Concept of Operations

Monitoring Traffic in Work Zones: The iCone System

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# Table of Contents

1  INTRODUCTION .......................................................................................................................... 1

   1.1 Document Purpose ................................................................................................................. 1

   1.2 Project Definition and Scope ............................................................................................... 1

2  BACKGROUND ................................................................................................................................. 1

   2.1 Federal Regulations Compliance ............................................................................................ 1

   2.2 Limitations of Existing Methods ............................................................................................ 1

   2.3 iCone System Components .................................................................................................... 2

   2.4 XML Data Feed ......................................................................................................................... 2

   2.5 Deployment Considerations ..................................................................................................... 2

3  PARTICIPATING AGENCIES ROLES AND RESPONSIBILITIES ............................................. 2

4  OPERATIONAL SCENARIOS ........................................................................................................... 3

   4.1 Closure Restrictions and Traffic Control Modifications .......................................................... 3

   4.2 Enforcement ............................................................................................................................. 4

   4.3 Mobility Measurement ............................................................................................................ 4

   4.4 Traffic Responsive Systems .................................................................................................... 4

   4.5 Non-Work Zone Applications ................................................................................................. 4

5  SUMMARY ....................................................................................................................................... 5
1 INTRODUCTION

1.1 Document Purpose
This document presents the Concept of Operations for Monitoring Traffic in Work Zones: The iCone System, a project funded by the Minnesota Department of Transportation’s (Mn/DOT) ITS Innovative Idea Program. The Concept of Operations offers deployment scenarios, operational scenarios and identifies measures of success for the iCone System. The document also provides a structured approach to implementing the iCone System while meeting a common vision provided by project stakeholders. This Concept of Operations document has been developed in conjunction with Mn/DOT and stakeholders and is consistent with U.S. Department of Transportation’s Federal Highway Administration (FHWA) documents on Systems Engineering for Intelligent Transportation Systems (ITS).

1.2 Project Definition and Scope
This project will deploy and test an innovative traffic monitoring device designed for deployment in work zones. The iCone System is a commercially available product that provides accurate and near real-time information on the level of congestion in construction sites to affiliated agencies, the media and the public at large.

2 BACKGROUND
Delays and travel time variability due to traffic congestion are a concern for many Minnesota motorists. Work zones in particular have significant impacts both from a traveler delay and safety standpoint due to their dynamic nature. Work zone safety is a major concern in the United States, with 1,065 fatalities and more than 40,000 injuries resulting from work zone crashes alone (2004 report).

2.1 Federal Regulations Compliance
Monitoring traffic through work zones is important to maintain sound work zone traffic management principles. The FHWA Work Zone Safety and Mobility regulation (23 CFR 630 Subpart J) places emphasis on mobility and safety in work zones, particularly for projects funded by the American Recovery and Reinvestment Act (ARRA). Transportation agencies funded by the stimulus bill will be required to address traffic mobility and safety in their traffic control plans and perform continuous process improvement. Construction and maintenance projects will be required to collect data and respond to issues of mobility and safety before, during and after work zones are set up.

2.2 Limitations of Existing Methods
Previous attempts to monitor work zone traffic have encountered problems with deploying roadside equipment and challenges related to capturing and integrating the data. The need exists for a portable, low-cost monitoring system that can withstand the challenging environment found within work zones and that can be rapidly deployed by field personnel with no specialized training.

Most current methods for monitoring work zones require trailers to be placed near the roadway. Trailers can be difficult to move once placed in a work zone and therefore often remain stationary throughout the construction period. Along with the limited placement options, trailer systems can create crash hazards, are susceptible to vandalism and can complicate construction activities. Data integration with existing methods can be challenging as well because there is no standard method for moving managing data the system captures.
2.3 iCone System Components
The iCone is a standard traffic barrel that houses specialized electronic components. Because the iCone resembles a conventional traffic control barrel, vandalism or driver distraction is less of a risk than for trailers. Furthermore, when viewed close up, the iCone is easily distinguishable from other traffic barrels because an arrow is imprinted on the top of the unit. This arrow shows the direction in which to point the iCone to properly detect oncoming traffic.

The iCone’s electronic components are housed within the traffic barrel. These components consist of a GPS antenna, radar controller, radar transducer, modem, antenna, mounting plate, sealing plate, controller board, and an Absorption Glass Mat (AGM) battery. The main component of the iCone is the circuit board which is environmentally sealed and contains the radar components. The circuit board also has ports for the GPS receiver and cellular antenna.

