ENTERPRISE Transportation Pooled Fund Study TPF-5 (231)

ENTERPRISE

Portable Travel Time Displays and ICM with Parallel Routes – Phase 1

PROJECT SUMMARY REPORT

Prepared by

Athey Creek CONSULTANTS

December 2016

Acknowledgements

This document was prepared for the ENTERPRISE Transportation Pooled Fund TPF-5(231) 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).

Project Champion

Roy Hulli, Ministry of Transport, Ontario (MTO), was the ENTERPRISE Project Champion for this effort and served as the overall lead for the project.

Members

The ENTERPRISE Board consists of a representative from each of the following member entities of the program.

- Federal Highway Administration
- Georgia Department of Transportation
- Illinois Department of Transportation
- Iowa Department of Transportation
- Kansas Department of Transportation
- Michigan Department of Transportation
- Ministry of Transportation Ontario
- Minnesota Department of Transportation
- Oklahoma Department of Transportation
- Pennsylvania Department of Transportation
- Texas Department of Transportation
- Transport Canada

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1.0 Introduction

The ENTERPRISE Pooled Fund completed a project in 2012 called the "Impacts of Traveler Information on the Overall Network" Project to understand the impacts that travel time message displays (web and roadside) have on the network. The outcome of the project concluded that travel time displays have an impact on traffic diversions as travelers react to the increased information presented to them. However the project did not go into a next phase to understand what locations are conducive to travel time displays being the most effective at diverting traffic.

This Phase 1 ENTERPRISE Portable Travel Time Display (PTTD) project was initiated in 2016 with the intent of exploring the feasibility of a system that would enable Departments of Transportation (DOTs) to temporarily locate and test travel time displays at additional locations in order to assess the anticipated impacts on the network without a permanent deployment. If a PTTD system is successfully developed, it could be a tool that DOTs deploy for limited periods of time (1-3 months) to assess the impact on the network to decide if a permanent deployment of a travel time display system is warranted, before moving the portable system to new sites for further assessment. Additionally, if enough PTTD deployments occur in multiple states, the ENTERPRISE members could begin to understand contributing factors that can help predict the impacts of travel time displays.

This document represents the summary report of Phase 1 of the PTTD Project. Following this brief introduction, the remainder of the document is structured as follows:

Section 2 describes the overall ENTERPRISE PTTD effort (Phases 1 and 2), describes the Phase 1 Project activities completed, summarizes the project deliverables, and describes the process for ENTERPRISE members to propose Phase 2 deployment sites.

Section 3 includes a Phase 2 Site Planning Worksheet/Questionnaire that is intended to assist ENTERPRISE members in identifying and assessing potential Phase 2 sites.

Section 4 presents project conclusions and summarizes next steps.

Appendix A includes the PTTD Concept of Operations document, a deliverable of Task 1 of this project.

Appendix B includes the PTTD System Requirements, a deliverable of Task 2 of this project.

2.0 ENTERPRISE PTTD Project – Summary and Results of Phase 1

2.1 ENTERPRISE PTTD Project Phases and Schedule

The ENTERPRISE PTTD Project was approved as a two phased project, with a go/no-go decision after Phase 1. The two phases were defined as follows:

Phase 1: Project Definition – The goal of Phase 1 was to complete the initial systems engineering analysis, and to create a plan for identifying Phase 2 locations. Ideally, Phase 2 locations would have been identified and confirmed within Phase 1. This has not yet occurred, however at least two ENTERPRISE member agencies are considering proposing Phase 2 deployment sites.

Phase 2: Technology Proof of Concept – In Phase 2, the goal is to assemble a PTTD System that matches the requirements defined in Phase 1, and deploy the system in one or more locations. Once deployed, an evaluation will be conducted to understand the benefits of a PTTD System.

Figure 1, below, illustrates the phases and high level schedule for this project.

<table>
<tr><th colspan="10">2016</th><th>2017</th></tr>
<tr><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td><td>Dec</td><td>Timing - TBD</td></tr>
<tr><td colspan="10">Phase 1 – Systems Engineering & Project Definition</td><td>Phase 2 – Proof of Concept & Readiness Assessment</td></tr>
<tr><td colspan="10">- Systems Engineering Analysis
- ConOps Development
- Requirements Development
- Develop Plan for Phase 2</td><td>- Final Site Selection and Commitment
- Limited technology deployment
- Test of technical readiness
- Test of institutional readiness
- Test of policy readiness</td></tr>
</table>

Figure 1 – Project Phases and Preliminary Schedule

2.2 Phase 1 Findings

Task 1 – Concept of Operations

The first task in Phase 1 of the PTTD Project was to work with the project champions (representatives from Ministry of Transport, Ontario – MTO) and other ENTERPRISE members to develop an overall Concept of Operations (ConOps) for the PTTD concept. The intent of the ConOps was to capture the stakeholder needs, identify project objectives, and create an overall operational concept for how PTTD systems would be used in Phase 2 of the project.

The ConOps was approved in August 2016, and is attached as Appendix A to this report. The ConOps is summarized as follows:

- A total of ten needs are identified for portable travel time functionality, each need was mapped to one or more challenges/issues;
- Three categories of project objectives were defined:
    - Objectives related to assessing the likely impacts of permanent systems;
    - Objectives related to temporary deployments in rural environments; and
    - Overall (universal) project objectives;
- Operational concepts were defined for two location type scenarios:
    - Location #1: An urban location to predict the impacts of a permanent travel time display system; and
    - Location #2: A rural (or urban) area where a temporary planned event or work zone will cause unusual delays along a primary route.

Task 2 – Functional Requirements and Phase 2 Project Planning

The objective of Task 2 was to build upon the ConOps developed in Task 1 and to prepare for Phase 2 deployment. In order to prepare for Phase 2 deployment, two key deliverables were prepared in Task 2, defined as follows.

Functional Requirements. The Functional Requirements document was approved in August, 2016 and is included as Appendix B of this report (note the Concept of Operations and Requirements were originally circulated to members and approved as one document, but are separated for purposes of presentation in this summary report. The set of requirements include:

- Site requirements. These are the minimum requirements understood to enable a Phase 2 location to properly assess the PTTD concept;
- Functional requirements for system components. These are requirements for the functionality of systems components that would be required for Phase 2 (either existing systems or new systems developed for the project); and
- Requirements for the project team. These are requirements for the participation of the project team, to consist of local individuals, ENTERPRISE members, and an evaluation contractor.

The intent of the requirements was to provide specific details about what is required to complete Phase 2 in order to allow ENTERPRISE members to fully understand the technical systems and institutional relationships anticipated for Phase 2 deployment, but not to define the requirements to such a level as to exclude various technical approaches.

Phase 2 Site Selection Plan. The second deliverable in Task 2 is a Phase 2 Planning Worksheet that was developed to assist ENTERPRISE members in working with others within their organization to identify Phase 2 sites, and plan for Phase 2 deployment. This document is included in Section 3 of this report.

2.3 PTTD Project – Phase 2 Planning

The original plan for the PTTD Project was to include a "go/no-go" decision at the conclusion of Phase 1 that could allow the ENTERPRISE Board to consider the outcome of Phase 1 and the proposed deployment locations for Phase 2 in order to make a final decision about funding Phase 2. As part of this plan, the original intent of Phase 1 of the project was that one or more ENTERPRISE members would have determined with certainty that they would like to participate in Phase 2 and be prepared to dedicate the resources to do so. Commitment by one or more ENTERPIRSE members to participate in Phase 2 has not yet been confirmed. Nonetheless, at least two member agencies are still actively discussing Phase 2 participation and the Phase 2 Site Selection Planning Worksheet, ConOps, and Functional Requirements are resources for their consideration.

In regards for funding of Phase 2, the ENTERPRISE Work Plan for Fiscal Year 2017 includes the Phase 2 PTTD Project (funded at $75,000) as the sixth highest ranking new project to be supported with Fiscal Year 2017 funds. The current status of the ENTERPRISE Pooled Fund is that there are uncertainties in the exact funding level for 2017, and the PTTD project is identified as a project that could potentially be funded in part or in entirety, depending upon final contribution levels.

Because funding levels are uncertain and members are still working to identify deployment sites for Phase 2, the proposed approach for moving forward is to encourage members to propose PTTD Project Phase 2 sites as part of the Fiscal Year 2018 Work Plan project submittal process (voting to occur in fall of 2017). With this approach, members are encouraged to use the Phase 2 Planning Worksheet, the requirements, and the ConOps to identify Phase 2 project sites for submittal.

3.0 Phase 2 Planning Worksheet / Questionnaire

In order to identify locations for Phase 2, a four-page document was prepared for ENTERPRISE agencies to use to identify potential locations for a portable travel time deployment site. The document is intended to be circulated as a stand-alone resource for ENTERPRISE members to communicate with other staff within their agencies in developing plans for Phase 2 deployment. The document includes background on the project and answers the following questions:

- What do we know about travelers' reactions to web and roadside travel time displays?
- What is the ENTERPRISE Portable Travel Time Displays and ICM with Parallel Routes Project?
- What is a Portable Travel Time Display System?
- What has been completed so far?
- How can we become involved?
- What would be expected to participate in the project?
- What are the next steps to explore our involvement (including a series of questions to help prioritize Phase 2 site selection)?

