Evaluation of Rural Travel Times During Construction

FINAL

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Executive Summary

During the summer 2012, three separate large construction projects occurred on I-35 between Hinckley and Duluth, Minnesota. Through the MnDOT Rural Travel Times During Construction Project, travel times were calculated and posted at seven different sign locations (4 signs northbound and 3 signs southbound) on I-35. MN-23, that runs parallel to I-35, was designated as an alternate route to help reduce congestion on I-35 during peak travel periods. Figure E-1 illustrates the extent of the project area.

The signs located at Hinckley and Duluth provided travel times for the two routes as shown in Figure E-2 below. The other signs in the project location provided travel times to selected cities along the I-35 route.

MnDOT procured the services of a Contractor that collected the data, calculated the travel times, and operated the dissemination mechanism as a stand-alone procurement (outside the contract for performing the construction services) using a Design-Bid-Build contract mechanism and Best Value Procurement.

The selected Contractor (Prime Contractor - Safety Signs, LLC, Subcontractor Renaissance Technologies, Inc.) was responsible for furnishing, installing, relocating, operating, maintaining, and removing an automated, temporary, real-time system to provide travel times at specified locations along I-35 and MN-23, between Hinckley and Duluth. The location of roadside static signs with inserted changeable modules was provided in the construction plans developed by MnDOT. The Contractor was responsible for determining the quantity and location of sensors to gather data to compute and communicate travel times to the signs.
## Travel Time Comparison and Results

The Real-time Travel Time Display System was required to operate 24 hours per day, 7 days per week. Updates to the travel time signs were required to occur at least every 5 minutes. MnDOT provided allowable accuracy and latency deviation times for each sign from the displayed travel times by the Contractor. MnDOT conducted a comparison of Contractor-generated travel times vs. actual travel times by driving the I-35 route throughout the duration of the project. MnDOT-employed drivers recorded travel times posted at each sign and actual drive times experienced. The difference between the posted times and the actual drive times were calculated. When the travel times posted were not in compliance with the project requirements, the calculated data was used to determine monetary deductions as specified in the contract.

A total of 145 drive runs were conducted during the comparison period. Each run compared the displayed travel times vs. actual travel times for 7 unique segments. Therefore, a total of 1015 instances of displayed vs. actual travel times were observed and recorded. Notable results include:

- Of the 1015 instances compared, 51 instances (5.0%) of the actual travel times were not within the allowable accuracy and latency deviation from the displayed travel time values as shown in Table 4-2, or “out of specification.”
- 49 of the 51 instances that were out of specification occurred during drive runs in the afternoon and evening, likely during higher traffic volumes.
  - Run 1 (typically conducted before noon) – 2 instances
  - Run 2 (typically conducted between noon and 4 PM) – 20 instances
  - Runs 3 and 4 (typically conducted after 4 PM) – 29 instances
- The majority (over 85%) of instances that were out of specification occurred during a transition to congested conditions or shortly after congested conditions began.

A summary of aggregate results can be found in Table E-1 below.

<table>
<thead>
<tr>
<th>Table E-1: MnDOT Vehicle Travel Time Comparison – Aggregate Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Drive Runs Conducted</strong>*</td>
</tr>
<tr>
<td>Number of Travel Times Compared per Run</td>
</tr>
<tr>
<td>Total Number of Instances Comparing Displayed vs. Actual Travel Times</td>
</tr>
<tr>
<td>Number of Instances Out of Specification</td>
</tr>
<tr>
<td>% Instances Out of Specification (51 instances out of 1015 MnDOT vehicle runs conducted)</td>
</tr>
<tr>
<td>Average Time Out of Specification (mins)</td>
</tr>
</tbody>
</table>

*The Travel Time Display System was operational 24 hours a day/7 days a week. The Vehicle Travel Time Runs were only conducted on weekends when traffic volumes were expected to be high. Therefore, the total number of instances (1015) does not reflect performance during the entire duration the system was in operation.*
Public Perception

MnDOT’s Office of Customer Relations conducted on-line surveys of two separate customer populations to collect information about the I-35 Real-time Travel Time Display System. Survey objectives included determining to what extent travelers noticed the travel information signs, if the signs were helpful, and to what extent travelers made decisions based on the information. The survey also asked questions about respondents’ tolerance for accuracy, having information accessible by smart phones, and for suggestions or other feedback. The surveys were administered during the second half of August 2012, after the travel information signs had been deployed yet before the highly-traveled Labor Day weekend.

Overall, survey results indicated that the Real-time Travel Time Display System was well-received among respondents. The travel time and alternative route information positively contributed to travelers’ experiences during a long construction period on a heavily-traveled summer route. Though the populations surveyed were not perfectly reflective of the general population, respondents’ written comments reflect benefits that are applicable to the general population – they appreciated having information with which they could make route and other planning decisions, set their expectations, and feel less stressed about their trip.

In terms of accuracy of the system, survey results indicated that travel time signage can be off by up to 10 minutes and still satisfy most users. Suggestions for improvements included:

- Additional signage with information regarding secondary destinations
- Information about upcoming exit closures related to the alternative route suggestions
- Additional signage earlier in the route to allow more time for planning, and
- Providing more lead time ahead of exits.

Lessons Learned

Staff from four MnDOT entities collaborated during the planning and execution of this project. These entities were MnDOT District 1, the Office of Traffic, Safety, and Technology (OTST), the Metro District Regional Traffic Management Center (RTMC), and the Office of Construction and Innovative Contracting (OCIC). During interviews with collaborating staff, a number of viewpoints and lessons learned were shared. Staff from the Contractor who provided the travel time system were also interviewed to gather input on their overall perspectives and lessons learned from the project.

See Section 6 for a full summary and details about the lessons learned, both from MnDOT’s and the Contractor’s perspectives. Table E-2, below, provides highlights from the lessons learned section.
Table E-2: Highlights from Lessons Learned

<table>
<thead>
<tr>
<th>Lessons Learned Area</th>
<th>MnDOT Perspective</th>
<th>Contractor Perspective</th>
</tr>
</thead>
</table>
| **Best Value Procurement Method** | • Best Value method allowed MnDOT to select a qualified Contractor for this specialized system | • A stand-alone contract was preferred  
• Previous experience criteria requirement in the RFP was too limiting and did not allow innovation for proposed systems |
| **System Details in Plans and Specifications** | • Most agreed that performance-based specifications appropriately transferred risk to the Contractor  
• Some felt that more detail would have increased accuracies and reduced contracting issues  
• Tradeoffs exist when considering cost versus system performance | • Detailed plans and specifications would have transferred more risk to MnDOT  
• Include a separate bid item for additional equipment (e.g. sensors) to be added if deemed necessary  
• Add a disclaimer to the signs, such as “estimated travel times” |
| **Quality Control** | • Require the Contractor to submit a plan for set-up, testing, monitoring, and correcting issues  
• Keep overall costs in mind when adding additional requirements | • Extensive testing and validation was conducted and adjustments were made by the Contractor |
| **System Requirements Language** | • Define terms (especially “latency”) and clarify requirements  
• State that current, rather than historical, traffic data must be used to calculate travel times | • Definitions of terms and added clarity would help to avoid misunderstandings |
| **Travel Time Comparison Method (to Determine Monetary Deductions)** | • Describe the travel time comparison method in the specifications  
• Consider alternate methods for comparing travel time that use technology such as video, Bluetooth, GPS, etc.  
• Increase the number of comparisons for “floating car” data collection | • Describe the travel time comparison method in the specifications  
• The “floating car” method used by MnDOT did not generate enough data points to create a representative sample for comparison |
| **Monetary Deductions** | • Consider associating deduction amounts with number of days and total project cost, rather than per occurrence | • Penalties that were applied to individual component failures could motivate the use of fewer components (e.g. more sensors increases likelihood of deductions)  
• Only penalize travel times that are out of specification, not individual system components |
<table>
<thead>
<tr>
<th>Lessons Learned Area</th>
<th>MnDOT Perspective</th>
<th>Contractor Perspective</th>
</tr>
</thead>
</table>
| Project Website      | • The password-protected function of the website provided a helpful tool for MnDOT to check on issues and view archived data | • Link to the project website was difficult to find on MnDOT’s 511 website  
• Consider full integration of the project website into MnDOT’s 511 website |
| Staff Training       | • This was the first time MnDOT deployed a travel time system along a long (70 miles) rural freeway segment  
• Plans and Specifications did not previously exist | • Because technology changes at a fast pace, it is difficult to maintain expertise in managing and testing these types of systems  
• It would be beneficial for the project owner’s (DOT) staff to have training on current technologies and practices before bid documents are developed |
| Public Feedback      | • Input via the public survey was positive, overall  
• Motorists appreciated having travel time and alternate route information  
• Number of emails reviewed by the Evaluation Team with negative feedback was relatively low  
• Motorists indicated that the sign at Hinckley should have been placed south of the exit so northbound travelers could exit after seeing the travel time | • N/A – was not discussed |
| System Performance   | • Overall, the system performed with a high degree of accuracy in free-flow traffic conditions  
• Most accuracies that were out of specification occurred during transitions to congested conditions  
• * 5% of instances that compared actual vs. displayed travel times were not within the accuracy values specified | • The system performed with a high degree of accuracy  
• Consider specifying additional signs, to increase accuracy at each sign |

*Note: The Travel Time Display System was operational 24 hours a day/7 days a week. The Vehicle Travel Time Runs were only conducted on weekends when traffic volumes were expected to be high. Therefore, the total number of instances (1015) does not reflect performance during the entire duration the system was in operation.*
Lessons Learned Area | MnDOT Perspective | Contractor Perspective
--- | --- | ---
Project Goals and Indicators of Success | • Travel time accuracies were generally acceptable to the public  
• The system fulfilled a need identified by the public to provide information about travel times and alternate routes during the I-35 construction  
• The MN-23 alternate route was not utilized as much as desired; use of this route did not appear to reduce congestion levels on I-35. | • N/A – was not discussed

Conclusion

Feedback provided to MnDOT from motorists in the District 1 area indicated a need for information about expected delays during road construction on I-35. The location of the construction and the existence of an alternate route created an opportunity to inform travelers of the expected travel times along the parallel routes. The MnDOT team working on this project faced several challenges:

- Limited funds were available for information dissemination, especially considering the long distance that was required to be monitored;
- The specialized nature of the work zone and MnDOT’s desire to provide accurate information warranted a stand-alone contract with performance criteria and deductions, in order to motivate high quality execution of the travel time system; and
- The proximity to Twin Cities was such that there were some concerns from MnDOT that inaccuracies or unreliability of travel time data could harm the trust that motorist in the Metro area had developed for the travel time messages on the Twin Cities highways.

