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Leann Koon, Douglas Galarus and David Veneziano

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9. PERFORMING ORGANIZATION NAME AND ADDRESS
Western Transportation Institute
College of Engineering
Montana State University - Bozeman
P.O. Box 174250
Bozeman, MT 59707-4250

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This document summarizes the work completed for continued Intelligent Transportation Systems (ITS) demonstration, evaluation and technology transfer in rural northern California and southern Oregon. The primary goal of California and Oregon Advanced Transportation Systems (COATS) Phase 6 was to provide research and support activities to help California and Oregon achieve the COATS vision. These activities included: promoting technology transfer, investigating traveler information data quality, and evaluating the Fredonyer Pass icy curve warning system. Technology transfer activities were centered on the growth and continuation of the annual Western States Forum. The evaluation of the Fredonyer Pass ICWS analyzed long-term speed and crash trends to establish true effectiveness of the system in terms of increased driver vigilance and reduced crashes. The traveler information data quality task documented a number of procedures and considerations relative to disseminating quality traveler information. It showed that data quality is crucial to safe, efficient operation of the transportation system, including provision of traveler information that is accurate, timely, and reliable.

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California and Oregon Advanced Transportation Systems (COATS) Phase 6: Final Report

by

Leann Koon
Research Associate

Douglas Galarus
Program Manager
Systems Engineering Development and Integration Program

And

David Veneziano, Ph.D.
Research Scientist II

Western Transportation Institute

College of Engineering

Montana State University

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EXECUTIVE SUMMARY

This document summarizes the work completed for continued Intelligent Transportation Systems (ITS) demonstration, evaluation and technology transfer in rural northern California and southern Oregon. This work was completed under the sixth phase (Phase 6) of the California and Oregon Advanced Transportation Systems (COATS) project. The purpose of the overall COATS effort has been and continues to be encouraging regional, public and private sector cooperation between California and Oregon organizations to better facilitate the planning and implementation of ITS in a rural bi-state area extending between Eugene, Oregon, and Redding, California. As COATS has matured, it, as well as projects which have spun off from the effort, have gained interest from surrounding states, specifically Washington and Nevada. Consequently, the COATS region is now the Western States Rural Transportation Consortium (WSRTC), which includes California, Oregon, Washington, and Nevada. Although future research efforts will be conducted under the umbrella of the WSRTC, the work discussed in this document was conducted under the COATS umbrella and is discussed as such.

The primary goal of COATS Phase 6 was to provide research and support activities to help California and Oregon achieve the COATS vision. These activities included: promoting technology transfer, investigating traveler information data quality, and evaluating the Fredonyer Pass icy curve warning system.

Technology transfer activities were centered on the growth and continuation of the annual Western States Forum. The evaluation of the Fredonyer Pass ICWS analyzed long-term speed and crash trends to establish true effectiveness of the system in terms of increased driver vigilance and reduced crashes. The traveler information data quality task documented a number of procedures and considerations relative to disseminating quality traveler information. It showed that data quality is crucial to safe, efficient operation of the transportation system, including provision of traveler information that is accurate, timely, and reliable.

1. INTRODUCTION

The purpose of this document is to summarize the work completed for continued Intelligent Transportation Systems (ITS) demonstration, evaluation and technology transfer in rural northern California and southern Oregon. This work was completed under the sixth phase (Phase 6) of the California and Oregon Advanced Transportation Systems (COATS) project. The purpose of the overall COATS effort has been and continues to be encouraging regional, public and private sector cooperation between California and Oregon organizations to better facilitate the planning and implementation of ITS in a rural bi-state area extending between Eugene, Oregon, and Redding, California.

As COATS has matured, it, as well as projects which have spun off from the effort (One Stop Shop (OSS), Integration of Aviation Automated Weather Observing System (AWOS) with Road Weather Information System (RWIS), Redding Responder, WeatherShare, Automated Safety Warning System Controller (ASWSC), etc.), have gained interest from surrounding states, specifically Washington and Nevada. This work has also generated interest based on being finalists and award winners for the following:

