manner, to initiate responses and manage traffic implications. Commercially available products can provide automated incident detection functionality with alerts to operators, to improve overall awareness and response. The objective of this project was to understand the current state-of-practice for commercially available traffic incident detection systems and define common user needs for agency use of these systems. As a first step, common user needs for automated incident detection from the perspective of TMC operators were developed. The common user needs were used to provide guidance for vendor and agency demonstrations of automated incident detection products. Seven vendors of automated incident detection systems agreed to participate in this research, sharing demonstrations of their systems via webinar and allowing the research to document current systems. In additional two State DOTs shared their in-house traffic incident detection software. State and local DOTs can implement this research by utilizing the common TMC operator user needs to develop system requirements and consider the functionality defined in the report to assist in procuring incident detection systems.

The final report is available on the ENTERPRISE State of Practice for Automated Traffic Incident Detection project web page.

3.16 Project 16: Traffic Operations Responses to the COVID-19 Pandemic

ENTERPRISE member states have had to adjust operational responses due to the COVID-19 Pandemic. The objective of this project was to document and share ENTERPRISE member agencies' traffic operations responses gathered through phone interviews and a peer exchange webinar. State and local DOTs can implement this research by reading the responses shared by each agency in the report, and considering any of these responses, if appropriate, to be implemented in their agency.

The final report is available on the ENTERPRISE Traffic Operations Responses to the COVID-19 Pandemic project web page.

3.17 Project 17: Best Practice in Future Proofing for Emerging Technologies

Transportation agencies continue to deploy and operate emerging technologies and ITS assets in both urban and rural areas. These assets serve key roles in operations of the transportation system. Maintaining the ability of these ITS assets to continue to be of value in the future is referred to as "future proofing the asset." The focus of this project was on researching best practices and overall approaches towards future proofing ITS assets. As part of this research, seven categories of threats have been identified that present possible risks to the future of ITS assets, including: natural, human interactions, functional performance, extended use, financial, license/policy/regulatory, and security threats. The research also identified multiple approaches for mitigating the future proofing risks to ITS assets. A business model suggesting roles for seven existing DOT activities was drafted, and finally an overall three-step approach to mitigating risks to ITS assets was developed. Lastly, the project recommends future research activities to further assist agencies with streamlining activities for future proofing ITS assets. State and local DOTs can implement this research by reviewing the recommended actions and considering which are appropriate for their organization to mitigate risks to the future use of ITS assets.

The final report is available on the ENTERPRISE Best Practice in Future Proofing for Emerging Technologies project web page.

3.18 Project 18: Pedestrian Detection Systems for Improved Safety

A significant increase in traffic-related pedestrian fatalities has been experienced in the U.S. over the past decade. The objective of this research was to increase ENTERPRISE members' understanding of pedestrian safety issues as well as detection-based systems that could improve pedestrian safety. The project conducted a literature search to summarize pedestrian safety issues and trends, providing overall context for the growing problem of increasing pedestrian fatalities. An industry scan was completed to identify detection-based systems that aim to improve pedestrian safety. Based on findings from the literature search and industry scan, potential additional research (e.g., testing technical feasibility of detection/alert systems, technology evaluation) was identified for consideration by ENTERPRISE. State and local DOTs can implement this research by considering pedestrian safety approaches identified and/or by identifying additional research to demonstrate and evaluate one or more approaches.

The final report is available on the ENTERPRISE Pedestrian Detection Systems for Improved Safety project web page.

3.19 Project 19: Patented and Proprietary Products Waiver Impact on ITS Procurements

This research explored the impacts of FHWA Final Rule Construction and Maintenance-Promoting Innovation in Use of Patented and Proprietary Products, in which the requirements in 23 CFR 635.411(a)-(e) were rescinded to encourage innovation in the development of highway transportation technology and methods. Per the rulemaking, State DOTs are no longer required to provide certifications, make public interest findings (PIFs), or develop research or experimental work plans to use patented or proprietary products in federal-aid projects. This project investigated how this waiver is being implemented in practice, through outreach to FHWA and State DOT staff. State and local DOTs can implement this research by reviewing the examples of how the waiver is being implemented and considering them for local use.