This project utilized an innovative approach to provide travel times and alternate route information to motorists along a 70-mile stretch of freeway. This project marked the first time MnDOT had implemented a travel time information system on a rural freeway segment of this distance.

Overall, the project was successful and kept travelers informed throughout the summer. Feedback obtained through the public survey was generally positive, and respondents appreciated having information that prepared them for congestion in the work zone, as well as, assisted them in making decisions about taking alternate routes.

The decision to procure a stand-alone contract was deemed successful by both MnDOT and the Contractor. While the Best Value Procurement Method was seen as effective to MnDOT in procuring a qualified Contractor, feedback from the Contractor indicated that the pre-qualification criteria limited their ability to deploy technologies appropriate for the unique circumstances of this work zone. MnDOT is aware that technology continues to change and improve, however, for this project MnDOT required the Contractor to propose a system in which the means and methods were previously successful in order to ensure the Contractor had experience with the proposed system.
There is always a challenge of determining ‘how accurate is accurate enough?’, and deciding how much funds should be spent to increase accuracies beyond a minimal level. This project appears to have captured a successful “sweet spot” where the project team worked with funding available to procure a service that helped a large number of travelers during a difficult construction season. While there may have been other methods that could have increased accuracy, reliability, or coverage of signs, the overall feedback was positive.

This evaluation details a number of aspects that could be improved for future deployments of this type. Most of the suggested improvements are related to providing additional definition and clarification in the Special Provisions (specifications) of the contracting process, to help avoid misunderstandings during project execution.

1.0 Introduction

This report summarizes an independent evaluation of the Minnesota Department of Transportation (MnDOT) Rural Travel Times During Construction Project. During 2012, three separate large construction projects on I-35 between Hinckley and Duluth were conducted that had a significant impact on traffic traveling to and from Duluth. The impacts were most notable on Fridays and Sundays from May 2012 to October 2012. I-35 is a recreational route with high traffic volumes over holidays and weekends. To provide motorists with travel time information in the construction work zones, MnDOT identified a Real-time Travel Time Display System that could alert travelers to expected delays on I-35. MnDOT was aware that there was not a current system in-place to provide travel times along this rural freeway. Similarly, MnDOT recognized that providing travel times along a rural freeway, especially during construction projects, has been difficult and cost prohibitive in the past. However, due to the need identified by MnDOT to provide motorists with travel time information, MnDOT hired a Contractor through its Design-Bid-Build contract process using Best Value Procurement to provide travel times during construction. This project offered an innovative approach to provide travel times and congestion information to motorists along a freeway containing multiple construction projects, while impacting traffic along approximately 70 miles of roadway.

The Project

The project included deployment of 7 roadside static signs along I-35 with inserted changeable modules that displayed travel times to the motorists in real-time. MN-23 was designated as an alternate route to help reduce congestion on I-35 during peak traffic periods that occurred on Fridays and Sundays due to recreational travel. Sensors were also deployed and installed by the Contractor to collect traffic volumes, as one source of data to include in the algorithm used by the Contractor to calculate travel times. See Figure 2-1 for the location of the project.
The Evaluation

In order to evaluate the effectiveness of the project and the impact on travelers, MnDOT decided to evaluate this project. The evaluation focused on both the accuracy of the system and the reactions of travelers.

To assess the accuracy of the system, vehicle travel time runs, conducted by MnDOT were compared to the travel time runs posted on the signs to determine accuracy and latency with the Real-time Travel Time Display System.

MnDOT also conducted online surveys to collect comments and feedback about the I-35 Real-time Travel Time Display System.

This primary goal of the evaluation is to document the overall process and lessons learned of the project. The Evaluation Team interviewed the following stakeholders to gather information on the procurement process and project execution as well as their perspectives on aspects of the project:

- MnDOT District 1;
- MnDOT Office of Traffic, Safety and Technology (OTST);
- MnDOT Metro District Regional Traffic Management Center (RTMC);
- MnDOT Office of Construction and Innovative Contracting (OCIC); and
- Contractor.

This evaluation report includes:

- A summary of the evaluation goals;
- Description of the planning and procurement process;
- Project execution summary;
- Performance evaluation summary and results;
- Lessons learned; and a
- Conclusion.
2.0 Evaluation Goals

The following goals were established for evaluation of the “MnDOT Rural Travel Times During Construction” project:

Goal #1: Document the procurement process MnDOT followed for the project, identifying aspects that worked well and opportunities for improvement.

Goal #2: Examine and summarize the travel time and public feedback data collected by MnDOT, articulating a summary of the project to help MnDOT understand what to expect in similar deployments.

Goal #3: Provide documentation that will assist MnDOT in making decisions about the value of Intelligent Work Zone (IWZ) systems that display travel times for future similar projects.
3.0 Planning and Procurement

3.1 Project Initiation
The MnDOT Rural Travel Times During Construction project was initiated though a request for funding from MnDOT’s Destination Innovation program. The program invites MnDOT employees to submit project requests that demonstrate innovation and advance the department’s Strategic Directions (Safety, Mobility, Innovation, Transparency and Leadership). The MnDOT Rural Travel Times During Construction project proposal included calculating and dissemination of real-time travel times to the public over a 70 mile stretch along I-35 in a construction zone. This demonstrated alignment with MnDOT’s Strategic Directions and outlined a number of benefits, including:

- Enhanced safety, mobility, and efficiency in work zones through an innovative approach
- Reduced delays to motorists, by taking alternative routes or by altering mode or time of travel
- Response to customers’ request for a uniform, easily understood system for the work zones on I-35 between Hinckley and Duluth during the 2012 construction season

Funding for the project was secured from the Destination Innovation program and other sources.

3.2 Procurement Method
MnDOT procured the Rural Travel Times During Construction project using a Design-Bid-Build contract mechanism and Best Value Procurement. This project was unique as MnDOT procured a stand-alone contract for the Real-time travel time display system, rather than including it as a bid item in one of the construction contracts for roadway improvements along I-35. Typically a signing contractor would be a Subcontractor to the Prime Construction Contractor in roadway improvement projects. In this project the signing contractor was the Prime Contractor serving in a lead role for all aspects in the project. Traditionally, price has been the sole factor considered in selection of construction Contractors by state departments of transportation. However, using a Best Value Procurement process, key factors such as qualifications, schedule, quality, and performance-based criteria, in addition to price considerations, were used in the evaluation and selection of a Contractor for this project. MnDOT tends to utilize Best Value Procurement when there are concerns that some bidders may not have appropriate qualifications. In some previous deployments of travel time information systems, Contractors did not perform as expected due to lack of expertise and/or experience. In this case, MnDOT wished to manage a potential risk that the Contractor may not perform adequately. The decision to procure a stand-alone contract, paired with using a Best Value Procurement process, enabled MnDOT to have more control in selecting a Contractor with specific expertise in deploying and operating these types of systems.

3.3 System Requirements and Performance Criteria
System requirements and performance criteria for the Real-time Travel Time Display System for I-35 between Hinckley and Duluth were outlined in the construction plans and Special Provisions. The system was called out as “Intelligent Work Zone System” in the plans and Special Provisions. The plans and Special Provisions were developed by MnDOT District 1 (Duluth), with input from the Office of Traffic,
Safety and Technology (OTST), the Metro District Regional Traffic Management Center (RTMC), and the Office of Construction and Innovative Contracting (OCIC). A “Concept of Operations and Functional Requirements” document, along with information from previously implemented travel time systems were used as resources in developing the bid documents. The Concept of Operations and Functional Requirements document identified project stakeholders, summarized the operational and stakeholder needs, provided scenarios for real-time traffic detection and dynamic message signs, and documented the operations and maintenance responsibilities of the travel time system for the project. The document also included key MnDOT functional requirements for the system (e.g. display travel time messages on each DMS based on conditions within the defined segment).

The summary below contains aspects of the Special Provisions that outlined the project purpose, system requirements, and operations/performance criteria. A copy of the construction plans can be found in Appendix A and the Special Provisions (specifications) can be found in Appendix B.