- One Stop Shop
    - 2014 Best of ITS (Awarded)
    - 2013 California Transportation Foundation Tranny Awards (Finalist)
- Redding Responder
    - 2010 Best of Rural ITS Award (Awarded)
    - 2009 California Transportation Foundation Tranny Awards (Finalist)
    - 2007 Best of ITS Award (Finalist)
- Automated Safety Warning System Controller
    - 2014 Best of Rural ITS Award (Finalist)
- Western States Rural Transportation Technology Implementers Forum
    - 2012 Best of Rural ITS Award (Awarded)

In light of this interest, the COATS region evolved during the course of Phase 4 into the Western States Rural Transportation Consortium (WSRTC), which includes California, Oregon, Washington and Nevada. The WSRTC was established to facilitate and enhance safe, seamless travel throughout the western United States. The Consortium seeks to promote innovative partnerships, technologies and educational opportunities to meet these objectives. Additionally, the Consortium seeks to provide a collaborative mechanism to leverage research activities in a coordinated manner to respond to rural transportation issues among western states related to technology, operations and safety. Consequently, activities of the Consortium are focused on technology transfer/education (Western States Rural Transportation Technology Implementers Forum) and incubator projects (small scale research tasks intended to serve as a "proof of concept" for larger subsequent efforts) centered on the Consortium pillars of technology, operations and safety. Although future research efforts will be conducted under the umbrella of the WSRTC, the work discussed in this document was conducted under the COATS umbrella and will be discussed as such.

1.1. COATS Vision

As part of the shift from COATS to the WSRTC, the vision of the group has been defined as follows: "The WSRTC shall promote innovative partnerships, technologies and educational opportunities to facilitate and enhance safe, seamless rural travel throughout the western United States." During the course of COATS Phase 6, the WSRTC vision has been employed in guiding the various efforts associated with the project.

1.2. COATS Mission

The COATS Project serves to focus member agencies on a seamless, state-of-the art, multi-modal transportation network benefiting travelers, goods movement, economic activity, and transportation systems operators in California, Nevada, Oregon and Washington. Collaboration between the COATS project and its partnership coalition provides information and serves to promote increased safety, mobility, traveler comfort, environmental quality, and operational efficiency and productivity. Again, as part of the shift from COATS to the WSRTC, the mission of this effort is presented as follows. "The WSRTC shall provide a collaborative mechanism to leverage research activities in a coordinated manner to respond to rural transportation issues among western states related to Technology, Operations and Safety." For this phase of COATS and all future phases, the mission of the WSRTC will be applied.

1.3. Phase 6 Goals

The primary goal of COATS Phase 6 was to provide research and support activities to help California and Oregon achieve the COATS vision. These activities included: promoting technology transfer, investigating traveler information data quality, and evaluating the Fredonyer Pass Icy Curve Warning system.

1.4. Project Tasks

The work plan for COATS Phase 6 consisted of the following six tasks:

- Task 1: Project Management
- Task 2: Project Technical Advisory Panel Meetings
- Task 3: Western States Rural Transportation Technology Implementers Forum
- Task 4: Year 1 Incubator Projects
    - Evaluation of the Fredonyer Pass Icy Curve Warning System – Before and After Study of Long-Term Effectiveness
    - Data Quality for Aggregation and Dissemination of DOT Traveler Information: An Analysis of Existing System Best Practices
- Task 5: Year 2 Incubator Projects
    - Bluetooth Evaluation for Siskiyou Summit Chain-Control Chain-Up Area North of Redding
    - Long-Term Operational and Safety Impacts of Radar Speed Signs
- Task 6: Submit Final Report and Workshop Presentation

Central to the project were the needs and interests of stakeholders within the COATS region. Their input was used to identify what activities would be pursued, as well as provide feedback and information in support of on-going work. WTI managed the project in consultation with the Project Manager and Steering Committee, to ensure integrity and unity in the project approach.

1.5. Report Organization

This report presents a summary of activities completed during Phase 6 of the COATS effort. Specifically, this report provides an overview of the major efforts of the project, including the Western States Forum and other general outreach and technology transfer activities, evaluation of the Fredonyer Pass icy curve warning system, analysis of best practices for traveler information data quality, and the Bluetooth evaluation for Siskiyou Summit chain-control chain-up area.

2. TECHNOLOGY TRANSFER

2.1. Western States Rural Transportation Technology Implementers Forum

The purpose of this task was to provide financial and logistical support for the 2015 and 2016 Western States Rural Transportation Technology Implementers Forums. An event focused on delivering high quality technology transfer and networking opportunities, the Forum targets an audience of professionals working in design and maintenance of ITS technologies in rural environments. It is unique nationally with respect to its audience and technical content, and its origin and development reflect the idea of using COATS as an incubator for innovations in the use of technology to address rural transportation challenges.