The largest component of the iCone is the battery. The AGM battery is a type of Valve Regulated Lead-Acid (VRLA) battery. This type of battery is able to be turned on its side without causing any problems. The iCone requires the battery to be recharged every 14 to 17 days, typically by connecting the iCone to an electrical outlet. Recharging takes between 12 and 20 hours.

2.4 XML Data Feed
An Extensible Markup Language (XML) data feed contains information from the iCone. The iCone reports its exact location determined by its onboard GPS. From this location, it collects near real-time traffic data. Using a cellular connection to the internet, the iCone relays data to a website (www.iconetraffic.com) where current traffic conditions can be viewed publicly. Password access to the site allows for agencies to download historic records of iCone data. An XML data feed can also be sent directly to agencies for use in traveler information systems, such as 511 or the Condition Acquisition and Reporting System (CARS).

2.5 Deployment Considerations
The iCone is a portable, low-cost, rapidly deployable system that does not require specialized training. iCone units can be placed in a variety of locations depending on the specific need for each work zone. For example, iCones could be set up with one upstream of the work zone, one at the beginning of the work zone, and one placed at the middle of the work zone. The iCone system can be moved and placed to capture data wherever it is needed.

There are multiple deployment strategies for an iCone system. This project will evaluate when it is best to leave the iCone in one location for several months versus frequently moving it within the work zone. This project will also look at balancing time and expense of the recharging the battery.

3 PARTICIPATING AGENCIES ROLES AND RESPONSIBILITIES
Roles and responsibilities for the stakeholders participating in this project are provided in the table below. The table identifies what aspects of current practices would change to accommodate the use of the iCone.
<table>
<thead>
<tr>
<th>STAKEHOLDER/ AGENCY</th>
<th>CURRENT ROLES AND RESPONSIBILITIES</th>
<th>CHANGE FROM EXISTING PRACTICES</th>
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<tbody>
<tr>
<td>Mn/DOT</td>
<td>• Work zone oversight</td>
<td>• Coordinate iCone movement within the work zones</td>
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<tr>
<td></td>
<td>• Traffic management/traveler information (real-time)</td>
<td>• Provide iCone system field inspections</td>
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<td></td>
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<td>• Collect iCone data</td>
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<tr>
<td></td>
<td></td>
<td>• Modify work zones based on data</td>
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<tr>
<td>Hennepin County</td>
<td>• Work zone oversight</td>
<td>• Coordinate iCone movement within the work zones</td>
</tr>
<tr>
<td></td>
<td>• Traffic management/traveler information (as conditions change)</td>
<td>• Provide day-to-day iCone system field inspections</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Collect iCone data</td>
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<tr>
<td></td>
<td></td>
<td>• Modify work zones based on data</td>
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<td>Law Enforcement</td>
<td>• Speed enforcement</td>
<td>• Utilize data from iCone to detect when speeding tends to occur, target enforcement accordingly</td>
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<tr>
<td></td>
<td>• State Patrol tracks traffic accidents through GIS data base</td>
<td>• Utilize data to determine effectiveness of enforcement</td>
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<tr>
<td>Contractor</td>
<td>• Maintain traffic control throughout work zone</td>
<td>• Utilize iCone data to continually improve traffic flow</td>
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<tr>
<td></td>
<td></td>
<td>• Provide and maintain iCones throughout project</td>
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</tbody>
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4 OPERATIONAL SCENARIOS

Four main types of operational scenarios will be considered in this project. They include mobility measurement, enforcement, closure restrictions/traffic control modification and traffic responsive systems as per the Intelligent Work Zone (IWZ) Toolbox.

4.1 Closure Restrictions and Traffic Control Modifications

The iCone data can be used to determine if any modifications should be made to the traffic control plan, such as any changes to lane closure restrictions. By using the iCone in this manner, it is possible to improve the traffic control plans throughout the construction project and use the data to help create better traffic control plans for future projects.

Mn/DOT project engineers could check iCone data on a weekly basis, or whenever they receive a report of heavy congestion. From the data, they could tell where and how often congestion is occurring. They could then modify the traffic control plans and monitor the iCone data to determine if there is any improvement in the congestion level throughout the work zone. The project engineer would work with Mn/DOT staff or the traffic control contractor to adjust the iCone placement as necessary. Note, in this project, Street Smart Rental will provide the iCone adjustments.