Portable Travel Time Displays & ICM with Parallel Routes

Phase 2 Planning Worksheet/Questionnaire

Identifying Portable Travel Time Deployment Sites

Departments of Transportation (DOTs) have found that displaying travel time messages on Dynamic Message Signs (DMS) can be an effective mechanism for informing travelers about expected delays along their route. This information provides the traveler with information to determine whether to continue along their route or consider an alternate route (if available). Deploying a DMS is a costly investment for a DOT and after the deployment it may be found that the anticipated impact on traffic is not recognized. Therefore, the ENTERPRISE members were interested in exploring a project to deploy portable DMS at locations where it is anticipated travelers may divert to another parallel route based on travel times posted to determine if the selected location will have an impact on traffic. The purpose of this document is to provide overall background information on the project and assist agencies in participating in this project by identifying a location(s) for a portable travel time deployment site in order to summarize results (e.g. benefits, lessons learned) based on multiple locations.

What do we know about travelers' reactions to web and roadside travel time displays?

ENTERPRISE completed a project in 2012 "Impacts of Traveler Information on the Overall Network" to understand the impacts that travel time message displays (web and roadside) have on the network. The project conducted on-line surveys that were linked from Minnesota DOT and Washington State DOT traveler information websites to gather feedback from travelers on their use of travel time information displayed on the web and on the roadside. In addition, historical travel time displays on DMS together with related traffic volume data (from locations downstream of the DMS) from Minnesota and Washington networks were analyzed. Both the survey and data analysis revealed that when roadside signs display travel times higher than typical, there is a direct correlation to the number of travelers that divert to alternate routes. The survey responses verified these findings. In addition, from the two metropolitan areas (Minneapolis/St. Paul, Minnesota and Seattle, Washington) studied, the thresholds for when travelers diverted based on travel time messages on DMS were approximately double the typical travel times. These results confirmed that travel time displays have an impact on traffic, however the project did not go into a next phase to understand what locations are conducive to travel time displays being effective at diverting traffic.

What is the ENTERPRISE Portable Travel Time Displays and ICM with Parallel Routes Project?

In 2016, ENTERPRISE began a project to develop a concept for a Portable Travel Time Display (PTTD) System that could be deployed in locations to display travel times (along the primary route and possibly along an alternate route). The overall intent of this portable system is to enable DOTs to test travel time displays and assess whether the impacts reduce congestion/travel times or have other impacts on driver behavior or benefit travelers.

If a PTTD system is successfully developed, it could be a tool that DOTs deploy for limited periods of time (1-3 months) in locations and assess the impact on the network in order to decide if a permanent deployment of a travel time display system is warranted, before moving the portable system to new sites for further assessment.

While the concept is simple, there are many unknowns, for example:

- How long would a portable system need to be operated in order to predict the impacts of a permanent travel time display system?
- What confidence would DOTs have in the results of a portable system?
- Beyond the quantitative benefits (e.g. reduced travel times along primary route as travelers divert to alternate routes) are there qualitative benefits recognized by travelers and transportation professionals?
- What are the institutional challenges associated with DMS displays that potentially create diversions onto local routes operated by other jurisdictions?

The overall goal of this ENTERPRISE project is to deploy multiple portable travel time display systems, and analyze the results of several deployments to assess the benefits and usefulness of this tool.

What is a Portable Travel Time Display System?

The concept of a Portable Travel Time Display system is equipment that can be positioned to monitor travel times (or speeds) along a primary route, and display this travel time to travelers upstream of a possible diversion point. Optionally, the system could also monitor the travel time (or speed) along the alternate route as well, providing travelers with information about both options. The data collection method may be physical infrastructure (e.g. Bluetooth readers) or data acquired through 3rd Party Data Providers. The display mechanism for the travel times is most likely to be a portable DMS.

The concept for a Portable Travel Time Display system is to be operated for three periods in order to assess the impacts, as follows:

- Period 1 will include data collection and retention to understand the current traffic patterns, with no information dissemination to travelers. A minimum of one week is required for Period 1, but as much as one month would be an ideal timeframe.
- Period 2 will include data collection and processing in conjunction with information dissemination to travelers, together with the same data collection and retention performed in Period 1 to understand the traffic pattern changes with information dissemination to travelers.
- Period 3 will include data collection and retention to understand the traffic patterns with no information dissemination to travelers to assess if the traffic pattern changes remain in effect after discontinuing the information dissemination.

What has been completed so far?

The first phase of the ENTERPRISE project conducted the initial stages of a systems engineering analysis. A Concept of Operations and Requirements document was developed that included:

- Challenges Regarding Urban and Rural Corridor Management
- Current Situation, Challenges and Needs
  - Current Tools for Traffic Data Collection and Information Dissemination
  - Transitional Technologies Expected to Impact Corridor Management
  - Challenges/Issues and Needs to be addressed by PTTD Systems
- Project Objectives
  - Objectives related to Assessing the Likely Impacts of a Permanent System
  - Objective related to Temporary Deployments in Rural or Urban Environments
- Operational Concepts
- Portable Travel Time Dissemination Requirements

The Portable Travel Time Displays and ICM with Parallel Routes Concept of Operations and Requirements document was completed by ENTERPRISE in August 2016.

How can we become involved?

ENTERPRISE has approved the second phase of the PTTD effort to use the Concept of Operations and Requirements developed to deploy PTTD systems. However, to finalize the funding available for deployments, locations for deployment of the PTTD systems need to be identified. The purpose of this document is request your participation in submitting and suggesting locations to serve as a deployment(s) of a PTTD system.

What would be expected to participate in the project?

Expectations of the PTTD sites are as follows:

- **Identify a location to test the PTTD system.** The location should include a primary route and at least one alternate route to reach approximately the same destination. Details about the site selection are included in the ConOps and Requirements document.

- **Deploy equipment and systems to operate the PTTD system.** It would be the responsibility of the agency participating to provide the equipment and system needed to monitor speed or travel times, display the speed or travel times on a DMS display, and record volume on the primary route. Details about the needed systems are included in the Concept of Operations and Requirements. In many situations, existing detection could provide the speed/travel time data. Existing permanent DMS upstream of a diversion point could be used, or portable DMS could be rented for the deployment by the agency.

- **Participate in the overall ENTERPRISE project.** As a Pooled Fund, ENTERPRISE projects do not typically deploy equipment, but rather serve as a central overall evaluation support to the project. In this project, the role of ENTERPRISE provided contractors will be to work with each member agency deploying a portable system to evaluate the data collected and synthesize data from multiple sites to draw any conclusions about lessons learned.

What are the next steps to explore our involvement?

To help you determine participation in this project, and ultimately to enable you to suggest a location for deployment, please answer the following questions.

1. Location.
   a. Is the candidate route 20 miles or less in length (although longer distances are acceptable)?
   b. Does the location include a primary route that is recognized to encounter congestion during non-recurring events such as incidents, weather, or other events?
   c. Does the location include an alternate route that travelers may use to reach a location near the destination of the primary route (or to rejoin the primary route)?

   If you answered yes to 1a, 1b, and 1c move to Question 2. Otherwise consider a different location.

2. Data Collection.
   a. Is there any data collection of speed or travel time on this route now?
      i. *Yes, move to Question 3*
      ii. *No, move to Question 2b*
   b. Would you have the capability to procure or deploy data collection for at least the duration of this project (up to 4 months)?
      i. *If no, consider a different location*
      ii. *If yes, move to Question 3*

3. Display Systems.
   a. Is there currently a DMS located within a few miles upstream of the divergent point?
      i. *Yes, move to Question 4*
      ii. *No, move to Question 3b*
   b. Would you have the capability to procure or deploy a portable DMS to a location upstream of the divergent point?
      i. *If no, consider a different location*
      ii. *If yes, move to Question 4*

4. Alternate Route.
   a. Is the alternate route you identified under the same jurisdiction as the primary route?
      i. *Yes, consider submitting your location for a PTTD deployment*
      ii. *No, move to Question 4b*
   b. Do you feel the relationship with the other jurisdiction would support your deployment of this system and be willing to participate in occasional meetings to discuss this project and the results?
      i. *If no, consider a different location.*
      ii. *If yes, consider submitting your location for a PTTD deployment*

Contact

For additional information regarding the ENTERPRISE PTTD project or to submit locations to consider for deployment of a PTTD system, please contact Roy Hulli, Ministry of Transportation Ontario at Roy.Hulli@ontario.ca or Dean Deeter, Athey Creek Consultants, at deeter@acconsultants.org.

4.0 Conclusions

Since 2012, ENTERPRISE members have had information describing the impacts that travel time displays have on driver diversion rates. However, the locations studied in the 2012 project "Impacts of Traveler Information on the Overall Network" were locations where MnDOT and WSDOT had identified to be key decision points, and therefore located travel time displays on DMS. As the transportation industry transitions to a more connected world, it is likely that additional DMS will be deployed and that travelers will receive more traveler information from mobile devices and ultimately connected vehicles. As this transition occurs, it will be important for state and local DOTs to predict the impacts to be expected if travel time displays (roadside DMS or in-vehicle) are operated at additional locations.