The 2015 and 2016 Forums were both held at the Holiday Inn Express in Yreka, California. By virtue of its location near the Oregon border, this site facilitated participation from other states while remaining within Caltrans District 2, provided an economical site with necessary facilities, and put the attendees in close proximity through the duration of the Forum. To promote continuity, the Forum has been held around the third week in June for the last two years.

Individual participation at the Forum indicates its growth and success. Starting with 15 in 2006, the 2016 Forum saw a record 47 participants. Thirty-nine individuals attended the 2015 Forum. The Forum continues to attract a diverse audience. Participants in the last two Forums have come from eight different states (CA, ID, MT, NV, OR, UT, WA, WY), with Utah being a new addition to the list of participant states. Along with the eight different states, attendees represented ten of the 12 Caltrans Districts, Caltrans Headquarters and DRISI, five universities, a city transportation division, the FHWA, and the Idaho National Laboratory. It should be noted that while the Forum aims to maintain a smaller audience around 40-50 people, ongoing travel restrictions in California and other states have certainly caused attendance numbers to fluctuate.

Each year, the Forum has been distinguished by informative, in-depth technical presentations and demonstrations given by a diverse group of rural ITS practitioners. Presenters have delved into how solutions were developed, focusing on applications that have been deployed in the field and are being used in live traffic situations. Success stories have been shared along with failures and problems so that participants learn not only what does work, but also what doesn't work and why. The extended length of the presentations (60-120 minutes) and the informal atmosphere have allowed frank discussion of equipment functionality, vendor claims, system performance, and other key information that practitioners need to know for successful rural ITS projects. The Committee has specifically encouraged presentations that discuss and/or demonstrate a project implemented or improved because of participation in a past Forum. For specific presentation/demonstration topics, please refer to the yearly reports completed as part of this task (1, 2).

The Western States Forum website (www.westernstatesforum.org) has been maintained and the Forum continues to have a presence on the Western States Rural Transportation Consortium (WSRTC) website (www.westernstates.org). The Forum website includes a home page and individual pages that describe the Forum and its history and share pertinent information about the current Forum such as registration, lodging, maps and directions, and things to do around the Forum location. Each past Forum has a set of pages that includes downloadable versions of the technical content and an image gallery. Contact information is also easily accessible.

To increase awareness of the Forum and its value, a one-page fact sheet that describes the Forum was updated, distributed, and posted on the Forum website as well as the WSRTC website. To build support for attendance, the Steering Committee also collected testimonials from past Forum attendees. The testimonials describe how knowledge gained at the Forum is being implemented in Caltrans districts and across the western states region. A one page hand out was updated with this information which was also posted on the Forum and Consortium websites. Additionally, this information was compiled into a separate page on the Consortium website detailing how the Forum is effectively impacting change across the WSRTC region (http://www.westernstates.org/Impact/WSF/Default.html).

Announcements about the Call for Abstracts and Forum registration were posted on the ITS Rocky Mountain website, and publicized in the ITS Rocky Mountain monthly e-newsletter, and the Transportation Communications Newsletter (TCN).

Participants repeatedly expressed a very high interest in attending a similar Forum the following year. Average evaluation ratings for quality, level of detail, relevancy and overall aspects of the Forum were consistently positive. Attendees appear to be satisfied with the length and general format of the Forum, including the small, focused group, detailed presentations, rural perspective, and excellent networking opportunities. The feedback suggests that the Forum is successfully meeting the needs of practitioners and the goals, mission and vision outlined for the Forum.

A more detailed review of this task can be found in the reports *Western States Rural Transportation Technology Implementers Forum: Review of 2015 Meeting* (1) and the *Western States Rural Transportation Technology Implementers Forum: Review of 2016 Meeting* (2).