3.3.1 Project Purpose
During the construction season of 2012 there were three construction projects with work zones along I-35 from Hinckley to Duluth. MN-23 was designated as an alternate route to help reduce congestion on I-35 during peak traffic periods that occurred on Fridays and Sundays due to recreational travel. The intent and purpose of the project was to:

1. Inform the travelling public of travel times on both the I-35 corridor and the parallel route via MN-23 with roadside static signs with inserted changeable modules which display real-time travel time information.
2. Reduce driver frustration, enhance safety, and increase traffic efficiency by sufficiently informing the public of travel times of the alternate route and thereby encouraging use of MN-23 during peak traffic volume periods.
3. Inform the travelling public, via a website link to the MnDOT 511 website, real-time travel time information as displayed on the signs.
4. Conduct a weekly meeting to assess the effectiveness of the system over the weekdays/weekends.
5. Record all data gathered by the project in a manner convenient for future analysis.
6. Adhere to specific accuracy requirements for each travel time display, as shown in the specifications.

3.3.2 System Requirements
The system consisted of furnishing, installing, relocating, operating, maintaining, and removing an automated, temporary, real-time system to provide travel times at specified locations along I-35 and MN-23, between Hinckley and Duluth.

Signs and Sensors
The locations and details of roadside static signs with inserted changeable modules were provided in the plans developed by MnDOT. Figure 3-1 shows the seven sign locations and messages on I-35, as
designated in the plans. The system was required to have sufficient traffic detection devices (sensors) to detect traffic speeds and, by the use of an algorithm, compute and communicate estimated travel times to the signs. The quantity and location of sensors were not specified in the plans. However, sensors were required to be relocated when construction stages changed. For example one of the concrete overlay construction projects was completed in mid-July so signs and sensors were required to be moved to accommodate traffic phasing.

![Sign Locations and Messages](image)

**Figure 3-1: Sign Locations and Messages**

### Intelligent Work Zone Manager

The Contractor was required to designate an “Intelligent Work Zone (IWZ) Manager” to be responsible for directly operating the system on a regular basis. The system was required to self-test for communication or sensor failures, and provide warnings to the system manager, the appropriate MnDOT personnel, and the website when communication or device failures were detected.

### Website

The Contractor was required to create and maintain a website to display a map-based representation of the project, showing sign locations and real-time travel times at each sign. The public portion of the website, accessible from MnDOT’s 511 webpage, enabled users to select individual signs to view travel times. The Contractor was also required to implement a password-protected portion of the website, to
be accessed by the Contractor and selected MnDOT personnel. Features of the password-protected website included:

- Display of current speeds at each sensor location on a real time basis
- Capability to verify actual travel times on a quality control basis
- Weekly reporting to provide accuracy information
- Archived data

3.3.3 System Operation and Performance

The system was required to operate 24 hours per day, 7 days per week. The system was to be maintained, supported, and warranted against material defects throughout the duration of the deployment. The Contractor was required to respond to MnDOT by phone within one hour of any malfunction in the system.

Updates to travel time information were required to occur at least every 5 minutes. Table 3-1 provides the allowable accuracy and latency deviation from the displayed travel time for each of the seven signs. The accuracy and latency values were determined by reviewing values used by MnDOT for travel time displays in the Metro area, calculations based on a percentage of travel times between signs at normal speeds, and a maximum deviation thought to be acceptable to the public. After this analysis, MnDOT estimated that the public would not likely accept more than a 15 minute deviation at any one sign. The final accuracy and latency deviation from the displayed travel time values in the table were determined using engineering judgment for each sign location.

Table 3-1: Allowable Accuracy and Latency Deviation Values

<table>
<thead>
<tr>
<th>SIGN</th>
<th>REFERENCE POINT</th>
<th>SIGN DISTANCE (MILES)</th>
<th>ALLOWABLE ACCURACY &amp; LATENCY DEVIATION FROM DISPLAYED TRAVEL TIME (MINUTES, PLUS OR MINUS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>184.20 NB</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>190.25 NB</td>
<td>60 (I-35)</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>64 (MN-23)</td>
<td>15</td>
</tr>
<tr>
<td>C</td>
<td>196.50 NB</td>
<td>41</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>234.70 NB</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>E</td>
<td>253.60 SB</td>
<td>71 (I-35)</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>59 (MN-23)</td>
<td>15</td>
</tr>
<tr>
<td>F</td>
<td>233.00 SB</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td>G</td>
<td>217.00 SB</td>
<td>34</td>
<td>10*</td>
</tr>
</tbody>
</table>

*Specified accuracy at Sign G was changed from 5 mins to 10 mins, via a Change Order during the project.

Performance Monitoring and Monetary Deductions

Performance of the system was monitored by MnDOT personnel on a continuous basis during the following critical traffic periods. I-35 from Hinckley to Duluth is a recreational route and peak hours occur on Fridays and Sunday afternoons.

- 11:00 AM Friday until midnight Friday night (Northbound)
- 11:00 AM Sunday until midnight Sunday night (Southbound)
11:00 AM Monday until midnight Monday night (Southbound) on Memorial Day and Labor Day weekends.

The following monetary deductions were specified:

1. **Northbound**: Any portion of the system not functional during the critical traffic periods will be assessed a deduction of $1000.00 per hour.
2. **Southbound**: Any portion of the system not functional during the critical traffic periods will be assessed a deduction of $1000.00 per hour.
3. **Accuracy**: Any accuracy determinations outside of the required level of accuracy and latency as described in Table 3-1 will be assessed a monetary deduction of $1000.00 per occurrence.
4. **Maintenance**: If the Contractor is negligent in correcting any deficiency within two hours of notification of system failure, a monetary deduction of $250.00 per hour will be assessed until the deficiency is corrected.
5. **Non-critical time periods**: During non-critical traffic periods, if any portion of the system is not functional resulting in accuracy non-conformance, a monetary deduction of $250.00 per occurrence will be assessed.
6. **Website**: The project web link is subject to deductions as described in the “maintenance” description above.

### 3.4 Bidding Process and Contractor Selection

A two-phase bidding process was used by MnDOT to select a Contractor. The first phase consisted of bidders submitting technical proposals to be evaluated by MnDOT. Bidders who were deemed responsive during the first phase proceeded to the second phase, when their price proposals were considered and the bidder with the lowest bid was selected.

Technical proposals were required to contain the following information:

**Cover Page**: Project number, bidder’s contact information, and other general information.

**Experience of Bidder**: Bidders were required to provide the qualifications including:

1. Two projects where the system provider delivered travel time information on a construction or maintenance project meeting the following criteria:
   a. Project must have been completed in the last five years
   b. Projects must have an Average Daily Traffic (ADT) greater than 10,000 vehicles per day
   c. Posted speed of project must be greater than 50 MPH
   d. Project duration must include more than 20 days of monitoring
   e. Project length must be at least 20 miles
   f. Project cost must be more than $50,000 worth of IWZ system contract work
2. Two completed reference letters signed by the Project Owner’s Contract Administrator
Experience of Personnel: The project required that an approved IWZ manager be assigned to perform duties as outlined in the plans and specifications. Required qualifications of the IWZ manager included:

1. At least two years of experience in installing, servicing, and maintaining IWZ systems in construction work zones.
2. Must identify two representative projects performed in the last five years where the project included real time IWZ systems.
3. Must have been directly responsible for management of the IWZ portion of the projects submitted.

MnDOT held a pre-bid meeting prior to the due date for technical proposals. The pre-bid meeting, which is standard protocol for Best Value projects, was held to answer questions from potential Contractors. In this instance, dialogue with Contractors at the pre-bid meeting was especially useful, as it helped identify aspects to be clarified in a Special Provisions amendment that was later issued by MnDOT.

MnDOT received eight technical proposals. Technical proposals were evaluated by a committee consisting of at least three individuals selected by MnDOT. Four of the eight proposers met the stated performance criteria and were deemed “responsive bidders.” Of these four responsive bidders, two submitted price proposals. Safety Signs, LLC submitted the lowest price bid and was awarded the contract (Contract # S120025.) Renaissance Technologies, Inc. was a Subcontractor to Safety Signs, LLC.
4.0 Project Execution

4.1 Project Timeline and Deployment Location
The travel time information system was operational from April 30, 2012 to November 5, 2012. The concrete overlay construction projects began on May 7, 2012 and were completed on November 5, 2012. The system was deployed along I-35 between Hinckley and Duluth. Roadside static signs with inserted changeable modules were deployed, displaying travel times for the I-35 and MN-23 corridors.

4.2 Start-up and Testing
The contract with the Contractor allowed the Real-time Travel Time Display System to be up and running prior to the start of the construction on I-35. The Contractor was responsible for conducting testing of the system prior to the system be turned on for view by the public.

4.3 Observed System Performance
There were very few mechanical issues and issues with the system malfunctioning observed by MnDOT District 1. However there was no automated notification if the system was beginning to malfunction (e.g. battery starting to fail).

The MnDOT District 1 construction engineer observed that the Real-time Travel Time Display system appeared to work well in free flow traffic conditions, however it did not seem to work well during backups and during transitions to congested conditions. Section 5.1.2 provides results of MnDOT’s Vehicle Travel Time Runs, which compared actual travel times to the displayed times on the signs in order to assess accuracy based on the specified performance criteria.

4.4 Change Orders
Two change orders were issued during the project. Change Order #1 modified the allowable accuracy and latency deviation value at Sign G (SB - Hinckley 34 miles) from 5 minutes to 10 minutes. This change was made in order to provide a more reasonable value, based on actual conditions observed in the field.