The final report is available on the ENTERPRISE Patented and Proprietary Products Waiver Impact on ITS Procurements project web page.

3.20 Project 20: Understanding Infrastructure Operations Impacts Based on AV Demonstrations

This project focused on agencies that have conducted low-speed automated vehicle (AV) shuttle demonstrations, with the intent to understand whether infrastructure changes identified in the demonstrations and the roles of agency and private-sector stakeholders are representative of needs and roles in future, long-term AV deployments. Information was collected through a literature review and interviews with 12 deploying agencies in the United States and Canada. Identified impacts to agency infrastructure and staff vary greatly depending on the use case and AV shuttle provider. The types of infrastructure changes for AV shuttle deployments include pavement markings, signage, roadside units, traffic signal timing adjustments, charging stations, secured parking areas, and vegetation management, as well as modifications to construction schedules. This project report captures insights from agencies that have conducted automated vehicle shuttle demonstrations and identifies likely impacts of AVs on infrastructure operations. The nature of these impacts is discussed, as well as the reasons these impacts may be greater for some agencies than others. State and local DOTs can implement this research by considering the project findings as they prepare for physical infrastructure and operations changes in their Connected and Automated Vehicle (CAV) planning activities.

The final report is available on the ENTERPRISE Understanding Infrastructure Operations Impacts Based on AV Demos project web page.

4.0 Conclusions

The ENTERPRISE Phase II research activities are the latest projects completed in a 30-year history of State and provincial DOTs collaborating for research related to common needs. While the members at any given year have fluctuated over the 30 years, and while the specific topics being researched have evolved in the same way that industry needs have evolved, the concept of collaboration together around common needs has remained in-tact. This chapter summarizes the conclusions of the research activities in five areas:

- The need for collaborative research;
- Topic areas of collaborative research;
- ENTERPRISE research process;
- Research completion time; and
- Addressing ENTERPRISE Pooled Fund Study objectives.

4.1 Conclusions from the Study

Need for Collaborative Research. The 20 projects completed during ENTERPRISE Phase II activities demonstrate there is still a need for collaboration among and between states and provincial DOTs to further advance transportation technologies. The majority of projects were applied research and the second most common category was exploratory research, suggesting that these are the areas that member agencies have identified as offering the most benefit from multi-agency collaboration.

Topic Areas of Collaborative Research. The topic areas of ENTERPRISE research have evolved since earlier years when the emphasis was more on demonstrations and evaluations of technologies. ENTERPRISE Phase II topics focus more on DOT operations and the use of technologies to support operations. The activities in ENTERPRISE Phase II also have expanded to include transit, mobility services, vulnerable road users (e.g., pedestrians) and collaboration with private vendors and automobile manufacturers, reflecting the changing industry.

ENTERPRISE Research Process. The process of members recommending, prioritizing, and selecting research activities functioned well during this process. Similarly, the process of one or more ENTERPRISE Phase II members serving as champion for each activity was effective. Monthly webinars led by the Program Support contractor, with technical updates and the option for all members to offer input to projects also was effective. Finally, the use of workshops (in-person or webinar) and project teams were effective at allowing collaboration around a specific project, and including additional individuals from each member agency, as well as outside vendors or technical subject matter experts when appropriate.

Research Completion Time. Feedback and input from members during the projects suggests that there is still very much a need for quick turnaround with research activities, especially regarding technologies. The ENTERPRISE business model of members collectively determining projects and support contractors being contracted to initiate activities as soon as possible provided a mechanism for 20 proposed topics to quickly be defined and completed, with each project typically completed within one year or less from project initiation, and all 20 projects completed within the overall duration of the Phase II effort.