2.2. Project Technical Advisory Panel (PTAP) Meetings

In addition to the technology transfer completed by the Forum, COATS/WSRTC PTAP meetings also provided an opportunity for discussion of current and future ITS activities in the region. Stakeholders were also able to meet and guide planning and decision-making related to the COATS project. The original proposal called for four PTAP meetings (two per year); during the course of the project, five meetings were held. In completing this task, two PTAP meetings were held in Yreka, California. These occurred on June 16, 2015, and June 21, 2016. Additionally, PTAP meetings were held in August 2014 in Branson, Missouri (in conjunction with the National Rural ITS conference), August 2015 in Snowbird, Utah (in conjunction with the National Rural ITS conference), and in March 2016 in Corvallis, Oregon (in conjunction with the Northwest Transportation Conference). Collectively, these meetings allowed for a discussion of the direction and focus of existing project tasks, presentation of initial and final task results, and discussion of future project directions. Presentations made at these meetings fulfilled the workshop presentation component of Project Task 6.

Teleconferences were also held on an as needed basis. This allowed for a travel savings which could then be applied to other aspects of the work, specifically the Western States Forum, travel to local conferences, and the progress and results of the incubator projects discussed later in this document. Aside from the organization and conduct of these meetings, associated deliverables included meeting presentations, meeting minutes, and related website updates.

2.3. Outreach

Technology transfer outside of the ITS community is also important, and this subtask provided for travel costs and time for one WTI staff member to attend "local" transportation conferences. As discussed in the previous section, attendance at such meetings did occur, with presentations and a presence made at the annual National Rural ITS (NRITS) conference and the 2016 Northwest Transportation Conference in Corvallis, Oregon. This attendance was viewed as beneficial in creating new interest in COATS outside of California, where such interest remained strong. It also allowed for results of COATS/WSRTC projects to be disseminated to a wider audience of rural ITS professionals. Results to date of the traveler information data quality incubator project task were presented at the 2015 NRITS conference.

3. EVALUATION OF THE FREDONYER PASS ICY CURVE WARNING SYSTEM

Fredonyer Pass, located in northeastern California, is a five-mile segment of State Highway 36 in Lassen County that has multiple curves and a history as a high-collision location, including multiple fatal crashes involving local residents. The vast majority of these crashes (note the terms crash and collision may be used interchangeably) occurred when the pavement was icy, despite static signage that Caltrans had installed to increase motorist awareness.

The Fredonyer Pass Icy Curve Warning System (ICWS) was deployed by Caltrans to increase motorist vigilance and reduce the number of crashes occurring during icy pavement conditions in real-time. The ICWS consists of pavement sensors to detect icy conditions, in combination with dynamically activated signage to provide motorists with real-time warning when icy conditions are either imminent or present. The system is intended to alert motorists of icy conditions, eliciting a decrease in vehicle speeds during such conditions. Consequently, lower vehicle speeds are expected to translate to reduced crashes along the length of the curves which have presented safety challenges in the past.

While the system was initially installed during the summer of 2002, it did not reliably operate in the manner envisioned by Caltrans and required an extensive rebuild, which began during the spring of 2006. The rebuild and subsequent testing and validation of the system required a significant amount of time. As a result, the ICWS was not considered fully operational and reliable until the winter season of 2008-2009. The work presented in the task report has evaluated the performance of the ICWS following the rebuild, focusing on the metrics of speed reduction under various conditions and safety performance through crash reduction. In addition, a review of literature pertaining to road condition warning systems was made, along with documentation of winter maintenance, ITS engineering and California Highway Patrol (CHP) perspectives of the ICWS.

A more detailed review of this task can be found in the report *Evaluation of the Fredonyer Pass Icy Curve Warning System* (3).

3.1. Results and Conclusions

The results of the statistical analysis of speed data suggest that the system is working as intended and that vehicle speeds are significantly lower. As expected, mean speeds were lower when the system was turned on versus off as well as during the day and at night. When general wet weather (snow, rain, etc.) conditions were evaluated, it was found that mean speeds were reduced when the system was on versus off during both the day and at night. The real effectiveness of the Fredonyer ICWS on vehicle speeds was its impact during clear, cold and not dry conditions, when snow melting or general water/ice pooling from the wet and cold environment of the curve locations may produce runoff across the roadway in the target curve and result in ice formation. When the base hypothesis that mean speeds differed from one another overall (0 mph) was examined, statistically significant differences in mean speeds between when the system was on versus off were observed during clear, cold and dry/not dry cases. These differences were also greater than 3 mph during most seasons. However, statistically significant mean speed differences greater than 5 mph were observed less frequently overall. Consequently, it appears that the ICWS is prompting motorists to reduce their speeds by approximately 3 mph in conditions where icy roads are not necessarily expected.