Change Order #2 included the following provisions:

1. The travel time comparison method was changed to indicate that “the actual drive time by MnDOT will be compared to the displayed time for each respective sign upon arrival at the sign destination.” (The previous method compared the actual drive time to the displayed time at departure/origin.)
2. The contract amount ($319,625) was reduced in the amount of $12,000.
5.0 Performance Evaluation

5.1 Travel Time Comparisons and Results
During the project, the Contractor calculated and communicated travel times to the driving public using static message signs with dynamic message boards as shown in Figure 5-1. The Contractor also created and maintained a public web site that showed congestion information and travel times along the I-35 and MN-23 routes. MnDOT conducted a comparison of Contractor-generated travel times vs. actual travel times by driving the I-35 route throughout the duration of the project (a travel time comparison was not conducted for the MN-23 route.) MnDOT-employed drivers recorded travel times posted at each sign and actual drive times experienced. The difference between the posted times and the actual drive times were calculated. The calculated data was used to determine monetary deductions as specified in the contract.

5.1.1 Determination and Communication of Travel Times
The Contractor was responsible for determining and communicating travel times along the I-35 and MN-23 routes throughout the duration of the project. Real-time travel time information was communicated using the signs and a publicly accessible travel time website created and maintained by the Contractor.

Sensors
The travel times at each sign was calculated by the Contractor. Data for the calculation included using data collected from a series of sensors that detected traffic volumes at various locations along the routes. Approximately 12 sensors were installed in the field by the Contractor; additional traffic data may have been obtained via other sources and utilized to supplement data from the sensors installed in the field to calculate the travel times posted at each sign along I-35. Sensors were re-located by the Contractor in order to accommodate construction phasing.

“TrafAlert” Website
The Contractor’s travel time website, “TrafAlert,” was accessible from MnDOT’s 511 Traveler Information website (www.511mn.org) and from MnDOT’s construction projects web pages (www.dot.state.mn.us/roadwork/current.html). The “TrafAlert” website was active only during the project period and was taken off-line at the conclusion of the project.

Using the public “TrafAlert” website, motorists could access real-time information about congestion levels and estimated travel times displayed at each sign. Figure 5-2 shows a website screenshot that contains a map with congestions levels (Green = “Normal”, Yellow = “Slowing”, Red = “Stopped”) and estimated travel times. Estimated travel times could be accessed by selecting the sign location on the map or the sign designation in the left-hand column.
The “TrafAlert” website contained a password-protected feature that allowed MnDOT staff to access information about the system. This feature included information that showed the current status of sensors and signs, indicating whether or not they were functioning properly. Other information available through the password-protected feature included real-time information about sign locations, sensor locations and data, archived sensor data, and archived travel times displayed on the signs. The website also included a secure level for the Contractor to operate the system. Figure 5-3 shows a screenshot of the sign locations and sensor locations, as displayed on the Contractor’s travel time website at a randomly selected point in time during the project.
5.1.2 MnDOT Vehicle Travel Time Comparison

Data Collection Method

MnDOT-employed drivers collected travel time data by driving the I-35 route on weekends (Fridays, Saturdays, and Sundays) during times of day when congestion was expected to be at high levels. Drive dates were adjusted and/or added to capture data for travel around the Memorial Day and July 4th holidays. Drive “runs” were conducted 3-4 times per day, typically at mid-morning, mid-day, early afternoon, and late afternoon/early evening. Drivers observed and recorded travel times displayed at each sign and actual drive times experienced. Log sheets were used to record observed travel time data. Table 5-1 shows an example of the driver observation log sheet used to record the data. Figure 5-4 shows a map of the sign locations that correspond to the observation log sheet.
### Table 5-1: Driver Observation Log Sheet Example

<table>
<thead>
<tr>
<th>SIGN</th>
<th>REFERENCE POINT</th>
<th>MESSAGE</th>
<th>TRAVEL TIME DISPLAYED</th>
<th>CLOCK TIME</th>
<th>AT DESTINATION CLOCK TIME</th>
<th>ACTUAL TRAVEL TIME</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>253.6</td>
<td>TRAVEL TIME TO HINCKLEY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>233</td>
<td>HINCKLEY 50 MILES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>217</td>
<td>HINCKLEY 34 MILES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>184.2</td>
<td>MOOSE LAKE 30 MILES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>190.25</td>
<td>TRAVEL TIME TO DULUTH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>196.5</td>
<td>CLOQUET 41 MILES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>234.7</td>
<td>TRAVEL TIME TO DULUTH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**OBSERVATIONS/COMMENTS**
Figure 5-4: Map of Sign Locations Corresponding to Driver Observation Log

Data collected during the MnDOT Vehicle Travel Time Runs were compiled into a spreadsheet, in a tabulated format. Table 5-2 shows a sub-set of the recorded data and comparisons between the driver experienced travel times and the DMS displayed travel times. A summary of the nomenclature used in the summary spreadsheet is as follows:

- The Date column indicates the date in which drive runs were conducted. The Run column indicates the run number on that day.
- Et, Ft, Gt, At, Bt, Ct, and Dt designate the recorded timestamp when each sign was passed (e.g. Et represents the timestamp at the time of passing Sign E).
- Hat indicates Hinckley arrival time, Mat indicates Moose Lake arrival time, Cat indicates Cloquet arrival time, and Dat indicates the Duluth arrival time.
- Displayed travel times are designated by the sign letter with a lower case “d” (e.g. Ed indicates the displayed travel time at Sign E).
- Actual drive times are designated by the sign letter followed by a lower case “a” (e.g. Ea indicates the actual drive time from Sign E to its designated destination).
- The Dif columns show the calculated difference between the displayed travel time and the actual drive time for each sign, i.e. actual drive minus the corresponding displayed travel time for each sign.
• Values highlighted in bright red indicate differences that are out of specification. (Sign E has a spec of ±15 minutes, F has ±15 minutes, G has ±10 minutes, A has ±10 minutes, B has ±15 minutes, C has ±10 minutes, and D has ±5 minutes).

• Runs highlighted in orange indicate there were instances within that run that were out of specification.

### Table 5-2: Example of Data Summary for MnDOT Vehicle Travel Time Runs

| Date   | Run | Et  | Ed  | Ea  | Dif | Ft  | Fd  | Fa  | Dif | Gt  | Ga  | Dif | Hat | At  | Ad  | Aa  | Dif |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|        | 2   | 12:29| 73  | 68  | -5  | 12:49| 51  | 48  | -3  | 1:04 | 35  | 33  | -2  | 1:37 | 1:58 | 44  | 56  | 12  |
| 16-Jun | 1   | 9:42| 73  | 68  | -5  | 10:03| 51  | 47  | -4  | 10:17| 36  | 33  | -3  | 10:50| 11:16| 31  | 30  | -1 |
|        | 2   | 12:35| 73  | 69  | -4  | 12:55| 51  | 49  | -2  | 1:10 | 36  | 34  | -2  | 1:44 | 2:03 | 30  | 30  | 0  |
|        | 3   | 3:25| 83  | 79  | -4  | 5:54 | 52  | 50  | -2  | 4:11 | 36  | 33  | -3  | 4:44 | 5:00 | 31  | 30  | -1 |
|        | 4   | 6:17| 73  | 68  | -5  | 6:37 | 51  | 48  | -3  | 6:52 | 36  | 33  | -3  | 7:25 | 7:32 | 33  | 30  | -3 |
| 17-Jun | 1   | 9:49| 73  | 68  | -5  | 10:09| 52  | 48  | -4  | 10:24| 36  | 33  | -3  | 10:57| 11:10| 31  | 30  | 0  |
|        | 2   | 12:26| 75  | 111 | 36  | 12:46| 57  | 91  | 34  | 1:01 | 39  | 76  | 37  | 2:17 | 2:40 | 31  | 30  | -1 |
|        | 3   | 4:10| 96  | 107 | 11  | 4:30 | 73  | 87  | 14  | 4:45 | 53  | 72  | 19  | 5:57 | 6:12 | 31  | 30  | -1 |

### Comparison Results

A total of 145 drive runs were conducted during the comparison period. Each run compared displayed travel times vs. actual travel times for 7 unique segments (i.e. Signs A, B, C, D, E, F and G.) Therefore, a total of 1015 instances of displayed vs. actual travel times were observed and recorded. Notable results include:

- Of the 1015 instances compared, 51 instances (5.0 %) of the actual travel times were not within the allowable accuracy and latency deviation from the displayed travel time values as shown in Table 4-2, or “out of specification.”
- 49 of the 51 instances that were out of specification occurred during drive runs in the afternoon and evening, likely during higher traffic volumes.
  - Run 1 (typically conducted before noon) – 2 instances
  - Run 2 (typically conducted between noon and 4 PM) - 20 instances
  - Runs 3 and 4 (typically conducted after 4:00 PM) – 29 instances
- The highest number of instances out of specification (15 instances out of 145 runs) occurred at Sign G - SB to Hinckley via I-35.
- The highest average amount of time out of specification (21 minutes) occurred at Sign F – SB to Hinckley via I-35.
- A majority (over 85%) of instances that were out of specification occurred during a transition to congested conditions or shortly after congested conditions began.

A summary of aggregate results can be found in Table 5-3. Results at each sign can be found in Table 5-4.