The ENTERPRISE PTTD Project Phase 1 was an initial step towards testing portable devices that could be used to assess the impacts of travel time displays at multiple locations. The resources developed within this Phase 1 project are now available for ENTERPRISE members to use when identifying locations for a Phase 2 effort to develop, deploy, and assess portable travel time display systems. The ranking of the Phase 2 of this project in the ENTERPRISE Fiscal Year 2017 Work Plan voting process demonstrates that members still see value in Phase 2, provided there are test locations and champions willing to participate in Phase 2 deployment.

ENTERPRISE members have agreed that this project should include a "go/no-go" decision following Phase 1. The ENTERPRISE project submittal process planned for Fiscal Year 2018 Work Plan will provide a formal mechanism for this process by enabling members to use the resources included in this document to finalize proposed Phase 2 locations and submit them for the overall Board "go/no-go" decision.

Appendix A – Portable Travel Time Displays Concept of Operations

ENTERPRISE Transportation Pooled Fund Study TPF-5 (231)

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Portable Travel Time Displays and ICM with Parallel Routes – Phase 1

CONCEPT OF OPERATIONS

Prepared by

Athey Creek CONSULTANTS

August 2016

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1.0 Summary of Challenges Regarding Urban and Rural Corridor Management

The Vision of a Connected, Integrated, and Managed Transportation Network

The benefits of technologies applied to transportation have been demonstrated over the past 40 years. Recently, a number of catalysts have expedited the rate at which technology solutions are becoming a reality. These 'catalysts' include such things as high speed wireless communications (e.g. 4G wireless communications, Long Term Evolution (LTE)), personal mobile devices (e.g. iPhones, Smartphones, and Tablets), in-vehicle navigation and communications systems, and reduced costs of Dynamic Messages Signs (DMS) and other field infrastructure.

Based on these and other catalysts, the evolving vision for moving people and goods as safely and efficiently as possible now includes:

- Vehicles and drivers connected wirelessly to central management centers, to the roadside infrastructure, and to other vehicles – engaged in a two-way exchange of data and information;
- Transportation providers managing freeway, arterial, and transit systems in a coordinated manner to direct travelers away from congested infrastructure and towards under-utilized transportation assets (freeway lanes, arterial segments, or transit options) in near real time.

Concepts Expected to Help Reach the Vision

Three technology 'concepts' are increasing in deployment throughout North America:

- The ***Connected Vehicle concept*** is to equip commercial and passenger vehicles with data monitoring, communications, and driver display/announcement technologies to effectively connect each vehicle to other vehicles, to roadside devices, and to central transportation management centers. In the coming years, as autonomous aspects of vehicles increase, the Connected Vehicle concept will merge with partial or full vehicle autonomy to become "Connected Automation."

- The ***Integrated Corridor Management (ICM) concept*** is to integrate the management of freeway, arterial, and transit systems to maximize efficiency and safety across all systems in both metropolitan areas and along rural corridors connecting metropolitan areas.

- ***Information Dissemination to Mobile Devices*** is increasingly being used by both public and private sector information service providers who reach travelers through their personal devices using mechanisms such as mobile applications, social media, and traditional cellular phone calls, texts, and Internet sites.

Together, aspects of each of these concepts will advance the vision of moving people and goods safely and with minimal impact on the environment. The concepts proposed in this document are envisioned to make the most impact when the dissemination approaches include wireless devices and Connected Vehicles. However, while the planned deployments during the Phase 2 demonstration will not exclude these approaches, the primary information dissemination technologies are expected to include more traditional roadside devices, such as DMS.

The Role of Portable Travel Time Dissemination (PTTD) Systems in the Overall Vision

The concept of monitoring delays and travel times on a primary and alternate route in order to inform travelers of the most effective route offers near-term localized traffic relief to key segments of a transportation network. As the number and geographic coverage of these deployments expands, the overall network will become better understood and can be managed at the holistic network-wide level.

PTTD Systems have the potential to play two key roles in this expansion towards network-wide management:

- Helping state/provincial and local transportation agencies assess and predict the benefits of permanent travel time displays and/or integrated corridor management systems at individual locations within the network by trialing deployments; and
- Becoming a solution to support management of short-term events (including: road work, major concerts, and large sporting events).

Enabling technologies that include portable DMS, Bluetooth and/or Wi-Fi traffic detection, probe vehicle travel time estimation, mobile phone, and social media outlets are all existing 'ground ready' solutions that can be deployed today to demonstrate and evaluate PTTD solutions. However, transitional technologies coming in the next 3 to 10 years such as Connected and Automated Vehicles (CAV) offer an even better opportunity to leverage lessons learned in trial deployments today to fully recognize the benefits of PTTD.

1.1 Project Goal

The overall goal of this project is to ***assess and understand the overall potential of PTTD systems for two primary purposes:***

1. ***To be used by state/provincial and local DOTs to assess the likely benefits of permanent travel time or ICM systems by trialing a system that informs drivers of travel times on primary and alternate routes for a limited period and assessing the impacts***
2. ***To be used as temporary traffic management / traveler information tools to assist during short term special events, especially in rural areas.***

1.2 Project Definition Phases and Schedules

In order to accomplish this goal, the ENTERPRISE Transportation Pooled Fund Study has created the Portable Travel Time Dissemination Evaluation Project (the Project). This two stage project will conduct a proof of concept assessment of at least one use of a PTTD. Preferably, multiple deployments will be conducted during the proof of concept phase.

This Concept of Operations document is a key component of Phase 1, as the findings of this document (including the requirements included in Section 5) will be used to create a project plan, defining details for the field deployment to occur in Phase 2. ENTERPRISE members are interested in Phase 2, but will reach a "go / no go" decision pending the outcome of Phase 1 and the ability to identify the deployment locations.

The ENTERPRISE Pooled Fund currently involves 12 state DOTs, MTO, Transport Canada, and the Federal Highway Administration (FHWA). ENTERPRISE members will be involved in this project, monitoring progress and results to understand the role that PTTD can play in their respective organization.

The Project is envisioned to have two primary phases:

Phase 1: Project Definition – In this phase, the initial systems engineering analysis will develop a Concept of Operations (ConOps) to document the current situation, challenges, and needs for a PTTD System, and define the project objectives. Once the ConOps is complete, Phase 1 will define functional requirements of technologies, and create a project plan. Finally, efforts will form the project partnerships, agreements, and task authorizations needed to begin the Proof of Concept phases, including any needed requests for proposals or other solicitations.

Phase 2: Technology Proof of Concept – In Phase 2, the goal is to assemble a PTTD System that matches the requirements defined in Phase 1, and deploy the system in one or more locations in accordance with the operational concepts defined in this ConOps and assess the impacts.

Figure 1, below, illustrates the phases and high level schedule for this project.

2016										2017							
Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug
Phase 1 – Systems Engineering & Project Definition										**Phase 2 – Proof of Concept & Readiness Assessment**							
- Systems Engineering Analysis - ConOps Development - Requirements Development - ID Phase 2 Project Partners - ID Phase 2 Project Location(s) - Confirm Schedule										- Limited technology deployment - Test of technical readiness - Test of institutional readiness - Test of policy readiness							

Figure 1 – Project Phases and Preliminary Schedule

2.0 Summary of the Current Situation, Challenges, and Needs

2.1 Current Tools for Traffic Data Collection and Information Dissemination

North American states and provinces currently operate a number of systems to monitor traffic conditions and inform other travelers of these conditions. The most typical scenario is that permanent DMS controlled by central Traffic Management Center / Transportation Operations Center (TMC/TOC) control systems post travel time messages for primary and secondary routes based on traffic data collected from DOT owned sensors or third party data providers.

2.2 Transitional Technologies Expected to Impact Corridor Management

The increased presence of private operated traveler information systems, such as Waze or Google Maps, together with increased availability of real-time traffic speeds is changing the travel patterns of today's drivers. In the coming 3 to 10 years, the number of vehicles "connected" to the infrastructure will increase drastically.

As a result, traveler information is currently very much in a transitional phase, leaving the era of a DMS centric environment to reach travelers en-route to more of a vehicle or hand-held device based information delivery system.

2.3 Challenges / Issues and Needs to be addressed by PTTD Systems

The following table summarizes the challenges, and articulates needs as a result of these challenges. The needs will be the basis for the remainder of the operational concepts and requirements defined for this project.

Table 2.1 – Challenges/Issues and Needs to be Addressed by the PTTD Systems

Challenges / Issues	Need for a Portable Travel Time Dissemination Functionality
DOTs are not always able to predict the extent to which permanent travel time monitoring and display systems would influence route choice and alleviate congestion until systems are deployed. The costs to deploy permanent systems often prevents deployments in areas where the impacts are unknown.	***Need 1:*** There is a need for a system for which all components are portable and can be deployed temporarily in situations to monitor and report conditions to travelers.
	Need 2: The System needs a source for travel time or delay information for the primary route.
	Need 3: The System needs a source of travel time or delay information for the alternate route(s).