In order to determine the safety effects of the ICWS, an observational before-after study using the Empirical Bayes technique was employed. This evaluation determined the effect of ICWS on crash frequencies. The results found that the deployment of the ICWS reduced the number of annual crashes by 15%. As no other changes occurred along the study segment (additional safety improvements, geometric changes, etc.), it is reasonable to attribute this observed safety improvement to the ICWS. Additionally, a crash rate method was used to investigate the effect of the ICWS on crash severities, with a focus on ice-related accidents. The results indicated that the ICWS has reduced crash severities. As a result of reduced crash severities, the system was estimated to provide safety benefits of $1.03 million dollars per winter season during the after deployment study period (2008-2015). Overall, the safety evaluation results indicate that the system is having a positive impact on reducing all types of crashes.

From the perspective of winter maintenance personnel, the ICWS is an improvement over typical static metal signage. Observations made over time have indicated that as the winter progresses, the system works better. The use of additional pavement surface sensors for detection of conditions in multiple lanes could improve system accuracy and reliability. The data produced by the ICWS are not presently employed by maintenance forces for any activity, although the CCTV camera associated with the system's RWIS at the summit is used frequently to obtain visual information on present conditions.

Feedback provided by ITS engineering indicated that the primary benefit provided by the system is that it is viewed to be saving lives. The system, while complex and requiring a vigilant attitude toward maintenance, has helped to reduce crashes. Tasks associated with the system include battery maintenance, sensor monitoring and recalibration/replacement, data download (radar speeds), and sign checks for function and condition. While these activities require a lengthy trip to and from the site, they are critical in making sure that the system is working properly. Potential future improvements to the system that have been identified or recommended include migration of the power supply from solar panels to standard distribution via the local utility, and the possible use of out-of-pavement sensors to monitor pavement condition.

Finally, feedback provided by CHP indicated that drivers appear to be slowing down when the ICWS is on (particularly in vicinity of the targeted curves). This is only perception though, and there has been no analysis performed by CHP (e.g., on ticket records) to verify whether this is in fact the case. There has not been a perceptible drop in crashes since the system became fully operational in 2009, at least from the perspective of CHP. The thoughts of CHP on this drop were that it could be related to the ICWS, as well as manned chain control policies employed by Caltrans. In general, the system appears to be accurate in indicating ice conditions.

3.2. Recommendations

A number of recommendations for future work and monitoring are advisable. First, while the crash data analysis completed during this work employed a longer period of time, it would be advisable to revisit this analysis at a future date, perhaps at approximately the ten year point post-deployment. The Empirical Bayes approach employed in this report could once again be used for that evaluation, examining crash data from throughout the year. Such work might also consider only winter months and employ the development of a specific Safety Performance Function. The development of such SPF's can be quite costly and time intensive, which is why such an approach was not employed in this work. However, through the development of an SPF specific for ICWS, the performance of an ICWS deployed elsewhere could be more easily evaluated.

Coincident with planning for future safety (and speed) evaluations, it is recommended that Caltrans District 2 continue to maintain records of manned chain control levels. These records can consist simply of saved .pdf files from the chain control report log. Such files were used during the course of the analysis presented here, and will be sufficient for future work as well. The key is to save this data/files on an annual basis for future use. To provide perspective on how long this data should be saved, another evaluation of the system could be considered at the ten year point following deployment.

Secondly, an evaluation of mean speed trends would also be advisable. Again, while the ICWS appears to be effective in producing a reduction in vehicle speeds under different conditions, particularly clear, cold and not dry conditions when ice isn't expected, the long term effectiveness of the system on speeds remains unclear. This aspect is particularly of interest given the observations of CHP staff in the field, which indicate that speeds appear to increase as the winter season goes on. It is possible that speeds will also begin to climb the longer the system remains deployed (in terms of years). Conversely, as the system remains deployed over a longer period, drivers may come to trust its indications of icy roads and the speed reductions observed here may remain somewhat constant.