### Table 5-3: MnDOT Vehicle Travel Time Comparison – Aggregate Results

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Drive Runs Conducted*</td>
<td>145</td>
</tr>
<tr>
<td>Number of Travel Times Compared per Run</td>
<td>7</td>
</tr>
<tr>
<td>Total Number of Instances Comparing Displayed vs. Actual Travel Times</td>
<td>1015</td>
</tr>
<tr>
<td>Number of Instances Out of Specification</td>
<td>51</td>
</tr>
<tr>
<td>% Instances Out of Specification (51 instances out of 1015 MnDOT vehicle runs conducted)</td>
<td>5.0%</td>
</tr>
<tr>
<td>Average Time Out of Specification (mins)</td>
<td>12.3</td>
</tr>
</tbody>
</table>

*The Travel Time Display System was operational 24 hours a day/7 days a week. The Vehicle Travel Time Runs were only conducted on weekends when traffic volumes were expected to be high. Therefore, the total number of instances (1015) does not reflect performance during the entire duration the system was in operation.*
Table 5-4: MnDOT Vehicle Travel Time Comparison - Results at Each Sign

<table>
<thead>
<tr>
<th>Sign</th>
<th>Sign Information (Travel Times)</th>
<th>Specified Accuracy (mins)</th>
<th>Number of Instances Comparing Displayed vs. Actual Travel Times***</th>
<th>Number of Instances Out of Specification</th>
<th>% Instances Out of Specification</th>
<th>Average Time Out of Specification (mins)</th>
<th>Sign Distance (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>NB to Moose Lake via I-35</td>
<td>10</td>
<td>145</td>
<td>5</td>
<td>3.4%</td>
<td>16.8</td>
<td>30</td>
</tr>
<tr>
<td>B</td>
<td>NB to Duluth via I-35</td>
<td>15</td>
<td>145</td>
<td>3</td>
<td>2.1%</td>
<td>7.3</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>* NB to Duluth via MN-23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>NB to Cloquet via I-35</td>
<td>10</td>
<td>145</td>
<td>2</td>
<td>1.4%</td>
<td>15.5</td>
<td>41</td>
</tr>
<tr>
<td>D</td>
<td>NB to Duluth via I-35</td>
<td>5</td>
<td>145</td>
<td>2</td>
<td>1.4%</td>
<td>6.0</td>
<td>15</td>
</tr>
<tr>
<td>E</td>
<td>SB to Hinckley via I-35</td>
<td>15</td>
<td>145</td>
<td>12</td>
<td>8.3%</td>
<td>12.3</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>* SB to Hinckley via MN-23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>SB to Hinckley via I-35</td>
<td>15</td>
<td>145</td>
<td>12</td>
<td>8.3%</td>
<td>21.0</td>
<td>50</td>
</tr>
<tr>
<td>G</td>
<td>SB to Hinckley via I-35</td>
<td>10**</td>
<td>145</td>
<td>15</td>
<td>10.3%</td>
<td>7.5</td>
<td>34</td>
</tr>
</tbody>
</table>

* MnDOT Vehicle Runs were not conducted on the MN-23 route
** Specified accuracy was changed from 5 mins to 10 mins, via a Change Order during the project
***Vehicle Travel Time Runs were conducted on weekends when traffic volumes were expected to be high

5.2 Public Perception

5.2.1 MnDOT Customer Relations Survey

MnDOT’s Office of Customer Relations conducted on-line surveys to two separate customer populations, to collect information about the I-35 Real-time Travel Time Display System. Survey objectives included determining to what extent travelers noticed the travel information signs, if the signs were helpful, and to what extent travelers made decisions based on the information. The survey also asked questions about respondents’ tolerance for accuracy, having information accessible by smart phones, and for suggestions or other feedback. The surveys were administered during the second half of August 2012, after the travel information signs had been deployed but before the highly-traveled Labor Day weekend.

The customer populations surveyed and response rates were as follows:

**Constant Contacts (CC)** are travelers who request MnDOT’s email updates for particular construction projects. Two thousand seven hundred twenty (2,720) Constant Contact participants were invited to take the survey; 476 responded, for an initial response rate of 18
percent. Of the 476 who responded to the survey, 350 (74 percent) had traveled on the designated route.

MnDOT’s OnLine Community (OLC) is a recruited, representative sample of Minnesotans who regularly give the department input on a variety of transportation issues in an on-line survey format. This survey screened for those who had traveled on I-35 sometime in the two months preceding the survey. Forty-seven (47) respondents reported seeing travel time information along I-35 and responded to survey questions regarding this specific route.

The questions in each survey were primarily similar; however, the OLC survey contained additional questions, and the questions were worded slightly differently because the two groups have different relationships with MnDOT.

Overall, survey results indicated that the Real-time Travel Time Display System was well-received among respondents. The travel time and alternative route information positively contributed to travelers’ experience during a long construction period on a heavily-traveled summer route. Though the populations surveyed were not perfectly reflective of the general population, respondents’ written comments reflect benefits that are applicable to the general population – they appreciated having information with which they could make route and other planning decisions, set their expectations, and feel less stressed about their trip.

In terms of accuracy of the system, survey results indicated that travel time signage can be off by up to 10 minutes and still satisfy most users. Suggestions for improvement included:

- Additional signage with information regarding secondary destinations
- Information about upcoming exit closures related to the alternative route suggestions
- Additional signage earlier in the route to allow more time for planning, and
- Providing more lead time ahead of exits.

Detailed survey results are summarized into the following categories:

- Travel Time Information
- Alternate Route Information
- Overall Perception of Travel Time/Alternate Route Signage
- Information Via Smart Phones
- Other Respondent Comments and Suggestions

**Travel Time Information**

**Awareness** - Nearly 100 percent of respondents (both CC and OLC), who had traveled the designated route, noticed the travel time signs and remembered seeing travel time information posted.
**Changed route as a result of seeing travel time signs** - Among the CC respondents, exactly half never changed their route, and almost half changed their route at some level of frequency. Among the OLC, 79 percent reported never changing their route, with the remainder reporting changing their route at different frequency levels. When the OLC was asked why they did not change their route, 60 percent responded that “there was never enough traffic to necessitate changing,” which may indicate that they were not traveling during peak times. Other written responses from both groups reflected not wanting to take alternate routes, not having alternate routes designated, and not traveling as far as Duluth.

**Helpfulness of travel time information** - Using a 1-10 scale, a strong majority of CC respondents reported that the travel time information was helpful (80 percent in the Top 4 boxes). Many of these respondents who commented said “thank you” for the signs. Of the OLC, 18 of 31 respondents (58%) rated the travel time information in the Top 4. Respondents’ comments on what they found particularly helpful or not helpful about the signage included:

- **Decreased drivers’ stress:** Many respondents commented that the travel time information made their drive less stressful, even if they didn’t take a detour. Respondents indicated that their stress was decreased because the information confirmed they were on the quickest route, and/or prepared them for upcoming congestion, and/or allowed them to make calls/communications indicating that they would be late.

- **Advised on alternate routes:** Drivers who took alternate routes (posted or otherwise) were appreciative, indicating that their drive times were reduced or they experienced less traffic.

- **Signage placement:** Respondents who rated the signs not as helpful primarily referenced the signage placement. For example, a number of drivers said that they wanted to see signs north bound prior to Hinckley, not after the Hinckley exit. Several noted that upcoming exit closures on the designated route should also have been posted on the signs.

- **Relevance:** Most respondents found the sign information relevant to their route decisions. Others who rated the signs lower on the helpfulness scale said that the signs didn’t provide...
information about their destination (the Iron Range, Cloquet, other non-Duluth destinations) or that they traveled during non-peak times and so the information wasn’t relevant to them.

- **Accuracy**: A number of respondents who found the signs helpful noted that the times they saw were accurate. However, some other respondents reported that the signs were “wrong” and drive time was “much longer than the signs indicated.” Nearly 20 percent of CC respondents thought that travel time signs needed to show the exact number of actual travel minutes to be useful; 55 percent thought that the signs could be off by 10 minutes and still be useful, and another 19 percent said up to 15 minutes. Of the OLC group, only six (6) percent of 218 respondents said that the travel time needed to be exact to be useful; 45 percent chose “roughly five minutes,” another 35 percent chose “roughly 10 minutes,” with the remainder choosing longer.

**Alternate Route Information**

**Awareness** - About 75 percent of CC respondents who reported noticing the travel time signs reported seeing the signs with alternate route information. Approximately 44 percent of that subset said that they changed their route with some degree of frequency.

**Helpfulness of alternate route information** - Using a 1-10 scale, almost two-thirds of CC respondents reported that the travel time information was helpful (62 percent in the Top 4 boxes). In general, written responses were similar to the responses regarding travel times – having the information was welcomed and helped to make informed decisions, even if travelers did not take alternative routes. Some respondents noted that they weren’t likely to use an alternate route if they weren’t familiar with it. Others said that the information helped them decide on taking an alternate route, though not the one suggested on the signage. A few commenters referenced alternate routes that would have been more helpful for their destination (e.g. Hwy 61 route to Cloquet and the Iron Range.)

**Overall Perception of Travel Time/Alternate Route Signage**

The survey asked respondents (including those who reported not traveling the route during the study period) their opinion of the signage: Based on a scale of 1 to 10 (1 = Hindrance/problem and 10 = Highly beneficial), how beneficial, if at all, do you think [posting travel time information/alternative route information in a construction work zone] is to overall traffic conditions?

Over 80 percent of the CC respondents selected responses in the Top 4 of the scale for both types of signs, with over 40 percent rating both as a “10” on the “beneficial” scale. Of the 218 OLC respondents, about 86 percent selected responses in the Top 4 of the scale for both types of signs, with 36 percent rating both as a “10” on the “beneficial” scale. (Note that 78 percent of these OLC respondents did not actually travel this route during the study period.)

**Information via Smart Phones**
The survey asked respondents about their likelihood of using their smart phones to access travel time and alternative route information. On a scale of 1 to 10 (1 = Very unlikely and 10 = Very likely), if traffic alerts regarding real-time travel times and alternate routes were available via a smart phone search or application, how likely would you be to ask a passenger to access this information through your phone or to check before your departure?