The ENTERPRISE Business Model is effective in:

- Allowing collaboration and cooperative research
- Completing research in a timely manner
- Addressing topics of interest to member agencies

Addressing ENTERPRISE Pooled Fund Study Objectives. Based on the outcomes of this research, the ENTERPRISE process of collaboration around common needs under the umbrella of addressing the common research objectives has proven to be effective at delivering timely research results. This collaboration is expected to continue as long as a group of states recognizes benefits from it. The ENTERPRISE Phase II Pooled Fund Study Objectives, listed below for reference, have been met consistently through the activities and findings of the 20 completed research projects.

ENTERPRISE Pooled Fund Study Objectives:

- Objective #1: Investigate and promote ITS approaches and technologies that are compatible with other national and international ITS initiatives.
- Objective #2: Support the individual ITS program plans of ENTERPRISE participants.
- Objective #3: Provide a mechanism to support multi-state and international project cooperation and technical information interchange.
- Objective #4: Facilitate the formation of public-private partnerships for appropriate program activities.
- Objective #5: Pursue emerging ITS project opportunities in areas of interest to the group.
- Objective #6: Provide test beds in a variety of environments and locations for emerging ITS technologies.
- Objective #7: Identify common needs within the group and proceed with appropriate technical activities.

Table 6 maps the seven ENTERPRISE Phase II objectives to the 20 completed projects.

Table 6: **ENTERPRISE Phase II projects mapped to ENTERPRISE Phase II objectives**

ENTERPRISE Project	Objective #1. Investigate and promote ITS	Objective #2. Support members individual ITS program plans	Objective #3. Support cooperation	Objective #4. Facilitate PPPs	Objective #5. Pursue emerging ITS	Objective #6. Provide test beds	Objective #7. Technical activities to address common needs
Project 1: The Evolution of ITS in Asset Management		✓					✓
Project 2 Evolving and Phasing out Legacy ITS Devices and Systems		✓					✓
Project 3: Real-time Integration of Arrow Board Messages into Traveler Information Systems Evaluation	✓	✓	✓	✓	✓	✓	✓
Project 4: Roadmap for Next Generation ICWS	✓	✓	✓	✓		✓	✓
Project 5: ITS Integration with CAV and MaaS	✓	✓			✓		✓
Project 6: Emerging Practices for Communications Infrastructure	✓	✓		✓		✓	✓
Project 7: Automated Classification of Winter Road Conditions – Phase 2	✓	✓				✓	✓
Project 8: Use Cases and Benefits of ATM Strategies	✓	✓	✓				✓
Project 9: Volumes from Probe Data	✓	✓	✓		✓	✓	✓
Project 10: Potential Approaches for Wrong-Way Driving Applications	✓	✓	✓			✓	✓
Project 11: Procurement Practices for Partnering with Emerging Technology Providers		✓		✓		✓	✓
Project 12: Synthesis of Probe Speed Data for Arterial Operations	✓	✓		✓			✓
Project 13: Traveler Information Collaboration – Phase 1		✓	✓				✓
Project 14: Establishing a Framework for Communicating DOT Map Updates to Mapping Companies	✓		✓	✓	✓		✓
Project 15: State of Practice for Automated Incident Detection	✓		✓	✓		✓	✓
Project 16: Traffic Operations Responses to the COVID-19 Pandemic	✓	✓	✓				
Project 17: Best Practices in Future Proofing for Emerging Technologies	✓	✓					✓
Project 18: Pedestrian Detection Systems for Improved Safety	✓				✓		✓
Project 19: Patented and Proprietary Products Waiver Impact on ITS Procurements		✓	✓	✓			✓
Project 20: Understanding Infrastructure Operations Impacts Based on AV Demonstrations	✓				✓		✓

4.2 Recommendations for Further Research

Throughout the course of the ENTERPRISE Phase II research effort, several project-specific research ideas were documented at the conclusion of some research projects. In addition, multiple high-priority topic areas emerged and can be considered for future research.

4.2.1 Research Ideas Identified During Project Activities

Table 7 shows potential future research efforts identified during project activities, based on research findings and as discussed with project champions and ENTERPRISE Board members.