When evaluating speed data in the future, it may also be advisable to collect speeds from the center of each targeted curve. The evaluation presented here only examined speed data from sign locations in advance of each curve. While the reviewed data provides a general sense of driver reactions to the ICWS message, it remains unknown whether, and to what extent, drivers slow down while passing through the targeted curves. Only through the collection of speed data at some point or points in each of the curves targeted by the ICWS can it be determined if drivers slow down to any significant extent (and, if so, by how much) as they pass through the curve. Of course, challenges may exist which make it more difficult to collect such data (e.g., permits to place data collection equipment and/or run power to that equipment on Forest Service lands). The inclusion of such speed measurement capability is envisioned during the upcoming pavement rehabilitation project (2019-2020).

The speed data collected by radar during the course of this task was aggregate and did not classify vehicles by their type. On a mountain pass, the type of vehicle traveling up or down a grade will play a significant role in the speeds observed. For example, a heavy vehicle will travel much slower upgrade because of its weight when compared to a passenger car, regardless of the presence of curves and potential for ice. Similarly, a heavy vehicle will also travel more slowly downgrade in order to maintain control. The presence of such slow moving vehicles may lower overall average speeds when analyzed collectively with all other vehicles. While this was not viewed to be a problem in this analysis, given the large sample sizes of data examined, it would provide interesting information related to the behaviors of specific vehicle types. If possible for future work, data should be collected by equipment which is capable of classifying and binning vehicles by type.

While not the focus of this work, agencies that may consider future ICWS deployments should be aware of a number of design and operational aspects that play a critical role in the success of such systems. Aside from obtaining reliable system components, it is essential to be sure that the system and sensors are calibrated correctly. The algorithms employed in determining icy conditions must correctly process the data being received from different sensors and determine what actions are warranted based on current conditions. Finally, the recurrence of ice in certain locations is likely due in part to microclimate features; as such, it is essential to design, install and calibrate an ICWS specifically for the microclimate it is used in.

4. DATA QUALITY FOR AGGREGATION AND DISSEMINATION OF DOT TRAVELER INFORMATION: AN ANALYSIS OF EXISTING SYSTEM BEST PRACTICES

The quality of data is a crucial consideration for the provision of meaningful traveler information. When drivers access traveler information that is up to date, correct, and accessible every time they need it, they will use it to make travel decisions which ultimately impact traffic management effectiveness. On the other hand, if for example, travelers see old or stale, incorrect information, they are less likely to make travel decisions based on the traveler information or even access the information in the first place. This can significantly diminish the effectiveness of traffic management efforts.

The goal of this task was to analyze and document existing system best practices for data quality for the aggregation and dissemination of state department of transportation traveler information. To achieve this goal, the research team conducted a survey of DOT practitioners in western states, as well as a literature review on data quality within the transportation field. "Best practices" were documented, and recommendations and next steps were formulated based on applicability to Caltrans traveler information data and processes.

For more detailed results of the practitioner survey and the literature review, refer to the final report for this task – *Data Quality for Aggregation and Dissemination of DOT Traveler Information: An Analysis of Existing System Best Practices (4).*

4.1. Results

The task aimed to compile a collection of best practices for the aggregation and dissemination of quality traveler information. At the onset of the task, it was recognized that there may not be any so called "best practices" established for traveler information data quality. Neither the survey of DOT practitioners nor the literature review found a comprehensive, well-defined plan for unified, multi-dimensional approaches to quality assurance of traveler information. However, all of the DOT practitioners that were surveyed, as well as the literature reviewed relative to data quality in transportation, indicated in some way that quality data was important for safe, efficient operation of the transportation system, including provision of traveler information that is accurate, timely, and reliable. This observation is especially valid given the current environment that is increasingly focused on performance measurements, accountability and "smarter" operation of roadways. With that said, a number of procedures and/or considerations relative to data quality were repeated in the literature or the DOT practitioner survey and were documented through this task.

4.2. Recommendations and Next Steps

The recommendations and next steps outlined below are made in light of Caltrans traveler information data and processes. Some of the practices identified in the practitioner survey or the literature review may be preferable to others, and some may only be applicable in certain situations.

- There is a need to define where the state DOT is in the traveler information environment. As a survey respondent commented, the DOT has limited flexibility or ability to move quickly. This makes it challenging to quickly design and publish an app for example, because it would already be obsolete by the time it was out for public use. In this case, the survey respondent indicated that the DOT's "niche" may be to provide quality data to others and allow the traveler information environment to sustain it from that point.