Challenges / Issues	Need for a Portable Travel Time Dissemination Functionality
Temporary events that restrict capacity or increase demand can cause excessive delays and travel times on affected routes. Because of the nature of temporary events, visitors are often unaware of alternate route options.	***Need 4:*** The System needs a mechanism to process travel time or delay information and formulate messages to disseminate to travelers.
	Need 5: When using the system to assess the impacts of travel time dissemination, there is a need for the system to determine some value(s) to estimate the impacts of deployed dissemination.
	Need 6: For evaluation purposes (e.g. comparing a work zone TMP vs. the actual delay, assessing the impacts of messages displayed, etc.), there is a need for all messages displayed to travelers to be timestamped and recorded for later review.
DOTs do not have excessive funds available either for temporary traffic management during events or to assess the benefits of permanent ICM type systems.	***Need 7:*** There is a need for the costs of deploying and operating the System for the designated timeframe to be less than the costs of permanent deployments.
In some scenarios, real-time TMC/TOC operators may be able to contribute to operational responses, in addition to the automated actions.	***Need 8:*** There is a need for an option of real-time access to data and control of field equipment from the TMC/TOC, with the option to not include this for cost savings or simplicity in sight specific deployments.
Beyond the technical challenges and potential, there are considerable institutional and inter-jurisdictional issues to be considered.	***Need 9:*** There is a need in this project to understand the issues and impacts surrounding system deployment with neighboring jurisdictions.
A series of non-traditional mechanisms either now or will soon exist to communicate with drivers to encourage route selection.	***Need 10:*** There is a need to explore non-traditional methods to both encourage route choice (incentives, gamification) and to communicate such encouragements to travelers.

3.0 Portable Travel Time Dissemination – Project Objectives

3.1 Objectives related to Assessing the Likely Impacts of Permanent Systems

3.1.1 The project will allow partner agencies to demonstrate the use of a low cost, portable Travel Time measurement and display system to predict the impact of a permanent system. (Need 1, 2, 3, 4, 5 and 7)

3.1.2 The project will allow partner agencies to understand the technical and institutional issues with the system. (Need 9)

3.1.3 The project will allow partner agencies to understand the benefits of using the system (e.g. did it help reach a decision about deploying permanent systems?). (Need 5 and 6)

3.1.4 The project will allow partner agencies to understand who requires access to real-time information (e.g. TMC, field staff, etc.) to be documented for future deployments. (Need 8)

3.1.5 The project will allow partner agencies to define minimum requirements for systems to be used in the future. (Need 8)

3.1.6 The project will allow partner agencies to document an approach for DOTs procuring/selecting vendor products or services to be used in the future. (Need 9)

3.1.7 The project will allow partner agencies to document the need for and issues surrounding a process of establishing needed inter-agency agreements with agencies operating alternate routes, together with any candidate approaches (to the extent they can be understood recognizing the issues differ for each jurisdiction). (Need 9)

3.1.8 The project will allow partner agencies to research and explore non-traditional methods to encourage route diversions (e.g. incentives and gamification). (Need 10)

3.1.9 The project will allow partner agencies to consider and explore systems to accommodate personal (e.g. Connected Vehicle, cell phone) delivery of travel time messages, either initially or as Connected Vehicle devices expand. (Need 10)

3.2 Objectives related to Temporary Deployments in Rural or Urban Environments

3.2.1 The project will demonstrate the use of a portable Travel Time measurement and display system to reduce congestion and travel times during a temporary planned event or work zone. (Need 1, 2, 3 and 4)

3.2.2 The project will allow partner agencies to understand the technical and institutional issues with the system. (Need 9)

3.2.3 The project will allow partner agencies to understand the benefits of using the system (e.g. did it help minimize delays?). (Need 6)

3.2.4 The project will allow partner agencies to define minimum requirements for systems to be used in future deployments. (Need 7, 9 and 10)

3.2.5 The project will allow partner agencies to document an approach for DOTs procuring/selecting vendor products or services to be used in the future. (Need 9)

3.2.6 The project will allow partner agencies to document the process of establishing needed inter-agency agreements with agencies operating alternate routes, together with issues and solutions. (Need 9)

3.2.7 The project will allow partner agencies to research and explore non-traditional methods to encourage route diversions (e.g. incentives and gamification). (Need 10)

3.2.8 The project will allow partner agencies to understand design considerations when considering systems to accommodate personal (e.g. Connected Vehicle, cell phone) delivery of travel time messages, either initially or as CV devices roll out. (Need 10)

3.2.9 The project will allow partner agencies to understand the extent to which trip diversions to alternate routes need to be modeled (e.g. micro, meso, or sketch modeling) to predict impacts to local roads. (Need 10)

3.3 Overall (Universal) Project Objectives

3.3.1 The project will prepare model systems engineering documents that can be used by member agencies (to be adapted as needed) to support local procurement, design, and development of PTTD Systems.

3.3.2 The project will work with one or more project partners to perform the system development, deployment, and operation.

3.3.3 The project will work with one or more transportation agencies to deploy the system in operational settings.

4.0 Portable Travel Time Dissemination Proof of Concept – Operational Concepts

The following subsections define operational concepts for two location type scenarios:

- Location #1: An urban location to predict the impacts of a permanent travel time display system; and
- Location #2: A rural (or urban) area where a temporary planned event or work zone will cause unusual delays along a primary route.

4.1 Location #1 - Assessment of Impacts - Operational Concept

Location #1 will be a site to perform a proof of concept that a set of technology tools (i.e. the System) can be deployed and operated for a limited period of time to understand if a permanent system would have an impact on congestion in the area. The final site selection for Location #1 will occur in the coming months. The intent is to find a location:

- With a primary corridor that experiences recurring congestion, and on some days experiences greater congestion (e.g. when incidents or stalled vehicles restrict capacity).
- With an alternate corridor/route that is a viable alternative for traffic to avoid congestion on the primary route, and both routes reach a common area.
- To understand if there is only one alternate route or if there are multiple routes. If there are multiple routes, the project should monitor those as well to understand the impacts that occur on all alternates.
- To understand the qualitative impact of PTTD deployment. Regardless of the extent of quantitative impacts (e.g. reducing delays or minimizing travel times) there will likely be qualitative impacts as observed by the traveling public (e.g. the traveling public may appreciate the system and have favorable views on it, or the traveling public may oppose the system) or by transportation agencies operating either the primary or alternate routes. Ideally, the selected route and participating partners will have enable some level of assessment of qualitative impacts (e.g. public opportunities to offer feedback or input, or other similar scenarios).
- It would be preferable if the alternate route is within the same jurisdiction of the primary route (note: the proposal is that the initial deployment avoid the challenge posed by multiple jurisdictions in order to invite other jurisdictions to observe and participate in the process such that they may be open to participating as a “Phase 2” site).
- With a connector (e.g. ramp or intersection) that enables traffic on the primary corridor to divert to the alternate corridor based on information to be disseminated.

- With no exceptional level of ITS deployments existing on the primary corridor (as the intent is to demonstrate this as a solution to be used in multiple locations, the site should not have any special level of technologies).

The overall timeframe anticipated for a Location #1 deployment is expected to be 1-4 months, but may be shortened or extended based on the specific location and situation. The ideal timeframe would be either spring or fall of the year to capture typical commute travel patterns.

The following operational concepts describe the planned deployment at Location #1.

4.1.1 The Deployment at Location #1 will include three Periods of Deployment:

- Period 1 will include data collection and retention to understand the current traffic patterns, with no information dissemination to travelers. A minimum of one week is required for Period 1, but as much as one month would be an ideal timeframe.
- Period 2 will include data collection and processing in conjunction with information dissemination to travelers, together with the same data collection and retention performed in Period 1 to understand the traffic patterns with information dissemination to travelers.
- Period 3 will include data collection and retention to understand the traffic patterns with no information dissemination to travelers to assess if the traffic pattern changes remain in effect after discontinuing the information dissemination.

Period 1 Concepts:

4.1.2 The Period 1 deployment in Location #1 will include a mechanism to monitor and record for analysis the travel times for a stretch of the primary corridor and a stretch of an alternate route to reach the same general location. (Objective: 3.1.1)

4.1.3 The tools deployed as part of the Period 1 deployment will remain operational and collecting data for a period to be determined by the final project team that is estimated to be 1 to 4 weeks. (Objective: 3.1.1)

4.1.4 The Period 1 deployment in Location #1 will be solely collecting data for review and analysis. Ideally, project partners will have access to the data as it is collected to understand findings to date, however real-time access for purposes of response are not required. (Objective: 3.1.1)

The Period 1 Location #1 concept is illustrated in Figure 2.