Of the 262 Constant Contact respondents, 72 percent responded in the Top 4 categories, with 39 percent rating their likelihood a “10.” Of the 100 OLC respondents who reported having a smart phone, 65 percent responded in the Top 4 categories, with a quarter rating their likelihood a “10.”

A number of respondents commented that they already used Google Maps for similar information. Several respondents cautioned against putting information on smart phones because they thought it might encourage use while driving, which they noted was unsafe. Several noted that the travel time signs were needed precisely because drivers should not be looking up information on their phones while driving.

**Respondent Comments and Suggestions**

Notable comments and suggestions from respondents included:

- A few respondents wondered about the methodology for the signs – who updates the time, how, and how frequently.
- A few travelers suggested that MnDOT put detailed project information on our website, including duration, and what is occurring each week. Others thought that project update signage would be helpful for future planning.
- Several respondents commented on other drivers not knowing how to merge correctly for upcoming lane closures, causing increased backups.
- A number of respondents expressed gratitude for the project and MnDOT.

### 5.2.2 Other Public Feedback

The Evaluation Team reviewed eight emails provided by MnDOT containing feedback related to the travel time information system during the duration of the deployment. Two emails communicated positive feedback on the system, and six emails provided negative feedback and/or suggestions for improvement. Common themes emerging from the emails are summarized below.

**Positive Feedback:**

- The signs were useful in providing information and time was saved by taking the alternate route.
- The information helped in deciding which route, I-35 or MN-23, would be quicker.

> “The advisory signs in the southbound lanes have been great. Last weekend, the wait looked like about 25 minutes at the single lane, so we took the Sturgeon Lake exit, enjoyed the tour through the country, and cut 20 minutes off the delay.”
**Negative Feedback:**

- The sign at Hinckley (Sign A) should have been placed south of the exit so northbound motorists could exit at Hinckley.
- The TrafAlert website was not functioning properly (e.g. travel time data does not appear when a sign location is selected.)
- Actual drive times were longer than times posted on the signs and/or shown on the TrafAlert website.
- Providing travel time and alternate route information is a good idea, but the information needs to be accurate in order to be useful.

When the “TrafAlert” website was not functioning properly, subsequent internal MnDOT emails indicated that they were aware of the issue and the Contractor was in the process of fixing it. In response to the feedback about the NB Hinckley sign placement, MnDOT’s Public Relations staff indicated that the sign location was chosen so that motorists entering I-35 from Hinckley would see the travel time information.

One notable observation from MnDOT staff was that no phone or email complaints were received over the Labor Day weekend, indicating that the system was likely functioning well during a high-volume traffic weekend.
6.0 Lessons Learned

This section includes lessons learned from the Rural Travel Time During Construction project from MnDOT and the Contractor. Interviews were conducted with selected staff to gain a number of viewpoints on the overall project. The information gathered from the interviews is provided in the following sections and is intended to provide MnDOT with suggestions and/or potential next steps to consider on similar future deployments.

6.1 MnDOT Perspective

Staff from four MnDOT entities collaborated during the planning and execution of this project. These entities were MnDOT District 1, the Office of Traffic, Safety, and Technology (OTST), the Metro District Regional Traffic Management Center (RTMC), and the Office of Construction and Innovative Contracting (OCIC). During interviews with collaborating staff, a number of viewpoints and lessons learned were shared. Lessons learned also emerged from the performance evaluation analysis.

Best Value Procurement Method

Those involved in the project felt that the Best Value Procurement method was beneficial to the project. This process enabled MnDOT to procure a Contractor with demonstrated qualifications, thereby increasing the likelihood that the Contractor could successfully provide reliable travel times to motorists.

System Details in Plans and Specifications

Most of the collaborating staff felt that MnDOT appropriately transferred risk to the Contractor by providing performance-based specifications rather than detailing all aspects of the system. As technology changes and improves rapidly, Contractors may be in the best position to determine the most appropriate methods. Being too prescriptive in the plans and Special Provisions could limit the Contractor’s ability to implement innovative approaches and transfer liability/risk to MnDOT. The achieved level of accuracy and dependability of the system was deemed to be successful by staff that supported the performance-based specification approach. There were a relatively low percentage of instances when travel times were out of specification and public feedback was generally positive.

Other staff felt the project would have been more successful if additional details defining system requirements would have been provided in the plans and Special Provisions. Details such as sensor spacing, detection capabilities, and a verification plan from the Contractor may have resulted in more accurate travel times during the project. There was also a recommendation to require shorter segment distances between signs and additional sensors in order to more accurately estimate travel times, especially during changing traffic conditions. This approach may have cost more, but it could increase MnDOT’s ability to provide reliable travel information on a more consistent basis state-wide.
The collaborating staff acknowledged that there were trade-offs when considering cost versus system performance. A travel time system that provides highly accurate information at all times during all traffic conditions could be costly, and MnDOT may not be willing to invest in the highest level of performance.

**Quality Control**

A recommendation was made to require a quality control plan from the Contractor that outlines how they will set up and test the system and monitor and correct issues. This could lead to more effective weekly discussions between MnDOT and the Contractor, to review comparison results and help inform where adjustments can be made. If additional requirements such as a quality control plan are specified, MnDOT will need to consider how this may impact overall project costs.

**System Requirements Language**

There was general agreement that language in the Special Provisions that outlined system requirements could be improved. The language could state that it is the Contractor’s responsibility to make adjustments to the system to achieve acceptable accuracies. The language stating “MnDOT recognizes that the system cannot be a predictive system…” should be eliminated; this statement was intended to communicate that travel times may not be calculated using historical traffic data, i.e. typical traffic levels during slow/peak periods based on past history along the corridor. Rather, the language should specify that current traffic data be used to calculate travel times and make adjustments in real-time. It was also desired to better define terms in the Special Provisions. For example, the term “latency” was not clearly defined and therefore was not clearly understood.

**Travel Time Comparison Method**

Collaborating staff noted that the method MnDOT used to compare displayed versus actual travel times, in order to determine monetary deductions, became a point of disagreement between the Contractor and MnDOT. Alternative methods, especially those that utilize technology such as video, Bluetooth, GPS, smartphone apps, etc., could be used in the future to conduct comparisons. These methods may be less expensive and more reliable than the “floating car” approach used for this project.

There was general agreement that MnDOT could have outlined the comparison method in the Special Provisions so the Contractor would have a better understanding of what to expect.

Other recommendations for improving the travel times comparison method included increasing the number of comparisons (e.g. increase the number of vehicle travel time runs) and increasing the variability of times when runs were conducted.

**Monetary Deductions**

Monetary deduction amounts, as specified in the Special Provisions, were established in a manner that was intended to motivate performance while maintaining fair and reasonable standards. Collaborating staff indicated that these deduction values may be determined differently in the future; an initial suggestion was to associate the deduction amounts to the number of days and total project cost rather
than deducting per occurrence. The final deduction amounts for this project will be archived with other historical data and used to help establish deductions for similar projects in the future.

Public Feedback

Feedback from the public provided via MnDOT’s customer survey was overall positive. Respondents appreciated having information to help them make decisions about route choices and time of day to travel. Respondents indicated that having travel time information reduced their frustration and stress because even if traffic was heavy, they could call ahead and/or adjust their plans. The total number of emails containing negative feedback was relatively low, given that the system was in place for over four months and over the summer, when the corridor experiences higher levels of tourist travel than in non-summer months. Feedback from the public, both via the survey and via emails, indicated that motorists traveling northbound would like to have had travel time information provided to them south of the Hinckley exit so they could modify their route accordingly if travel times were high.

System Performance

The MnDOT Travel Time Comparison Runs indicated that the displayed travel times were most likely to be out of specification during the afternoon and evening, during more congested conditions. MnDOT District 1 construction staff observed that the system appeared to work well in free flow, but did not work well during backups and/or during transitions to congested conditions. This observation was confirmed by the travel time comparison analysis.

Some collaborating staff noted that MnDOT should maintain a consistent level of accuracy in travel time systems statewide, in order to maintain a level of confidence with the traveling public. For instance, inaccuracies in travel times for a rural deployment might lessen motorists’ confidence in these types of systems, both in work zones and in the Twin Cities metro area where travel time data is provided on a regular basis. Ultimately, tradeoffs exist in terms of investments in accuracy. If funding is not available to deploy a highly accurate/redundant system in a rural area, perhaps a less costly system is “good enough,” based on the public’s feedback for this particular deployment.

Project Goals and Indicators of Success

The project was intended to meet several goals, including achieving acceptable travel time accuracies, encouraging alternate routes to reduce congestion on I-35, and providing information that will reduce driver frustration. Collaborating staff expressed various opinions about prioritization of these goals and whether the goals were met. Perspectives included:

Achieving Acceptable Travel Time Accuracies

When MnDOT provides travel times to motorists, the information needs to be within an acceptable level of accuracy. Feedback from the public survey suggested that the displayed times were accurate enough and the signs provided options at decision points, indicating that this goal was achieved. Contract issues related to the travel time comparison method and the associated monetary deductions suggest that though the travel time accuracies were acceptable to the public, the specifications could be improved for future deployments. Changes may lead to improved accuracies and less contract issues.
Providing Information to Reduce Driver Frustration

One perspective was that this goal was less important than achieving acceptable travel time accuracies, while others indicated that there is value in simply providing information. Input from motorists in District 1, prior to this project, indicated that they would experience less frustration if they had information about delays caused by construction, so they could plan ahead. Providing information can set expectations so motorists less likely to make unwise choices, such as driving in the shoulder to circumvent traffic. Survey respondents indicated that they appreciated having information so they could alter their route, call ahead, and/or modify their plans; this feedback indicated that that this goal was achieved.