Table 7: **Potential future research identified during projects**

Project Title	Potential Future Research
Project 4: Roadmap for Next Generation Intersection Conflict Warning Systems (ICWS)	- Conduct peer exchange activities (e.g., surveys and/or agency sharing) for topics such as liability mitigation, programming ICWS controllers, deployment costs, remote monitoring, maintenance, and public response regarding usefulness and signage content. - Document best practices for power options, detection technology platforms, detection methods/conditions, programming ICWS controllers, remote monitoring, and maintenance. - Evaluate ICWS deployments to assess safety effectiveness (e.g., mainline and minor road warnings, gap acceptance, site distance, crash rates); cost/benefit analysis; data collection parameters; effectiveness of sign messaging; actuation durations; and sign placement. - Conduct driver behavior research to identify at-risk intersection characteristics, identify frequently used ICWS solutions based on at-risk intersection characteristics, and determine appropriate signage, messages, warning indications (e.g., flashing beacons). - Develop/update guidance for use of ICWS based on volume thresholds, driver profile, and at-risk intersection characteristics. NOTE: See the final report for additional descriptions and a prioritized road map of recommended future research.
Project 10: Potential Approaches for Wrong-Way Driving Applications	Conduct a Phase 2 research project: - Expand industry outreach to spur interest in developing wrong-way driving alerts in their products (e.g., in-vehicle systems, mobile apps) - Conduct discussions with FHWA, industry, and transportation agencies to explore the potential for a National Wrong-Way Driving Data Feed.
Project 14: Establishing a Framework for Communicating	- Define and standardize a process (e.g., a standard data format or feed) on a national scale that states could use to share map updates for access by mapping/navigation companies. NOTE: At the conclusion of this project, ENTERPRISE became aware that the Eastern Transportation Coalition is identifying standard information

Project Title	Potential Future Research
DOT Map Updates to Mapping Companies	fields for states to provide to mapping companies. This common data format would be beneficial for real time changes.
Project 17: Best Practices in Future Proofing for Emerging Technologies	- Research and document specific examples of recommended actions from this project. - Research the potential to transition findings from this project into mainstream operational procedures. - Research the logic of an automated software tool to support risk mitigation. - Develop a software package to automate the logic of risk mitigation. NOTE: See the final report for additional descriptions of the above ideas for potential future research.
Project 18: Pedestrian Detection Systems for Improved Safety	- Continue to document research and evaluation findings for pedestrian safety technologies through literature search, surveys, and/or interviews with agencies. - Develop user needs for a specific use case and coordinate demonstrations of pedestrian safety technology capabilities. - Deploy commercially available pedestrian safety technologies, with proof-of-concept evaluation. - Conduct research to correlate crash or conflict causes with appropriate safety technologies. - Conduct research on distraction with use of mobile apps and effective signage for pedestrians and bicyclists. - Develop a centrally located collaborative platform to share and access safety data at specific locations, to help inform safety improvements at locations with similar attributes. - Conduct pilot testing of camera systems that integrate lidar, for data collection and analytics. NOTE: See the final report for additional descriptions of the above ideas for potential future research.

4.2.2 Project Synergies and Potential Research Topics

In addition to the targeted research ideas identified through project activities, several synergies among research projects were also noted, signifying topics that may be focus areas for new research in the future. These topics could also be indicative of interest within the broader community of ITS practitioners for continued research.

- **Procurement of ITS Technologies** – Agency procurement of technology assets is an emerging issue for ITS professionals. Two research efforts (*Project 11: Procurement*

Practices for Partnering with Emerging Technology Providers and *Project 19: Patented and Proprietary Products Waiver Impact on ITS Procurements*) addressed procurement practices for advanced transportation technologies. Significant interest in this topic demonstrates a changing landscape in the transportation sector that must adapt beyond traditional procurement practices to enable innovation in an agency environment.