- It is recommended that preliminary steps be taken to establish a data governance model. This model should clearly define who owns what data, as well as uses and associated thresholds for the specified data.
- Relevant quality metrics and requirements should be clearly defined. This includes how to determine that requirements are being met with quality data.
- Common statewide standards for data quality, performance, maintenance, and calibration should be defined and established using an engineering approach. These standards should be tied to all specific uses of the data.
- It is recommended that implementation of additional automated feeds should be investigated.
- This task was conducted under the auspices of the Western States Rural Transportation Consortium as a technology incubator project. Incubator projects are smaller research efforts that serve as a "proof of concept". Based on the results of an incubator project, further research on a larger scale may be pursued. This incubator project merely scratched the surface of the challenge of traveler information data quality. Additional research is needed to more thoroughly evaluate and establish best practices.

5. BLUETOOTH EVALUATION FOR SISKIYOU SUMMIT CHAIN-CONTROL CHAIN-UP AREA NORTH OF REDDING

On northbound I-5 north of Redding, CA, when chain controls are in place, trucks are required to chain up near Fawndale. When these chain restrictions are in place, there can be a backup of trucks for 5 miles or more, all the way to Pine Grove, CA, and beyond. Determining accurate delay times that could be displayed on changeable message signs (CMS) before the backup starts may reduce the wait times and backup length, which could improve safety and reduce driver frustration within this corridor. The goal of the task was to develop a preliminary prototype algorithm to predict delays through a chain-up area.

For COATS Phase 5, recommendations were made regarding prospective locations for deploying Bluetooth readers relative to the Fawndale chain-up area. The sites were prioritized based on the assumption that between three and eight Bluetooth readers would be deployed in order to provide sufficient data to accurately determine delay. The Fawndale CCTV site was ranked number 1 on the list, followed by the Pit River Bridge CCTV site and the Riverside CCTV site. Alternately, the SR 44 CCTV site in Redding could be used as a third site.

The task was continued in COATS Phase 6 and work included identification of Bluetooth readers that could potentially be deployed for this application. The project team determined that the most important criteria for Bluetooth readers for this application were availability of raw data (MAC addresses and timestamps), long detection range, and no requirement for cellular data service. Other useful options were WiFi reader capability and a GPS receiver. The four readers recommended for further investigation were the Traffax Inc. BluFAX Chandler, the Savari Networks StreetWave, the DigiWest Blue MAC, and the Iteris Vantage Velocity. The StreetWave and Vantage Velocity were the only U.S.-manufactured Bluetooth readers identified with a Wi-Fi option.

Further work on this task was deferred to a subsequent COATS project phase pending deployment of Bluetooth sensors in proximity to the chain-up area.

For more details about the potential deployment locations and Bluetooth reader sources/vendors, refer to the recommendations and sources report – *Chain-up Delay Tracking with Bluetooth: Prospective Deployment Recommendations and Sources for Bluetooth Readers (5).*

6. LONG-TERM OPERATIONAL AND SAFETY IMPACTS OF RADAR SPEED SIGNS

Per guidance from the project manager and the PTAP, this task was deferred potentially to a subsequent phase of the COATS project. This was done in order to focus resources on Task 4, which included the evaluation of the Fredonyer Pass ICWS and identification of best practices for traveler information data quality.

7. CONCLUSION

This report has discussed the various activities during the COATS Phase 6 project. Phase 6 tasks focused on three areas: technology transfer, evaluation of the Fredonyer Pass Icy Curve Warning System (ICWS), and traveler information data quality. Technology transfer activities were centered on the growth and continuation of the annual Western States Forum. The evaluation of the Fredonyer Pass ICWS analyzed long-term speed and crash trends to establish true effectiveness of the system in terms of increased driver vigilance and reduced crashes. The traveler information data quality task documented a number of procedures and considerations relative to disseminating quality traveler information. It showed that data quality is crucial to safe, efficient operation of the transportation system, including provision of traveler information that is accurate, timely, and reliable.