Encouraging Alternate Routes to Reduce Congestion on I-35

One of the motivations for providing the travel time information system was to encourage motorists to use the alternate route MN-23, thereby helping to relieve congestion on I-35. Though traffic counts were not conducted to determine whether travel behavior changed during the project, MnDOT District 1 staff observed that traffic volumes on the MN-23 route did not appear to increase significantly. The public survey results indicated that more than half of the total respondents never modified their routes, with many others doing so at various levels of consistency. When asked why they did not change routes, a majority responded that traffic levels on I-35 were not high enough to motivate a change. Others responded that they were not familiar with the alternate route or not traveling as far as Duluth.

6.2 Contractor Perspective

Staff from the Contractor who provided travel times during the 2012 construction season on I-35 from Hinckley to Duluth were interviewed to gather input on their overall perspectives and lessons learned from the project.

Best Value Procurement Method

The Contractor indicated that the Best Value Procurement Method chosen by MnDOT may have constrained some qualified bidders from submitting a technical proposal. Contractors were required to propose a Real-time Travel Time Display System that was exactly like a system the Contractor used on a prior project. Technology continues to change and this limited the ability to propose other systems/approaches tailored to the I-35 project area. The Contractor was also required to provide prior experience on projects greater than 20 miles and speeds greater than 50 mph. It was suggested to revise the requirement to greater than 49 mph which may have provided additional qualified bidders in the selection process. The Contractor indicated that with the speed and length requirements specified, other technologies (e.g. Bluetooth) could not be proposed because previous experience didn’t exactly match the requirements. The Contractor noted that Bluetooth technology would enhance the calculation of travel times; however, a change order and additional funds would have been required. Therefore the Contractor did not formally request a change to the original proposal.
It was noted that the single most important aspect for the success of the project was MnDOT’s decision to procure the project as a stand-alone contract rather than including it with the other construction projects. The Contractor was able to focus exclusively on the Real-Time Travel Time Display System because it was the only aspect of the contract.

**System Details in Plans and Specifications**
The Contractor agreed with MnDOT in that providing additional details defining system requirements in the construction plans (e.g. sensor spacing required at least every half mile) would put more risk on MnDOT and less on the Contractor. A suggestion was made to consider having the Contractor include a separate cost of bid items if, for example, it is deemed necessary by the Contractor and MnDOT that additional sensors are needed to successfully complete the project. This does offer some complexity to the cost portion of the Contractor’s bid and increases project costs after the contract is underway.

It was also suggested by the Contractor to consider displaying delay times instead of travel times on a long stretch of roadway in a rural area. The Contractor also suggested adding a disclaimer to the message on the signs, such as “estimated travel time” vs. “travel time”.

**System Requirements Language**
The Contractor agreed with MnDOT’s suggestion that the language in the Special Provisions stating “MnDOT recognizes that the system cannot be a predictive system...” should have been removed. The Contractor also agreed that definition of terms is needed in the bid documentation to avoid misunderstandings.

**Travel Time Comparison Method**
The comparison method of how MnDOT would evaluate the accuracy of the travel times displayed on the signs was not explained in the bid documents. It was suggested to detail out the comparison method in the bid documents to help the Contractors with their overall bid process. If the comparison method is known, bidders could determine how accurate the verification is likely to be and determine the risks of deploying a system that will meet the accuracy requirements. MnDOT conducted vehicle travel time runs and compared the data to the travel times displayed on the signs. It was noted by the Contractor that the number of vehicle travel times runs conducted by MnDOT produced a small number of data points to compare to the full duration that the travel time system was in place. Vehicle travel time runs were only conducted on weekends. It was recommended to conduct a statistical analysis to identify a sufficient number of vehicle travel times need to provide a 90% or 95% confidence level in the sample and to describe the comparison process in the bid documents. This recommendation falls in line with a suggestion from MnDOT to provide additional data points (more vehicle travel time runs) for the comparison.

Another recommendation for comparing travel times is to deploy a parallel real-time travel time system to the one selected for the project. The Contractor is aware that this is additional cost to the project, but would provide an adequate number of data points for comparison.

MnDOT identified the location and number of signs in the bid documents. To increase accuracy of travel times to the drivers it was also recommended to provide additional signs along the route.
Monetary Deductions
The Contractor noted that the contract stated that deductions would be applied if any part of the system was not functional. It was suggested to revise the penalty language in the contract to note that a penalty will not be charged if the malfunctioning component does not affect the travel times. For example, if one sensor is not working, there may be other sensors that provide redundancy and the travel times may not be adversely affected. Contractor’s may have bid the project differently or changed their sensor location plan based on revised language related to monetary deductions.

Project Website
A project website was developed for this project by the Contractor that provided users the ability to view the travel times and congestion of I-35 and MN-23 during construction. The Contractor’s website was linked from MnDOT’s 511 page, however it was noted that the link to the construction map was difficult to find. A suggestion was made to explore true integration with MnDOT’s 511 website. However the Contractor is aware that this would be of additional cost to MnDOT for a temporary system.

Staff Training
ITS projects and technology continue to change. As such, it is difficult to maintain a high level of experience with managing and testing these types of Intelligent Work Zone Systems. It was recommended to provide training to staff who will oversee work zones, prior to developing bid documents, in order to become familiar with technologies being considered for use in the work zone.
7.0 Conclusion

Feedback provided to MnDOT from motorists in the District 1 area indicated a need for information about expected delays during road construction on I-35. The location of the construction and the existence of an alternate route created an opportunity to inform travelers of the expected travel times along the parallel routes. The MnDOT team working on this project faced several challenges:

- Limited funds were available for information dissemination, especially considering the long distance that was required to be monitored;
- The specialized nature of the work zone and MnDOT’s desire to provide accurate information warranted a stand-alone contract with performance criteria and deductions, in order to motivate high quality execution of the travel time system; and
- The proximity to Twin Cities was such that there were some concerns from MnDOT that inaccuracies or unreliability of travel time data could harm the trust that motorist in the Metro area had developed for the travel time messages on the Twin Cities highways.

This project utilized an innovative approach to provide travel times and alternate route information to motorists along a 70-mile stretch of freeway. This project marked the first time MnDOT had implemented a travel time information system on a rural freeway segment of this distance.

Overall, the project was successful and benefitted travelers throughout the summer. Feedback obtained through the public survey was generally positive, and respondents appreciated having information that prepared them for congestion in the work zone and assisted them in making decisions about taking alternate routes.

The decision to procure a stand-alone contract was deemed successful by both MnDOT and the Contractor. While the Best Value Procurement Method was seen as effective to MnDOT in procuring a qualified Contractor, feedback from the Contractor indicated that the pre-qualification criteria limited their ability to deploy technologies appropriate for the unique circumstances of this work zone. MnDOT is aware that technology continues to change and improve, however, for this project MnDOT required the contractor to propose a system in which the means and methods were previously successful in order to ensure the contractor had experience with the proposed system.

There is always a challenge of determining ‘how accurate is accurate enough?’, and deciding how much funds should be spent to increase accuracies beyond a minimal level. This project appears to have captured a successful “sweet spot” where the project team worked with funding available to procure a service that helped a large number of travelers during a difficult construction season. While there may have been other methods that could have increased accuracy, reliability, or coverage of signs, the overall feedback was positive.

This evaluation details a number of aspects that could be improved for future deployments of this type. Most of the suggested improvements are related to providing additional definition and clarification in the Special Provisions (specifications) of the contracting process, to help avoid misunderstandings during project execution.
Appendix A: Plans for “Intelligent Work Zone System”
## STATEMENT OF ESTIMATED QUANTITIES

<table>
<thead>
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<th>TAB.</th>
<th>SHEET NO.</th>
<th>ITEM NO.</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
<th>TOTAL ESTIMATED QUANTITIES</th>
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<td></td>
<td>2563.601</td>
<td>INTELLIGENT WORK ZONE SYSTEM</td>
<td>LUMP SUM</td>
<td>1</td>
</tr>
</tbody>
</table>

### NOTES

1. **No Utilities Will be Affected by this Project.** Utility Quality is Level D.
2. This quality level was determined according to the guidelines of Mn/DOT 02-CD 03-02, Entitled Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data.
3. Place travel time signs as shown on general layout sheets for 2012 construction season.
4. Place speed sensors as required to determine travel times as shown on plan.
5. Note sensors and signs will need to be relocated/adjusted when 2012 construction projects change stages.
6. See special provisions for specific intelligent work zone requirements.
Appendix B: Special Provisions for “Intelligent Work Zone System”
Special Provisions for “Intelligent Work Zone System”

(2563) INTELLIGENT WORK ZONE SYSTEM

S-34.1 SYSTEM OVERVIEW

This Project will consist of providing travel time information to the motoring public on I-35 and TH 23. The Contractor is required to determine and post travel times at the planned locations along the I-35 corridor. In addition to the signs shown in the plan, the Contractor will need to provide sufficient detection devices along the I-35 corridor to gather and process the current speeds to derive accurate segment travel times. The Contractor will be required to install sensors within several construction projects that have been or will be let separately. These Projects are SP 5880-173, SP 0980-138 and SP 0980-139 as shown on plan sheet 6. The sensors within the construction zones may need to be relocated when the construction stages change. All three of the construction projects have multiple stages. For the purposes of these special provisions the Intelligent Work Zone System described below will be referred to as the “system”.