- **Emerging Capabilities in Traffic Detection Technologies** – Capabilities in traffic detection are evolving and improving rapidly, as demonstrated by ENTERPRISE members' interest in technologies for detecting incidents and performing traffic data collection. Two projects (*Project 15: State of Practice for Automated Traffic Incident Detection* and *Project 18: Pedestrian Detection Systems for Improved Safety*) documented commercially available systems that offer automated incident detection functionality to detect various traffic-related conditions and provide alerts to road users and TMC operators. In addition, *Project 9: Volumes from Probe Data* and *Project 12: Synthesis of the Use of Speed Data from Probes for Arterial Operations* researched current practices and use cases for third-party probe-based traffic data.
- **Proactive ITS Planning and Assessment** – Three research projects (*Project 1: The Evolution of ITS in Transportation Asset Management, Project 2: Evolving and Phasing Out Legacy ITS Devices and Systems*, and *Project 17: Best Practices in Future Proofing for Emerging Technologies*) focused on how agencies can improve long-term planning, assessment, management and decision-making for ITS systems. These projects addressed this issue from both an 'asset' or 'device' management perspective as well as from a proactive, strategic viewpoint as technologies evolve and agency needs change.
- ***Infrastructure Readiness for Emerging Technologies*** – As ITS professionals are increasingly charged with planning for advanced technologies, they need information about the expected impacts and how to adapt agency-operated infrastructure accordingly. *Project 5: ITS Infrastructure Integration of CAV and MaaS* and *Project 20: Understanding Infrastructure Operations Impacts Based on AV Demos* provided insights on identifying impacts and improving preparedness strategies, based on experiences from across the country and through development of likely deployment scenarios.

4.3 Recommendations for Implementation

The recommendations for implementation vary for each activity. In Chapter 3, after the description of each of the 20 research projects from ENTERPRISE Phase II, there is a description of the recommendations for implementation specific to each project. See the Appendix for a summary of implementation outcomes as completed at the time of this publication. This summary provides tangible examples of how results have been implemented and offers further insight to agencies as they consider utilizing these research findings in practice.

Appendix: Implementation Outcomes

Table A-1: Implementation outcomes

Project	Overview	Implementation Outcomes
Project 1: The Evolution of ITS in Asset Management	Summarized the current state of ITS asset management, both in the ENTERPRISE member agencies and across North America, and described the attributes and criteria being used to effectively support ITS asset management.	*Consider the attributes identified in this research for inclusion into their own asset management plans*. • Iowa DOT will reference this as they procure an ITS asset management system.
Project 2: Evolving and Phasing out Legacy ITS Devices and Systems	Documented nearly 60 case studies, including decision factors, criteria, approaches, and tools agencies use to help guide decision-making when evolving and phasing out ITS devices and systems.	*Use the criteria defined and tools identified to assist with identifying and navigating through multiple considerations while assessing ITS devices and systems to determine potential evolutions or eliminations.* • Iowa DOT to use when making decisions to phase out or upgrade existing ITS devices. Ideally, the decision factors and criteria could be incorporated into a life cycle cost analysis tool within an asset management system. • Project results were presented to transportation practitioners during the following events: – 2019 ITS Alaska Annual Meeting (Anchorage, AK) – 2020 Northwest Transportation Conference (Corvallis, OR) – North/West Passage Operations Task Force - October 2020 "Sunsetting Technologies" webinar (virtual) – AASHTO Committee on Transportation System Operations Working Group on ITS – February 2021 meeting (virtual)
Project 3: Real-time Integration of Arrow Board Messages into	Evaluated the deployments of the arrow board concept in Minnesota and Iowa and included an overview of the	*Consider similar deployments of real-time arrow board functionality in future construction and maintenance activities.* • Contributed to Iowa DOT's implementation of arrow boards in construction and maintenance projects throughout the state.