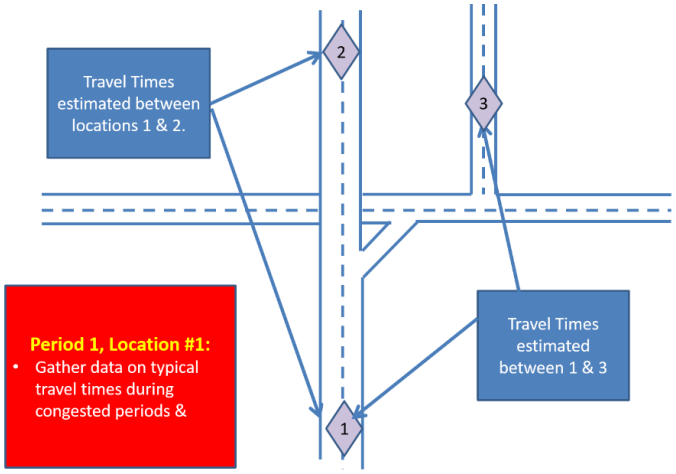

Figure 2 – Illustration of Period 1 – Location #1 Concept

Period 2 Concepts:

4.1.5 The Period 2 deployment in Location #1 will continue to include the mechanisms to monitor and record travel times on the primary and alternate route. (Objective: 3.1.1)

4.1.6 The Period 2 deployment in Location #1 will add the functionality to disseminate information to travelers using a DMS located upstream of the diversion point. Please note that the DOT may wish to assess the impacts of alternate information dissemination (e.g. Connected Vehicle roadside unit, Highway Advisory Radio (HAR), personal communication to a handset). In either situation, the DOT should deploy the field equipment being considered. (Objective: 3.1.1)

4.1.7 The Period 2 deployment in Location #1 will add the functionality to process the travel times on the primary route and the travel times on the alternate route, and display both times on the DMS, or an alternate message, as determined locally. (Objective: 3.1.1)

4.1.7.1 Data estimating the travel times along the primary and secondary routes will be reported regularly.

4.1.7.2 Care will be given to determining the frequency that updated messages are displayed to prevent driver distraction.

4.1.7.3 The operational system will allow for user settings to designate the periods of time during the day that the system will calculate and disseminate travel times (e.g. to enable selection of a peak period, but avoid operation 24/7).

4.1.7.4 *An optional feature* would make the travel time message(s) displayed on the DMS also available through an Internet accessible Extensible Markup Language (XML) feed to allow local Advanced Traffic Management System (ATMS) or Road Condition Reporting Systems to ingest the data.

4.1.8 The tools deployed as part of the Period 2 deployment will remain operational and collecting data for a period to be determined by the final project team that is estimated to be two to eight weeks. (Objective: 3.1.1)

4.1.9 The Period 2 deployment in Location #1 will be performing two separate functions: collecting data for review and analysis, and computing and disseminating appropriate messages to describe travel conditions. Ideally, project partners will have access to the data as it is collected to understand findings to date, however real-time access for purposes of response are not required. (Objective: 3.1.3)

The Period 2 concept is illustrated in Figure 3.

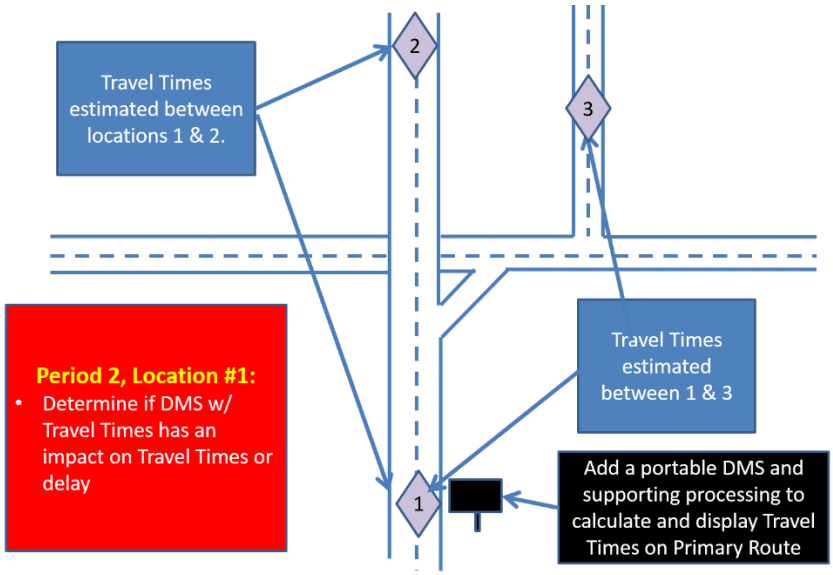

Figure 3 – Illustration of Period 2 – Location #1 Concept

Period 3 Concepts

4.1.10 The Period 3 deployment in Location #1 will remove the data processing and DMS displays that occurred in Period 2. Period 3 will return to a situation where the travel times on the primary and alternate route are measured and recorded. (Objective: 3.1.1)

4.1.11 The tools deployed as part of the Period 3 deployment will remain operational and collecting data for a period to be determined by the final project team that is estimated to be approximately one month. (Objective: 3.1.5)

4.1.12 The Period 3 deployment in Location #1 will be solely collecting data for review and analysis. Ideally, project partners will have access to the data as it is collected to understand findings to date, however real-time access for purposes of response are not required. (Objective: 3.1.1)

The Period 3 concept is illustrated in Figure 4.

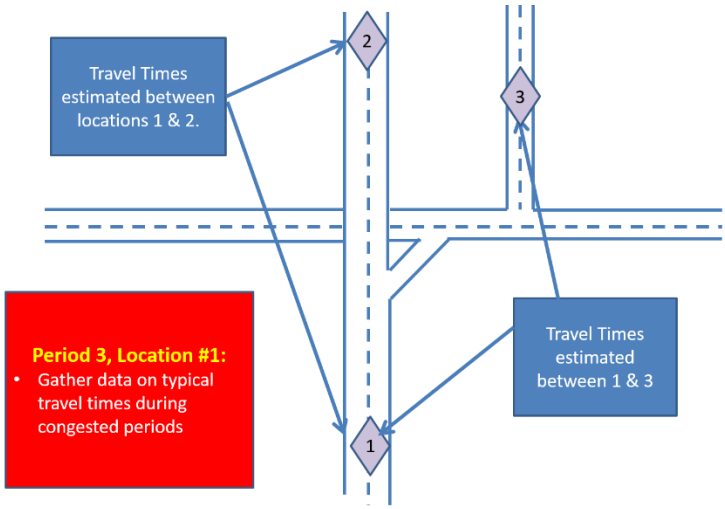

Figure 4 – Illustration of Period 3 – Location #1

Overall Location #1 Concepts:

4.1.13 Post deployment analysis at location #1 will be conducted to understand the travel times recorded on both the primary route and alternate route during all three periods. Analysis of this data will help the project team understand:

- The impact the PTTD had on reducing overall delay in the corridor while information dissemination was operational (Objective: 3.1.3); and
- Any long term impact on delay once the PTTD was removed (Objective: 3.1.3).

4.1.14 The data collected and stored in all phases will be frequent enough to perform analysis of specific time periods. The minimum time slice recommended is:

- Travel times along the corridor updated at least every 1 minute; or
- Travel speeds along pre-defined segments updated at least every 1 minute.

4.1.15 A local Project Team will be formed to discuss and resolve any local issues related to the deployment, operation, and removal of system components. Key issues to be addressed by the Local Project Team include:

- Definition of what agencies, staff positions, and individuals benefit from access to the data (e.g. does the local TMC benefit from real-time data and/or archived data). (Objective 3.1.4)
- Discussion about minimum requirements (based on the experience with the trial system) for:

- Timing of each Phase.
- Accuracy of travel time/delay information. (Objective 3.1.5)

4.1.16 An Overall Project Team will be formed to contribute to the higher level decisions of the project (e.g. data analysis and reporting). The overall project team will be kept informed of progress and decision as each Period deployment occurs. This will most likely consist of ENTERPRISE Board members.

4.1.17 An independent evaluation of the deployment will be included to work with the Local Project Team, Overall Project Team, and contractor to analyze the data and determine the benefits of the system for the purposes of predicting the impact of a permanent system. (Objective 3.1.3)

4.1.18 While Location #1 is expected to include a primary and alternate route operated by the same agency, at least one adjacent agency (e.g. local city or county) will be invited to be included in the project team to allow an assessment of the institutional issues to be addressed when the alternate route is operated by a different jurisdiction. (Objective: 3.1.7)

4.1.19 Depending upon the approach used to disseminate information, the Project Team, Evaluator, and Contractor will work to identify potential alternate solutions for disseminating the information, even if they are not deployed and tested during this deployment. (Objective 3.1.8, 3.1.9)

4.1.20 In addition to the quantitative assessment of the impacts of the PTTD, the Location #1 deployment will include a qualitative assessment of the impacts in order to understand if there are other benefits such as improvements in driver satisfaction, increased safety, or reduced DOT operations costs.

4.2 Location #2 – Urban or Rural Temporary Deployment – Operational Concept

Location #2 will be a site to perform a proof of concept that a PTTD System can be effective at informing travelers of travel times and options for a short-term event in either an urban or a rural environment. The final location will be selected with project partners, but is expected to include the following:

- A location where excessive delays are expected along a primary route due to either a planned event that will increase demand on the route for a limited time, a work zone causing delay, or other activities that will reduce capacity of the primary route. (Objective 3.2.1)
- In addition to the anticipated excessive delays, the location should include one or more alternate routes to the common destination that can be accessed by travelers diverting at a diversion point near the event.