The specific intent and purpose of the project is to:

1. Inform the travelling public of accurate travel time on the northbound I-35 corridor and via T.H. 23 with roadside static signs at the planned locations with inserted LED changeable modules which display changeable travel time information. All travel time signs shall be operational 24 hours per day/ 7 days per week.
2. Reduce driver frustration, enhance safety and increase traffic efficiency by sufficiently informing the public of travel times of the alternate route and thereby encourage use of T.H. 23 during peak traffic volume periods.
3. Inform the travelling public of accurate travel time to Hinckley on the southbound I-35 corridor and via T.H. 23 with roadside static sign with inserted changeable modules which display changeable travel time information.
4. Inform the travelling public via a website link to the MnDOT 511 website with updated near real time travel time information as displayed on the signs.
5. Conduct a weekly meeting/phone conference on each Monday afternoon assessing the effectiveness of the system over the week/weekend.
6. Record all of the data gathered by the project in a manner convenient for future analysis.
7. See the chart in S-34.3 below for specific accuracy requirements.

S-34.2 SYSTEM REQUIREMENTS

1. The system shall consist of furnishing, installing, relocating, operating, maintaining, and removing an automated, temporary, real-time system meeting the requirements noted herein during the time the Projects as shown on plan sheet 6 has lane closures. This system will be mounted on Contractor provided and installed signs. See the appropriate plan sheets for the size, mounting and legend detail. The changeable message signs shall meet the requirements of the MUTCD and the letter heights shall be a minimum of 18 inches. The system will be operational no later than April16, 2012. Due to traffic staging, several sensor movements will be required. Included in the operational responsibilities is the responsibility of all power and communication costs such as cellular telephone, satellite, web posting and internet subscription charges. In addition to these requirements, the Contractor shall assume all responsibility for any damaged equipment due to crashes, vandalism, adverse weather, Acts of God etc. that may occur during the systems deployment.

2. The system shall have sufficient traffic detection devices to detect traffic speeds and by the use of an algorithm compute and communicate estimated travel time to the signs at the locations in the plan. These detection devices shall be identical to the examples of previous intelligent work zone projects as submitted by the Contractor in accordance with Special Provision 1301. All traffic sensors for this project shall be
non-intrusive to the pavement except as permitted by the Engineer. All sensors allowed in the pavement shall be removed to the satisfaction of the Engineer. The system message shall update at least every 5 minutes. The system shall self-test for communication or sensor failures. All sensors shall be of a type whose accuracy and latency are not degraded by inclement weather or degraded visibility conditions including precipitation, fog, darkness, excessive dust, and road debris and have sufficient power capability to run 24 hours per day/7 days per week for the duration of the project.

3. The system shall have a reliable communication system and provide warnings to the system manager, the appropriate MnDOT personnel and the website when communication or device failures are detected via the Contractor website. The system manager is the person who is directly operating the system on a regular basis. All communication costs shall be included in the bid price for the system.

4. The system shall have reporting features to a password protected secure website. Only the Contractor and the appropriate MnDOT personnel shall have access to this website. The website shall, at a minimum, show the current speeds at each detector location on a real time basis. This website shall have the capability to verify the actual travel times of the traffic on a quality control basis. The website shall provide a weekly report providing accuracy information and the system availability for discussion at the weekly meetings. The website shall provide access to archival data for the duration of the project. This archival data shall be printable and in a format that allows for analysis in the future. It shall be preserved on a CD or other device as approved by the Engineer. All data collected shall be in IRIS standard data format for xml feed. All data collected shall show the current speed or derived travel time or segment averaged speed in a near real-time basis. All data from the system shall become the property of MnDOT with exclusive rights forever.

5. The Contractor shall create a website which is accessible from a link on the MnDOT 511 website which displays a map-based representation of the project showing the sign locations and the near real-time travel times as shown on the actual signs on TH 35. This website is a different website as the website indicated in S-34.2.4

6. MnDOT recognizes that the system cannot be a predictive system and that the displayed travel time is based on current conditions. Performance will be evaluated based on these Special Provisions and to the satisfaction of the Engineer as determined in MnDOT 1501.

7. All sensor and communication devices utilized for the system will remain the property of the Contractor. MnDOT will not retain any system hardware for future use.

S-34.3 SYSTEM OPERATION and PERFORMANCE

Performance of the system will be monitored by MnDOT personnel on a continuous basis during the “critical traffic periods” defined as follows:

1. 11:00 am Friday until midnight Friday night (Northbound)
2. 11:00 am Sunday until midnight Sunday night (Southbound)
3. 11:00 am Monday until midnight Monday night (Southbound) on Memorial Day and Labor Day weekends.

The system shall be capable of continuous 24 hours per day/7 days per week operation with updates at least every 5 minutes.

The remote web access shall allow the system manager or MnDOT personnel to shut-down the system during apparent system failures. The Contractor shall be responsible to making the system operational as soon as possible. Monetary deductions for the system failure will be assessed as per S-34.5

If during the duration of the project it is found that the detectors need to be relocated due to a change in the project’s traffic conditions or queuing patterns, the Contractor shall provide this adjustment during the project time frame. The replacement, relocation, repositioning or the addition of detectors to maintain the system’s operational accuracy may be required throughout the project duration and shall be included in the bid lump sum pay item.
In the event of a system failure, the Contractor shall notify the MnDOT representative within one hour. Repairs shall commence immediately.

Performance will be evaluated based on the following chart with monetary deducts as outlined in S-34.5 below:

<table>
<thead>
<tr>
<th>SIGN</th>
<th>REFERENCE POINT</th>
<th>SIGN DISTANCE (MILES)</th>
<th>ALLOWABLE ACCURACY &amp; LATENCY DEVIATION FROM DISPLAYED TRAVEL TIME (MINUTES, PLUS OR MINUS)</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>184.20 NB</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>190.25 NB</td>
<td>60 (I-35) 64 (TH 23)</td>
<td>15 15</td>
</tr>
<tr>
<td>C</td>
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<td>41</td>
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<tr>
<td>E</td>
<td>253.60 SB</td>
<td>71 (I-35) 59 (TH 23)</td>
<td>15 15</td>
</tr>
<tr>
<td>F</td>
<td>233.00 SB</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td>G</td>
<td>217.00 SB</td>
<td>34</td>
<td>5</td>
</tr>
</tbody>
</table>

**S-34.4 SYSTEM TRAINING**

Interested parties shall attend an education and training session at or near the time and place of the pre-construction meeting. The training shall include at least one representative from each of the following entities:

1. Prime Contractor
2. Minnesota Department of Transportation (Project Engineer and other MnDOT personnel)
3. Subcontractor personnel as deemed necessary

The training shall consist of the following:

1. List of telephone numbers to call to request technical support 24 hours per day / 7 days per week.
2. In the event of a power failure, instructions detailing how to power cycle the system.
3. How to shut the system down in the event of system failure.
4. Data storage location and access for real time and future analysis.
5. Supply 5) manuals for all items above for MnDOT usage.

**S-34.5 SYSTEM WARRANTY, MAINTENANCE, AND SUPPORT**

The system shall be maintained, supported, and warranted against material defects by its supplier throughout the duration of the deployment. The Contractor (system provider) shall assign a system manager for the system deployment. The system manager shall respond to all system failures.

The Contractor shall be required to respond within one hour to any call from the Engineer or his designated representative concerning any request for correcting any deficiency in the system. The Contractor shall respond to MnDOT by phone within one hour of any malfunction in the system subject to S-34.5.4 below.

Monetary deductions for the system or a portion of the system is non-operational will be assessed as follows:

1. Northbound: Any portion of the system not functional during the critical hours of 11:00am Friday to midnight Friday night a monetary deduction of $1000.00 per hour will be assessed.
2. Southbound: Any portion of the system not functional during the core hours of 11:00am Sunday to midnight Sunday night a monetary deduction of $1000.00 per hour will be assessed.
3. Southbound: Any portion of the system not functional during the core hours of 11:00 am Monday to midnight Monday night on any 3 day weekend a monetary deduction of $1000.00 per hour will be assessed.
4. Accuracy: Any accuracy determinations outside of the required level of accuracy and latency as described in S-34.3 above will be assessed a monetary deduction of $1000.00 per occurrence. An occurrence is defined as any time period the system is not operating as designed and as per these Special Provisions.

5. Maintenance and non-critical time periods: If the Contractor is negligent in correcting any deficiency within two hours of notification a monetary deduction of $250.00 per hour will be assessed until the deficiency is corrected. During non-critical traffic periods if any portion of the system is not functional resulting in accuracy as described in S-34.3 above will be assessed a monetary deduction of $250.00 per occurrence.

6. The web link requirements as described in S-34.2.5 above will be subject to the maintenance requirements of S-34.5.5.

7. Monetary deductions may apply equally, separately, and may be assessed concurrently.

S-34.6 MEASUREMENT and PAYMENT

Measurement and payment will be made at the Contract Unit Price under the pay item 2563.601 Intelligent Work Zone System (Lump Sum) which shall be compensation in full for furnishing, installing, relocating, operating, maintaining and removing the system.

If the system is non-functional or inaccurate as defined in this Special Provision for two or more weekends, The Engineer may decide to cancel any future use of the system and reduce the payment to the Contractor.

The Payment Schedule for this Pay Item will be as follows:
1. 40% payment of the Lump Sum bid price when the system is fully functional as per S-34.3
2. 5% payment of the Lump sum bid price per month per after
3. The remaining 30% to be paid upon the completion of the project