Project	Overview	Implementation Outcomes
Traveler Information Systems Evaluation	RTC of Southern Nevada real-time arrow board reporting system deployment as another perspective.	• Contributed to Iowa DOT's Work Zone Data Exchange (WZDx) approach and success in receiving a demonstration grant from the USDOT as a WZDx pilot site. • Developed Minnesota's baseline information and understanding of its feasibility of integrating arrow board information into MnDOT's road condition reporting system (CARS/511). Also, enabled Minnesota to plan for a future TSMO build-out project.
Project 4: Roadmap for Next Generation Intersection Conflict Warning System (ICWS)	Identified and documented issues related to the development and deployment of next-generation approaches to ICWS to develop a roadmap of prioritized next steps to help guide future ICWS deployment efforts.	*Use the roadmap as a resource for future deployments of ICWS systems.* • Iowa DOT suggests ENTERPRISE identify a few next steps identified in the report to complete as a next phase to address the ICWS issues documented. • MnDOT used this to communicate better with other states and their key experts and define next steps for Minnesota Rural ICWS.
Project 5: ITS Integration with CAV and MaaS	Used secondary research to identify the kind of outcomes anticipated from CAVs and MaaS, summarized potential impacts on ITS/traffic operations, and suggested agency actions to stay engaged as CAV and MaaS continue to evolve.	*Share the anticipated outcomes and potential impacts identified in the report with planning and traffic operations staff for consideration when forecasting future activities.* • Iowa DOT staff are engaged on this topic and aligning with state, regional (e.g., MAASTO), and national partners (e.g., ITS America) and will continue to monitor opportunities and how national policy (e.g., FFC on 5.9ghz spectrum) will impact deployment and testing as well as potential funding/programmatic changes are needed going forward. • MnDOT used this to share with and inform the Minnesota Governor's Advisory Committee on Connected and Automated Vehicles on the role of MaaS. • Project results were presented at the 2019 ITS Minnesota Fall Forum (St. Paul, MN).

Project	Overview	Implementation Outcomes
Project 6: Emerging Practices for Communications Infrastructure	Explored agencies' long-distance data communications needs and options for related infrastructure and documented long-term management practices for long-distance data communications infrastructure assets.	*Consider the options for communications presented in the report and the needs driving each option to identify candidate communications solutions for each agency.* • Provided Iowa DOT with a good resource on the current and emerging options that other states are considering as well as fiber sharing with the private sector to consider. • Project results were presented at the AASHTO Committee on Transportation System Operations (CTSO) Working Group on Communications Technology – April 2021 meeting (virtual).
Project 7: Automated Classification of Winter Road Conditions – Phase 2	Concluded Phase 1 activities by exploring specific attributes of data that can be used to automate road condition reporting with the intent of increasing agencies' understanding and evaluation of this data.	*Consider automated classifications of winter road conditions and the potential approaches and early examples of use for traveler information or roadway maintenance.* • Iowa DOT has conducted several pilots, using various methods to automate winter road condition reporting. Iowa DOT used this document as a guide to help write the requirements for the RFP. The hope is to have a solution that will take the burden of reporting conditions off of maintenance staff. • MnDOT used these finding to measure automated classification system capabilities. • Project results were presented at the 2020 ITS Minnesota Fall Forum (virtual).
Project 8: Use Cases and Benefits of ATM Strategies	Identified resources and documented lessons learned related to the development and deployment of ATM strategies with an emphasis on deployments in urban areas that include multiple	*Consider the prepared materials and summaries when evaluating or considering active traffic management deployments.* • As part of the Des Moines Integrated Corridor Management (ICM) part-time shoulder running and queue warning are being considered. This report provided useful information on available resources and what other states are doing in this area related to the Iowa DOT.