The overall timeframe anticipated for a Location #2 deployment is expected to be the duration of the event, with possible deployment 1-7 days prior to the event to pre-warn travelers.

The following operational concepts describe the planned deployment at Location #2.

4.2.1 The PTTD System deployment at Location #2 will include a mechanism to determine the travel conditions along the primary and alternate route. This mechanism may be a measurement of actual travel times, the actual delays, or a prediction of delays due to anticipated activities (e.g. if the event is expecting 3,000 attendees arriving in a 1 hour period, anticipated delay can be predicted).

4.2.2 The PTTD System deployment at Location #2 will include a mechanism to determine or estimate the travel conditions along the alternate routes. This mechanism may be a measurement of actual travel times/delays or a prediction of delays due to anticipated activities (e.g. if the event is expecting 3,000 attendees arriving in a 1 hour period, anticipated delay can be predicted).

4.2.3 The PTTD System deployment at Location #2 will include a processing system to determine specific messages to be disseminated to travelers approaching the event. These messages may include:

- Travel times along both routes;
- Delays along both routes;
- Wayfinding arrows directing traffic to events; and
- Text describing activities (e.g. “pavement work between 7:00 PM and 5:00 AM”)

4.2.4 An overall strategy for selecting messages for each medium selected shall be determined and finalized by the project team.

4.2.4.1 Message displays on portable DMS is a candidate dissemination approach. The strategy for disseminating messages may include travel times for one or more approaches, or way-finder type displays directing traffic based on travel times.

4.2.4.2 Pre-event email/text/social media announcements of suggested routes to the event or through the work zone is a candidate dissemination approach. This may include selection of specific portions of the attendees to receive one suggested route, while other attendees receive a different approach.

4.2.5 The PTTD System deployed at Location #2 will include the functionality to automatically generate the messages (according to procedures defined by the Project Team) and communicate the messages to the selected mediums for broadcast to the travelers, receiving confirmation that the medium has received and is disseminating the information.

4.2.6 Temporary traffic pattern changes will be discussed as an option for increasing capacity on one or more routes, and the issues and challenges documented.

4.2.7 A key aspect of the PTTD System deployment at Location #2 will be discussions with the agencies responsible for the primary and alternate corridors, as well as the event owner/coordinator (i.e. the event owner may be the agency performing the road work or the venue hosting a concert or other event).

4.2.7.1 Project members will discuss scenarios for modeling the impacts on the alternate routes, mostly likely using sketch modeling techniques based on estimated travel to/from the event.

4.2.7.2 Project members will discuss different options for interagency agreements that might be used to reach agreement on an overall "Interjurisdictional PTTD System Agreement".

4.2.7.3 In addition to the jurisdictions directly involved in the project, additional jurisdictions maybe invited to participate in the process to enable the Project Team to better understand likely scenarios for other locations (e.g. to avoid the pilot deployment only representing one agencies perspective on what agreements are required).

4.2.8 Post deployment analysis at location #2 will be conducted to understand the travel times recorded on both the primary route and alternate route(s) during the time the system is operational. Analysis of this data will help the project team understand:

- The impact the PTTD had on reducing overall delay in the congested corridor while information dissemination was operational. (Objective: 3.2.3)

4.2.9 The data collected and stored in all phases will be frequent enough to perform analysis of specific time periods. The minimum time slice recommended is:

- Travel times along the corridor updated at least every 1 minute); or
- Travel speeds along pre-defined segments updated at least every 1 minute. (Objective 3.2.4)

4.2.10 A local Project Team will be formed to discuss and resolve any local issues related to the deployment, operation, and removal of system components. Key issues to be addressed by the Local Project Team include:

- Definition of any interagency agreements required for deployment of the system; (Objective 3.2.6)
- Discussion about minimum requirements (based on the experience with the trial system) for accuracy of travel time/delay information; (Objective 3.2.3)
- Discussion of real-time data needs during operations (e.g. a nearby TOC/TMC may wish to receive real-time data feeds).

4.2.11 An Overall Project Team will be formed to contribute to the higher level decisions of the project (e.g. data analysis and reporting). The overall project team will be kept informed of progress and decision as each Period deployment occurs. This will most likely consist of ENTERPRISE Board members.

4.2.12 An independent evaluation of the deployment will be included to work with the Local Project Team, Overall Project Team, and contractor to analyze the data and determine things such as:

- Best practices and/or lessons learned regarding procurement and specification of systems used in the deployment; (Objective 3.2.5)
- The need for modeling (e.g. sketch modeling) to predict the impacts on alternate routes) (Objective 3.2.9); and
- Technical and institutional issues identified.

4.2.13 Depending upon the approach used to disseminate information, the Project Team, Evaluator, and Contractor will work to identify potential alternate solutions for disseminating the information, even if they are not deployed and tested during this deployment. (Objective 3.2.7 and 3.2.8)

4.2.14 The Project Team involved in the Location #2 deployment will include activities to understand any qualitative benefits such as improvements in driver satisfaction, increased safety, or reduced DOT operations costs.

Appendix B – Portable Travel Time Displays Requirements

ENTERPRISE Transportation Pooled Fund Study TPF-5 (231)

ENTERPRISE

Portable Travel Time Displays and ICM with Parallel Routes – Phase 1

REQUIREMENTS

Prepared by

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August 2016

Table of Contents

1.0 Introduction

This document accompanies the Portable Travel Time Displays (PTTD) Concept of Operations document. The intent of this document is to define requirements for PTTD Phase 2 deployment.

The requirements are organized by two location types, defined in the Concept of Operations as follows:

- Location #1: An urban location to predict the impacts of a permanent travel time display system; and
- Location #2: A rural (or urban) area where a temporary planned event or work zone will cause unusual delays along a primary route.

The requirement tables below refer to "Concept IDs". These are numbered concepts contained in the Concept of Operations document.

2.0 Portable Travel Time Dissemination Requirements

The following tables define requirements for the PTTD Deployments described in the PTTD Concept of Operations. Table 2.1 defines requirements for all three phases of Location #1. Table 2.2 defines requirements for Location #2.

The majority of the requirements are defined as requirements for the functions that the ***PTTD System*** must perform. However additional requirements describe requirements for the ***Local Project Team***, the ***Overall Project Team***, and the ***Evaluator***.

Finally, many of the requirements are intentionally vague so as not to limit the locations that the PTTD might be deployed during this initial deployment, and the technologies described are not specified to the extent they would be if a known location was defined. There is an expectation that some modifications to the requirements would be performed in conjunction with the contractor performing the deployments. The primary use of these requirements would be to share with potential contractors and infrastructure owners and operators that might participate in the demonstrations.

Table 2.1 – Requirements for Location #1

Concept ID	Operational Concept	Req ID	Requirement
4.1.1	The Deployment at Location #1 will include three Periods of Deployment:	1-1	The PTTD System components shall be available for the duration of all three periods.
4.1.2	The Period 1 deployment in Location #1 will include a mechanism to monitor and record for analysis the travel times for a stretch of the primary corridor and a stretch of an alternate route to reach the same general location. (Objective: 3.1.1)	1-2	Location #1 shall include two corridors/routes with approximately the same distance to reach approximately the same destination (i.e. alternate corridors).
		1-3	The PTTD System components deployed for the duration of Period 1 shall include the functionality to measure travel time or delay along both of the alternate corridors.
4.1.3	The tools deployed as part of the Period 1 deployment will remain operational and collecting data for a period to be determined by the final project team that is estimated to be 1-4 weeks. (Objective: 3.1.1)	1-4	The PTTD System components deployed during Period 1 shall remain operational for the duration of Period 1, as defined by the project team.
4.1.4	The Period 1 deployment in Location #1 will be solely collecting data for review and analysis. Ideally, project partners will have access to the data as it is collected to understand findings to date, however real-time access for purposes of response are not required. (Objective: 3.1.1)	1-5	The travel time and/or delay data collected during Period 1 shall be retained and saved in a manner that project partners may retain the data permanently.
		1-6	The travel time and/or delay data collected during Period 1 shall be available to project team members who wish to access the data periodically (e.g. through data download, XML feed, etc.).
4.1.5	The Period 2 deployment in Location #1 will continue to include the mechanisms to monitor and record travel times on the primary and	1-7	The PTTD System components deployed for the duration of Period 2 shall include the functionality to measure travel time or delay along both of the alternate corridors.