Similarly, Hennepin County project engineers could use the iCone data to help monitor and modify traffic control plans as well. Since Hennepin County projects are generally on lower volume roads than Mn/DOT’s roads, the iCone data would tell the project engineers when and where the traffic is moving slowly through the work zone as well as congestion locations. This information could be used to change the traffic control plans throughout the construction project.
4.2 Enforcement
The iCone collects data at regular intervals and then wirelessly transmits all the data to the iCone website. On the website, the data is presented in both table and graph forms. Under this scenario, law enforcement would access this data to determine specific time periods when speeding tends to occur. This would allow them to dispatch personnel to construction sites only when their presence has the most impact, reducing the amount of time spent on enforcement.

State Patrol currently makes an educated guess on enforcement times based on what is seen at the work zone. They do not have any data collection methods in place before or after enforcement efforts occur. State Patrol and/or their Mn/DOT counterparts could check the iCone website weekly to examine traffic speeds at key locations near work zones and intelligently target enforcement. This data would be a useful reference point for understanding trends in the GIS traffic accident database. Currently, this database is only precise to the nearest mile marker.

Local law enforcement is used on Hennepin County construction projects. Hennepin County does not directly pay for enforcement at work zones. However, the County does contact local police to request enforcement when construction workers or local residents feel that the speed of traffic is too high.

4.3 Mobility Measurement
Mobility measurement consists of capturing speed data in a work zone in order to monitor the flow of traffic. For the purposes of this study, mobility is defined as either the change in travel time through the work zone, or delay through the work zone as compared to when the segment is not under construction. The iCone has the ability to approximate mobility by capturing traffic speeds at the iCone’s location. This information can be used to help improve the mobility of the work zone by modifying the traffic control plan, such as adding additional signage.

For Mn/DOT construction projects, the Mn/DOT Project Engineer could examine the iCone data on a weekly basis in order to track mobility in the work zone. A significant reduction in speeds would be an indicator that delays are increasing. Specific iCone placement to address mobility would include locations where free-flow conditions would be expected.

Hennepin County is not expected to use the iCone for mobility tracking on the identified construction projects because these projects are on low volume roadways that do not experience heavy congestion.

4.4 Traffic Responsive Systems
A task under consideration for this project is to integrate iCone data into Mn/DOT’s traffic management and traveler information systems, such as 511. The data would provide another input into the RTMC’s network of traffic sensors. In this scenario the iCone would be deployed to provide supplemental detection information on work zones, or to replace RTMC sensors that are inoperable due to construction activities.

A related application is to use iCone data to actively manage traffic, such as integrating iCone data with dynamic message signs (DMS) to warn drivers of conditions within work zones. These signs could communicate directly with the iCones, allowing for the displayed information to be near real-time and accurate. For example, the iCone could be placed anywhere within a work zone and could communicate information to a DMS at the beginning of the work zone. The DMS could provide delay information or warn of queued traffic ahead. Back of queue protection is a concern on Mn/DOT projects near Owatonna, St. Cloud and Rochester.

4.5 Non-Work Zone Applications
The iCone can be used in applications beyond work zones. For example, an iCone could be used to warn motorists they are approaching the back of a queue, an application similar to the work zone application
described earlier. Unexpected traffic queue situations can result in rear end crashes. If an iCone were placed near where the backups occur, it could transmit information to a DMS or blank-out sign upstream of the backup that would alert drivers to expect a queue.

Traditionally, speed studies focus on determining the 85th percentile speeds. These studies need per-vehicle records which the iCone is not capable of providing. However, the iCone data can give information that can help focus when these speed studies should be done and what general speeds to expect. With that data, the speed studies and enforcement can be targeted for effective use.

Traffic control during special events creates unique challenges. The iCone could be used as a flexible, low-cost, and inconspicuous means of capturing traffic flow data, attributes that are suited to the short-term nature of special events.

The detection component for the applications listed above can be provided by a variety of traffic sensors. The decision to use iCone should consider aspects of the sensor that make it advantageous, such as self-powered, inconspicuous and easy to deploy. The operational scenarios for non-work zone applications will be flushed out in future discussions throughout the course of this project. Many of the scenarios will also be tested to determine the added value they give to the agencies. The usefulness of the iCone for future construction projects will be determined as well.

5 SUMMARY
At this time, Minnesota highway managers and the general public have limited real-time information available to monitor the impacts that construction projects have on traffic flow. The iCone system will help to monitor work zone speeds to identify when and where congestion occurs. Improvements to the work zone, such as changing or adding additional signage, could be made based on data from the iCone.

There are many possible applications of the iCone system, including integrating the data into driver information systems, monitoring the safety and mobility of work zones, and aiding in targeting law enforcement. This project will look at all of these applications as well as quantify the system’s accuracy in measuring traffic speeds. The end of the project will possibly see iCone data integrated into Mn/DOT’s traffic management and Intelligent Work Zone applications.