Project	Overview	Implementation Outcomes
	applications (e.g., VSLs, dynamic queue warning, part-time shoulder running).	
Project 9: Volumes from Probe Data	Documented 22 potential agency use cases for probe volume data and four business cases outlining benefits and implementation considerations.	*Consider the uses and benefits described to plan for and implement probe volume data across several agency functions and user groups.* • Results were used by the Eastern Transportation Coalition's Vehicle Probe Project research team from the National Renewable Energy Laboratory (NREL) and the University of Maryland CATT Lab, to clarify agency use cases as they improve probe volume data estimations through ongoing research efforts. The results also helped NREL researchers communicate practical uses for the data to their U.S. Department of Energy grant committee members, thereby informing grant activities aimed at improving accuracy of traffic volume data from vehicle probes.
Project 10: Potential Approaches for Wrong-Way Driving Applications	Explored the potential for in-vehicle navigation systems and mobile apps to provide wrong-way driving alerts by conducting outreach to automobile manufacturers and mobile app developers and proposed a concept for a national data exchange framework for wrong-way driving reports.	*Upload and consume data on wrong-way driving vehicles if a national data exchange for wrong-way driving is initiated.* • Reached multiple automobile manufacturers and third-party providers of in-vehicle applications, to influence future deployments. • Led a concept proposed to FHWA for a national data exchange for wrong-way driving reports. • This project reached one of the "Big Three" auto makers in the U.S. with this effort. If implemented, others would be likely to follow. Will not know the true benefits of this project for a few more years. Well worth the small budget. Iowa DOT is in support of a next phase in lobbying FHWA for a national framework of WWD information (similar to WDZx). • Saves MnDOT from trying to examine and move this national discussion by ourselves. • The project's wrong-way driving applications concept was presented at:

Project	Overview	Implementation Outcomes
		– 2020 Society of Automotive Engineers (SAE) International World Congress (WCX) Digital Summit (virtual) – 2021 SAE International World Congress (WCX) Digital Summit (virtual)
Project 11: **Procurement Practices for Partnering with Emerging Technology Providers**	Researched recent applications of new procurement practices, or traditional procurement practices applied in new ways, to partner with emerging technology providers.	*Share project outcomes with project managers and procurement staff for consideration in future procurements of ITS solutions.* • As Iowa DOT continues to formalize and standardize their program by creating an ITS Program Guidance document while also exploring opportunities to pursue emerging technologies in the ITS space, this document will be a good resource. • Through the Iowa Advisory Council on Automated Transportation (AT), the concept of a competitive grant challenge program has been identified as a tactic in the Iowa AT Vision. Funding hasn't been secured for the challenge, but when funding is secured, this document will certainly be considered.
Project 12: **Synthesis of Probe Speed Data for Arterial Operations**	Assisted in understanding the overall status and key uses of arterial probe speed data for operations by focusing on vehicle probe speed data without the need for deploying and maintaining equipment in the right-of-way and excluding probe speed data that required additional roadside infrastructure (e.g., Bluetooth, nonintrusive detectors).	*Consider key uses of current state of practice arterial probe data and consider this when scoping projects or procuring data.* • Iowa State University (ISU) has done a lot of use of operational analysis and research for the Iowa DOT and lessons learned could be shared in the future. In addition, Iowa DOT uses INRIX data for their statewide screening tool, called Infrastructure Condition Evaluation for Operations (ICE-Ops) – a similar tool that Ohio DOT developed called TOAST and was noted in the report.

Project	Overview	Implementation Outcomes
Project 13: Traveler Information Collaboration – Phase 1	Polled traveler information coordinators in all states to help understand the need for collaboration in traveler information for reporting road weather events and developed a concept for a Traveler Information Community of Practice. AASHTO has agreed to initiate and run a Traveler Information Community of Practice within the CTSO.	*Participate in AASHTO's Traveler Information Community of Practice without need for ongoing ENTERPRISE activities.* • Led to the AASHTO initial discussion in forming a traveler information community of practice, that will fulfill the intended vision of this project. • Iowa DOT with a connected national group of traveler information colleagues, will be able to collaborate and share lessons learned as we keep evolving our traveler information systems. This is something that proved beneficial with the 511 Deployment Coalition many years ago. • Project findings and potential next steps were presented during the 2021 AASHTO Committee on Transportation System Operations (CTSO) Annual Meeting (virtual).
Project 14: Establishing a Framework for Communicating DOT Map Updates to Mapping Companies	Developed a consistent communication approach for providing transportation agency map updates to mapping companies that utilize DOT-generated data for applications such as route guidance.	*Use the guidelines developed to communicate future map updates to help improve the accuracy of information disseminated through traveler information mechanisms such as mobile applications.* • Having all of this information in one place is a great resource for Iowa DOT to help travelers have the safest and most efficient trip on our roads. Also, because of this project, Iowa DOT was able to influence one of the major mapping companies to start developing an authoritative source program to make these mapping updates. • MnDOT created a better understanding of the methods needed to push map updates.
Project 15: State of Practice for Automated Incident Detection	Created an understanding of the current state-of-practice for commercially available automated traffic incident detection systems and defined common user needs for agency use of these systems.	*Utilize the common TMC operator user needs to develop system requirements and consider the functionality defined in the report to assist in procuring incident detection systems.* • Iowa DOT is always looking for ways to learn about incidents before they become more serious. This project allowed Iowa DOT to get a good picture of what types of detection are out there and even do a small informal pilot with one of the vendors. Iowa DOT will definitely use this