Concept ID	Operational Concept	Req ID	Requirement
	alternate route. (Objective: 3.1.1)		
4.1.6	The Period 2 deployment in Location #1 will add the functionality to disseminate information to travelers using a Dynamic Message Sign (DMS) located upstream of the diversion point. Please note that the DOT may wish to assess the impacts of alternate information dissemination (e.g. Connected Vehicle roadside unit, HAR, personal communication to a handset). In either situation, the DOT should deploy the field equipment being considered. (Objective: 3.1.1)	1-8	PTTD System components in Period 2 shall include (as a minimum) portable DMS deployed upstream of the diversion point (i.e. the point where traffic has the option to divert from one route to the other).
		1-9	Portable DMS deployed in Period 2 shall provide for a minimum of three lines of text display, to be used as follows: Line 1: Travel Time to <Destination>: Line 2: <Route 1 ID> … <time> Line 3: <Route 2 ID> …. <time> Note: an alternate to Line 1 may be "Delays to <Destination>"
		1-10	Portable DMS displays shall adhere to all standards and regulations for roadside dynamic messages signs.
		1-11	The Portable DMS deployed in Period 2 shall include functionality to receive messages from the PTTD System and display messages on the sign display.
		1-12	The Portable DMS deployed in Period 2 shall include functionality to send a verification message that the message was received and is displayed on the sign.
4.1.7	The Period 2 deployment in Location #1 will add the functionality to process the travel times on the primary route and the travel times on the alternate route, and display both times on the DMS, or an alternate message, as determined locally. (Objective: 3.1.1)	1-13	The PTTD System components deployed for the duration of Period 2 shall include the functionality to calculate travel time or delay information in real-time.
		1-14	Travel time or delay shall be calculated for both the primary and secondary routes.
		1-15	The PTTD System shall store all calculations of travel time or delay, together with timestamps.
		1-16	PTTD System components in Period 2 shall include the functionality to communicate the messages generated to the roadside DMS, and receive verification that the message is displayed on the sign.
		1-17	PTTD System components in Period 2 shall include the functionality to receive verification from the DMS that the message is displayed on the sign.

Concept ID	Operational Concept	Req ID	Requirement
		1-18	PTTD System components in Period 2 shall store all messages posted to the DMS, together with timestamp of when the message was posted (as received from the sign).
4.1.7.1	Data estimating the travel times along the primary and secondary routes will be reported regularly.	1-19	The PTTD System shall determine travel time or delays and send message updates to the DMS at a frequency determined by the project team, but no less frequent than once every 1 minute.
4.1.7.2	Care will be given to determining the frequency that updated messages are displayed to prevent driver distraction.	1-20	The PTTD System shall include the capability to adjust the frequency that messages are generated and updates displayed on the DMS.
4.1.7.3	The operational system will allow for user settings to designate the periods of time during the day that the system will calculate and disseminate travel times (e.g. to enable selection of a peak period, but avoid operation 24/7).	1-21	The PTTD System shall be configurable to process data, generate messages, and send message commands to the DMS for only selected periods of the day, as determined by the Project Team.
		1-22	Configurations to the PTTD to adjust time settings shall not require software programmers to make adjustments.
4.1.7.4	*An optional feature* would make the travel time message(s) displayed on the DMS also available through an Internet accessible XML feed to allow local ATMS or Road Condition Reporting Systems to ingest the data.	1-23	The PTTD System shall accommodate additional display mechanisms of the travel time/speed displays.
		1-24	The PTTD System shall generate an XML feed of the data displayed to the DMS.
4.1.8	The tools deployed as part of the Period 2 deployment will remain operational and collecting data for a period to be determined by the final project team that is estimated to be two to eight weeks. (Objective: 3.1.1)	1-25	The PTTD System components for Period 2 shall be available and functional for a period of at least 2 weeks to 8 weeks, as determined by the Project Team.
4.1.9	The Period 2 deployment in Location #1 will be performing two separate functions: collecting data for review and analysis, and computing and disseminating appropriate messages to describe travel conditions. Ideally, project partners will have access to the data as it is collected to understand findings to date,	1-26	The PTTD System shall provide a mechanism for Project Partners to access data (i.e. travel time/delay data, messages generated and sent to the DMS, verification from DMS when messages were displayed, etc.) in a useful manner (e.g. spreadsheet, csv file, etc.).

Concept ID	Operational Concept	Req ID	Requirement
	however real-time access for purposes of response are not required. (Objective: 3.1.3)		
4.1.10	The Period 3 deployment in Location #1 will remove the data processing and DMS displays that occurred in Period 2. Period 3 will return to a situation where the travel times on the primary and alternate route are measured and recorded. (Objective: 3.1.1)	1-27	The PTTD System components deployed for the duration of Period 3 shall include the functionality to measure travel time or delay along both of the alternate corridors.
4.1.11	The tools deployed as part of the Period 3 deployment will remain operational and collecting data for a period to be determined by the final project team that is estimated to be approximately one month. (Objective: 3.1.5)	1-28	The PTTD System components deployed during Period 3 shall remain operational for the duration of Period 3, as defined by the project team.
4.1.12	The Period 3 deployment in Location #1 will be solely collecting data for review and analysis. Ideally, project partners will have access to the data as it is collected to understand findings to date, however real-time access for purposes of response are not required. (Objective: 3.1.1)	1-29	The travel time and/or delay data collected during Period 3 shall be retained and saved in a manner that project partners may retain the data permanently.
4.1.13	Post deployment analysis at location #1 will be conducted to understand the travel times recorded on both the primary route and alternate route during all three periods. Analysis of this data will help the project team understand: - The impact the PTTD had on reducing overall delay in the corridor while information dissemination was operational (Objective: 3.1.3); and - Any long term impact on delay once the PTTD was removed (Objective: 3.1.3).	1-30	The travel time and/or delay data collected during Period 3 shall be available to project team members who wish to access the data periodically (e.g. through data download, XML feed, etc.).

Concept ID	Operational Concept	Req ID	Requirement
4.1.14	The data collected and stored in all phases will be frequent enough to perform analysis of specific time periods. The minimum time slice recommended is: - Travel times along the corridor updated at least every 1 minutes); or - Travel speeds along pre-defined segments updated at least every 5 minutes.	1-31	Travel time or delay data shall be calculated no less frequent than once every 1 minute, during all Phase of the project.
4.1.15	A local Project Team will be formed to discuss and resolve any local issues related to the deployment, operation, and removal of system components. Key issues to be addressed by the Local Project Team include: - Definition of what agencies, staff positions, and individuals benefit from access to the data (e.g. does the local TMC benefit from real-time data and/or archived data) (Objective 3.1.4) - Discussion about minimum requirements (based on the experience with the trial system) for: - Timing of each Phase - Accuracy of travel time/delay information. (Objective 3.1.5)	1-32	A Local Project Team shall form for the duration of Phases 1, 2, and 3, as well as preparation periods.
		1-33	The Project Team shall discuss data access during the project to better understand needs for data access (to benefit agencies deploying PTTD in the future).
		1-34	The Project Team shall discuss timing of each phase to better understand needed adjustments to the timing as future deployments occur.
		1-35	The Project Team shall discuss minimum accuracy needed in the calculation of travel times or delays.

Concept ID	Operational Concept	Req ID	Requirement
4.1.16	An Overall Project Team will be formed to contribute to the higher level decisions of the project (e.g. data analysis and reporting). The overall project team will be kept informed of progress and decision as each Period deployment occurs. This will most likely consist of ENTERPRISE Board members.	1-36	An Overall Project Team shall be formed to provide input to the Local Project Team.
4.1.17	An independent evaluation of the deployment will be included to work with the Local Project Team, Overall Project Team, and contractor to analyze the data and determine the benefits of the system for the purposes of predicting the impact of a permanent system. (Objective 3.1.3)	1-37	An independent evaluator shall be engaged to analyze the data created by the PTTD System describing the travel times during all periods of deployment in order to determine the extent to which the PTTD System impacted travel.
4.1.18	While Location #1 is expected to include a primary and alternate route operated by the same agency, at least one adjacent agency (e.g. local city or county) will be invited to be included in the project team to allow an assessment of the institutional issues to be addressed when the alternate route is operated by a different jurisdiction. (Objective: 3.1.7)	1-38	The Local Project Team shall attempt to engage at least one additional jurisdiction to participate and offer input on topics related to deployment in their area.
4.1.19	Depending upon the approach used to disseminate information, the Project Team, Evaluator, and Contractor will work to identify potential alternate solutions for disseminating the information, even if they are not deployed and tested during this deployment. (Objective 3.1.8, 3.1.9)	1-39	The Evaluator shall lead a process to identify potential alternate technologies and/or solutions, even if not attempted during this initial deployment.

Concept ID	Operational Concept	Req ID	Requirement
4.1.20	In addition to the quantitative assessment of the impacts of the PTTD, the Location #1 deployment will include a qualitative assessment of the impacts in order to understand if there are other benefits such as improvements in driver satisfaction, increased safety, or reduced DOT operations costs.	1-39	The Evaluator shall lead a process to identify qualitative metrics and related data or information gathering to help assess any qualitative benefits of the PTTD deployed at Location #1.