7.1. Summary of Major Efforts

The COATS Phase 6 project, running between 2014 and 2016, focused on technology transfer, evaluating the Fredonyer Pass ICWS, and traveler information data quality. The Western States Forum served as a technology transfer platform where informative, in-depth technical presentations could be given by rural ITS practitioners. Presenters delved into how solutions were developed, focusing on applications that have been deployed in the field and are being used in live traffic situations. Success stories have been shared along with failures and problems so participants could learn what does and doesn't work and why. The Forum has included live demonstrations of rural ITS technologies and "hands-on" question and answer periods. Participants have brought actual ITS equipment and performed informal "show and tell" sessions during the breaks. This event has continued under the scope of COATS Phase 7/Western States Rural Transportation Consortium and is expected to keep providing an intimate forum for the discussion of rural ITS applications, successes, and failures. In providing such a venue for ITS discussion, one of COATS' overriding goals was met: promoting technology transfer.

The incubator projects completed during the course of COATS Phase 6 provided information that is expected to contribute to the future development and deployment of systems and approaches that will benefit ITS in rural areas.

7.2. Summary of Deliverables

During the course of the Phase 6 effort, a number of deliverables were produced. Specific report documents and memoranda are listed in the References section of this report. In terms of deliverables produced over the course of the project, these included:

- Quarterly progress reports and quarterly updates on the Consortium website (http://www.westernstates.org/Projects/COATS/Default.html);
- Meeting minutes, meeting presentations (Steering Committee meetings and conference calls) which are posted on the Consortium website (http://www.westernstates.org/Documents/Default.html);
- Organization and conduct of the Western States Rural Transportation Technology Implementers Forum in 2015 and 2016;
- Annual reports summarizing the Western States Rural Transportation Technology Implementers Forum (1, 2);

- Annual website updates (Forum and Consortium websites) documenting the Western States Rural Transportation Technology Implementers Forum:
    - Forum website, Past Forums pages:
      2015 - http://www.westernstatesforum.org/PastForums/2015/Default.html;
      2016 - http://www.westernstatesforum.org/PastForums/2016/Default.html.
    - WSRTC website, Forum project pages:
      2015 - http://www.westernstates.org/Projects/WesternStatesForum/Updates/2015-08-24.html;
      2016 - http://www.westernstates.org/Projects/WesternStatesForum/Updates/2016-07-14.html.
- Maintenance and expansion of the COATS (http://www.westernstates.org/Projects/COATS/Default.html), Western States Rural Transportation Consortium (http://www.westernstates.org/Default.html), and Western States Forum (http://www.westernstatesforum.org/) websites;
- Development, support and final documents associated with the *Evaluation of the Fredonyer Pass Icy Curve Warning System (3)* (http://www.westernstates.org/Projects/COATS/Phase6/Documents/FredonyerEval_FINAL_2016-02-17.pdf);
- Development, support and final documents associated with the *Data Quality for Aggregation and Dissemination of DOT Traveler Information: An Analysis of Existing System Best Practices* task (4) (http://www.westernstates.org/Projects/COATS/Phase6/Documents/DataQualityProjectReport_FINAL_2016-08-17.pdf);
- Conference presentations:
    - *Data Quality for Aggregation and Dissemination of DOT Traveler Information: Best Practices* – 2015 National Rural ITS Conference (http://www.westernstates.org/Projects/COATS/Phase6/Documents/SessionC1GalarusDataQuality_NRITS2015_FINAL.pdf) (6).

8. REFERENCES

1 Koon, Leann A.F. Western States Rural Transportation Technology Implementers Forum: Review of 2015 Meeting. Western Transportation Institute, February 2016.

2 Koon, Leann A.F. Western States Rural Transportation Technology Implementers Forum: Review of 2016 Meeting. Western Transportation Institute, June 2016.

3 Veneziano, David. Evaluation of the Fredonyer Pass Icy Curve Warning System. Western Transportation Institute, February 2016.

4 Koon, Leann A.F. and Douglas Galarus. Data Quality for Aggregation and Dissemination of DOT Traveler Information: An Analysis of Existing System Best Practices. Western Transportation Institute, June 2016.

5 Hayden, Larry and Douglas Galarus. Chain-up Delay Tracking with Bluetooth: Prospective Deployment Recommendations and Sources for Bluetooth Readers. Western Transportation Institute, February 2015.

6 Galarus, Douglas, Leann Koon, Sean Campbell, and Ian Turnbull. Data Quality for Aggregation and Dissemination of DOT Traveler Information: Best Practices. Presented at the 2015 National Rural ITS Conference, Snowbird, Utah, August 10, 2015.