Project	Overview	Implementation Outcomes
		report as they decide what type of automated incident detection to use in the future. • MnDOT is leveraging the findings from this project and incorporating them into our own implementation efforts.
Project 16: ENTERPRISE Agencies Operational Responses to the COVID 19 Pandemic	Documented and shared ENTERPRISE member agencies' traffic operations responses gathered through phone interviews and a peer exchange webinar.	*Read and consider responses shared by each agency for implementation, if appropriate, in their agency.* • MnDOT was able to better understand other State DOT responses and use that understanding to consider in our environment.
Project 17: Best Practice in Future Proofing for Emerging Technologies	Researched best practices and overall approaches towards future proofing ITS assets, drafted a business model suggesting roles for seven existing DOT activities, and developed an overall three-step approach to mitigating risks to ITS assets.	*Review the recommended actions and consider which are appropriate for organization to mitigate risks to the future use of ITS assets.* • This resource will be helpful for the Iowa DOT ITS guidance document as well as the forthcoming Iowa DOT ITS Asset Management plan. • Suggestion from the Project Champion from PennDOT that this document should be considered in the overall Transportation Asset Management Plan (TAMP) development and use (as it relates to ITS). • Project results were presented at the 2021 ITS Alaska Annual Meeting (virtual).
Project 18: Pedestrian Detection Systems for Improved Safety	Increased ENTERPRISE members' understanding of pedestrian safety issues as well as detection-based systems that could improve pedestrian safety.	*Consider pedestrian safety approaches identified and identify additional research to demonstrate and evaluate one or more approaches.* • The industry scan developed in this project was utilized to help inform a Michigan DOT research effort that will test various detection-based pedestrian safety systems.

Project	Overview	Implementation Outcomes
		• Initial learnings from this project were shared with MnDOT ITS staff to help inform a current project that is testing/evaluating pedestrian detection technologies.
Project 19: Patented and Proprietary Products Waiver Impact on ITS Procurements	Explored impacts of FHWA Final Rule Construction and Maintenance-Promoting Innovation in Use of Patented and Proprietary Products, in which the requirements in 23 CFR 635.411(a)-(e) were rescinded to encourage innovation in the development of highway transportation technology and methods.	*Review the examples of how the waiver is being implemented and consider them for local use.* • WisDOT will share the results with agency staff to increase awareness of options for procuring innovative products.
Project 20: Understanding Infrastructure Operations Impacts Based on AV Demos	Developed an understanding of whether infrastructure changes identified in low-speed AV shuttle demonstrations and the roles of agency and private-sector stakeholders are representative of needs and roles in future, long-term AV deployments.	*Consider the project findings in preparation for physical infrastructure and operations changes in CAV planning activities.* • While Iowa DOT doesn't have any current or planned low speed shuttle demonstrations, this information will be very useful to support readiness activities being pursued by a few different subcommittees of the Iowa Advisory Council on Automated Transportation. This work will be shared at upcoming meetings for policy, infrastructure, and public safety stakeholders. • MnDOT used this as great baseline information to inform us on what other State DOTs are doing and compare them against our own demonstration projects. • Project results were presented at the 2021 ITS Minnesota Fall Forum (virtual).

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