Table 2.2 – Requirements for Location #2

Concept ID	Concept	Req ID	Requirement
4.2.1	The PTTD System deployment at Location #2 will include a mechanism to determine the travel condition along the primary and alternate route. This mechanism may be a measurement of actual travel times, the actual delays, or a prediction of delays due to anticipated activities (e.g. if the event is expecting 3,000 attendees arriving in a 1 hour period, anticipated delay can be predicted).	2-1	Location #2 shall include one primary corridor where excessive delays are anticipated, together with at least one alternate corridor with approximately the same distance to reach approximately the same destination (i.e. alternate corridors).
		2-2	The PTTD System components deployed at Location #2 shall include the functionality to measure or predict travel time or delay along the primary route.
		2-3	PTTD System components deployed at Location #2 shall store all travel time or delay calculation results and timestamp all data.
4.2.2	The PTTD System deployment at Location #2 will include a mechanism to determine or estimate the travel conditions along the alternate routes. This mechanism may be a measurement of actual travel times/delays or a prediction of delays due to anticipated activities (e.g. if the event is expecting 3,000 attendees arriving in a 1 hour period, anticipated delay can be predicted).	2-4	The PTTD System components deployed at Location #2 shall include the functionality to measure travel time or delay along the alternate route(s).
		2-5	PTTD System components deployed at Location #2 shall store all travel time or delay calculation results and timestamp all data.
4.2.3	The PTTD System deployment at Location #2 will include a processing system to determine specific messages to be disseminated to travelers approaching the event.	2-6	The PTTD System components deployed at Location #2 shall include the functionality to process the measured or predicted travel time or delay information acquired for all routes, and generate one or more messages to be disseminated to travelers.
		2-7	Messages displayed shall vary depending upon the specific technologies used at Location #2, but may include: - Travel times along both routes, - Delays along both routes, - Wayfinding arrows directing traffic to events, - Text describing activities (e.g. "pavement work between 7:00 PM and 5:00 AM"
4.2.4	An overall strategy for selecting messages for each medium selected	2-8	The Local Project Team shall define a plan for the mediums to be used to disseminate

	shall be determined and finalized by the project team.		the messages generated. These mediums may include: - DMS - HAR - Social Media - Connected Vehicle Applications - 3rd party dissemination (e.g. Waze or Google Traffic).
		2-9	PTTD dissemination of message may include pre-event information dissemination (e.g. informing travelers of planned activities).
		2-10	PTTD System components deployed at Location #2 shall store all messages generated for all mediums, and timestamp all messages.
4.2.4.1	Message displays on portable DMS is a candidate dissemination approach. The strategy for disseminating messages may include travel times for one or more approaches, or way-finder type displays directing traffic based on travel times.	2-11	If DMS are a selected dissemination device at Location #2, portable DMS deployed shall provide for a minimum of three lines of text display, to be used as follows: Line 1: Travel Time to <Destination>: Line 2: Route 1 ID … <time> Line 3: Route 2 ID …. <time> Note: an alternate to Line 1 may be "Delays to <Destination>"
		2-12	If DMS are a selected dissemination device at Location #2, portable DMS displays shall adhere to all standards and regulations for roadside dynamic messages signs.
		2-13	If DMS are a selected dissemination device at Location #2, the Portable DMS deployed at Location #2 shall include functionality to receive messages from the PTTD System and display messages on the sign display.
		2-14	If DMS are a selected dissemination device at Location #2, the Portable DMS deployed at Location #2 shall include functionality to send a verification message that the message was received and is displayed on the sign.
4.2.4.2	Pre-event email/text/social media announcements of suggested routes to the event or through the work zone is a candidate dissemination approach. This may include selection of specific portions of the attendees to receive one suggested	2-15	The Local Project Team shall consider other "alternate" methods of disseminating information about the planned event to potential travelers who may be impacted (e.g. those who may be attending the event or those who may be driving through the work zone).

	route, while other attendees receive a different approach.		
4.2.5	The PTTD System deployed at Location #2 will include the functionality to automatically generate the messages (according to procedures defined by the Project Team) and communicate the messages to the selected mediums for broadcast to the travelers, receiving confirmation that the medium has received and is disseminating the information.	2-16	The PTTD System shall automatically formulate the messages and communicate the messages to the selected mediums.
		2-17	If DMS are a selected dissemination device at Location #2, PTTD System components at Location #2 shall include the functionality to communicate the messages generated to the roadside DMS, and receive verification that the message is displayed on the sign.
		2-18	If DMS are a selected dissemination device, PTTD System components in Location #2 shall include the functionality to receive verification that the message is displayed on the sign.
		2-19	If DMS are a selected dissemination device, PTTD System components for Location #2 shall store all messages posted to the DMS, together with timestamp of when the message was posted (as received from the sign).
		2-20	The PTTD System shall include the functionality to send messages to other dissemination mechanisms, as determined by the Project Team.
		2-21	The PTTD System shall save a record of all messages sent to be disseminated by various mechanisms, and timestamp the time the message was sent.
4.2.6	Temporary traffic pattern changes will be discussed as an option for increasing capacity on one or more routes, and the issues and challenges documented.	2-22	The PTTD System shall be configured to disseminate messages describing traffic pattern changes.
4.2.7	A key aspect of the PTTD System deployment at Location #2 will be discussions with the agencies responsible for the primary and alternate corridors, as well as the event owner/coordinator (i.e. the event owner may be the agency performing the road work or the venue hosting a concert or other event).		
4.2.7.1	Project members will discuss scenarios for modeling the impacts	2-23	The Local Project Team shall discuss and reach conclusion on the extent to which

	on the alternate routes, mostly likely using sketch modeling techniques based on estimated travel to/from the event.		modeling is needed to predict impacts on alternate routes.
		2-24	If modeling is deemed necessary, the local Project Team shall perform the modeling and document the process and costs incurred.
4.2.7.2	Project members will discuss different options for interagency agreements that might be used to reach agreement on an overall "Interjurisdictional PTTD System Agreement".	2-25	The Local Project Team shall document the procedure, challenges, and resolutions agreed when discussing the display of information describing alternate routes, especially routes operated by other jurisdictions/agencies.
4.2.7.3	In addition to the jurisdictions directly involved in the project, additional jurisdictions may be invited to participate in the process to enable the Project Team to better understand likely scenarios for other locations (e.g. to avoid the pilot deployment only representing one agencies perspective on what agreements are required).	2-26	The Local Project Team will invite other agencies and/or individuals to be involved and to comment on the likely scenarios for expanding the PTTD Location #2 deployment to other locations.
4.2.8	Post deployment analysis at location #2 will be conducted to understand the travel times recorded on both the primary route and alternate route(s) during the time the system is operational.	2-27	The PTTD System deployed at Location #2 shall save the calculated or predicted travel times and/or delay data describing all routes.
		2-28	The PTTD System deployed at Location #2 shall provide a mechanism for project partners to access travel time data saved during the operational period.
			The PTTD System deployed at Location #2 shall save travel time/delay data for all periods that the system is operational.
4.2.9	The data collected and stored in all phases will be frequent enough to perform analysis of specific time periods.	2-29	Travel time or delay shall be calculated and saved at time increments no longer than once per minute.
4.2.10	A local Project Team will be formed to discuss and resolve any local issues related to the deployment, operation, and removal of system components. Key issues to be addressed by the Local Project Team include: - Definition of any interagency agreements required for deployment of the system	2-30	The Local Project Team shall document any interagency agreements reached, and any background information about the process of forming interagency agreements.
		2-31	The Local Project Team shall discuss and document their observations about minimum time periods defined for the collection or data and calculation of travel times / delays.
		2-32	The Local Project Team shall discuss and

	(Objective 3.2.6) - Discussion about minimum requirements (based on the experience with the trial system) for accuracy of travel time/delay information. (Objective 3.2.3) - Discussion of real-time data needs during operations (e.g. a nearby TOC/TMC may wish to receive real-time data feeds).		document their observations about additional data needs that might benefit future deployments.
4.2.11	An Overall Project Team will be formed to contribute to the higher level decisions of the project (e.g. data analysis and reporting). The overall project team will be kept informed of progress and decision as each Period deployment occurs. This will most likely consist of ENTERPRISE Board members.	2-33	An Overall Project Team shall form and be involved in high level decisions and findings of the Local Project Team.
4.2.12	An independent evaluation of the deployment will be included to work with the Local Project Team, Overall Project Team, and contractor to analyze the data and determine things such as: - Best practices and/or lessons learned regarding procurement and specification of systems used in the deployment; (Objective 3.2.5) - The need for modeling (e.g. sketch modeling) to predict the impacts on alternate routes) (Objective 3.2.9); and - Technical and institutional issues identified.	2-34	An independent evaluator shall be engaged to analyze the data created by the PTTD System describing the travel times during all periods of deployment in order to determine findings such as: - the extent to which the PTTD System impacted travel, - the lessons learned, the institutional challenges with working with multiple jurisdictions. - The need for sketch modeling - Technical and institutional issues.
4.2.13	Depending upon the approach used to disseminate information, the Project Team, Evaluator, and Contractor will work to identify potential alternate solutions for disseminating the information, even	2-35	The Evaluator shall lead a process to identify potential alternate technologies and/or solutions, even if not attempted during this initial deployment.

	if they are not deployed and tested during this deployment. (Objective 3.2.7, 3.2.8)		
4.2.14	The Project Team involved in the Location #2 deployment will include activities to understand any qualitative benefits such as improvements in driver satisfaction, increased safety, or reduced DOT operations costs.	2-36	The Evaluator shall lead a process to identify qualitative benefits, and metrics to assess these qualitative benefits when evaluating Location #2.