Concept of Operations

_Truck Rollover Warning System (TROWS)_

Minnesota Department of Transportation

Innovative Ideas Program

MnDOT Contract No. 02200
SEH No. MNTMD 123391

April 15, 2013
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1.0 Project Description

The proposed Truck Rollover Warning System (TROWS) is an enhancement of IRD’s current Truck Rollover Warning System and will be designed to provide a specific warning directed specifically to trucks that are in danger of a rollover crash. The warning system uses both Weigh-in-Motion (WIM) and Road Surface Detection technologies to provide a new solution to the rollover problem. This single system is a new approach that has not been previously implemented. This project will use the IRD iSINCTM technology to incorporate truck rollover and road condition warnings at a single site. A two-sign display is proposed for this project to provide a cost-effective solution. The project will also evaluate the means to notify drivers of the imminent crash potential.

2.0 Problem Statement

Road geometry and traffic conditions can create hazardous situations such as a sharp curve on an exit ramp from a high speed freeway. More than 10,000 truck rollovers occur annually in the United States. Commercial vehicles have a higher center of gravity and experience more difficulty in decelerating rapidly than general traffic.

Truck rollover accidents result in costly damages in the form of injury, loss of life, property damage, environmental damage, clean-up costs, and traffic delays. A single accident can result in damages in the millions of dollars.

Specific contributing factors to truck rollovers include; vehicle weight, vehicle load shift, vehicle speed/deceleration, road surface condition and road geometry or various combinations of these factors contribute to the truck rollover crash likelihood, the problem is finding a means to reduce the probability of the crashes before they occur.

3.0 Stakeholder Description

Over the course of this project a number of stakeholders will be involved. Involvement will vary depending on stakeholder roles and responsibilities. Stakeholders that have direct involvement in delivering the project will form the Project Management Team (PMT). Following is a list of PMT members:

MnDOT Project Manager
Dan Rowe
daniel.rowe@state.mn.us
651.234.7059

SEH Project Manager
Tom Sohrweide
tsohrweide@sehinc.com
651.490.2072
There are also a number of stakeholders who have either expressed interest or may become interested as they are exposed to the project. These stakeholders include:

**Truck Drivers/Carriers:** This group is the intended beneficiary of the project. They will notice a dynamic warning on the appropriate sign if their approach speed to the curve is too fast and/or the roadway conditions are adverse.

**Other Vehicle Drivers:** This group will be aware of the project because of the signing, and will see evidence of the system operation under adverse road conditions.

**MnDOT Staff:** This group is comprised of MnDOT area management and Freight and Commercial Vehicle Operation. This group will be monitoring the progress of this project and evaluating the project’s potential use throughout the State.

**Law Enforcement/Emergency Services:** This group is affected by truck rollovers and their required presence at a rollover. The ability of this system to reduce the number of truck rollovers will be beneficial to this group.

**Other Interested Parties:** Other interested parties may include the media, the Minnesota Trucking Association, and road safety organizations.
4.0 **Project Objectives**

This project is a significant enhancement of a proven system and will not require an on-going commitment of specialized resources to remain operational after the project has been completed. It is the intent to prove that addition of road surface condition to the WIM Truck Rollover Warning System will cause a change in driver behavior to help reduce the number of rollover crashes and is a system that is sustainable and maintainable. The two systems will function independently.

The WIM electronics analyze the signals to determine axle weights, spacing between axles, axle group weights, gross vehicle weight, and vehicle classification. These components give the system enough information to determine a safe speed, called the threshold speed, for the vehicle to negotiate the exit ramp based on the ramp geometry. The vehicle weight, vehicle type, curve radius, and curve super elevation are all considered in a calculation utilizing a FHWA algorithm of the maximum safe speed for the specific conditions of the road and vehicle. The speed determined by the calculation is also checked against the predetermined maximum speed for the road for any vehicle. The lower of the two values is used in determining whether the warning system should be activated.

An In-Road Surface Condition Detector will be installed downstream of the rollover detection equipment to detect pavement temperature, pavement dry/wet levels, icing conditions and snow build-up on the roadway surface.

If the Road Surface Detector identifies a potentially slippery and/or icy condition it will activate a warning to inform all drivers of slippery conditions. The roadside warning will only be active when a potentially unsafe pavement condition is detected.

5.0 **Concept of Operation – General Operational Description**

This concept of operations general operational description is provided to aid the development of the TROWS requirements, detailed system design, installation, operations and maintenance. The concept of operations is focused on providing the project team clarity in how the system will be used. Presented below are descriptions of how the system will be used and will be described from various stakeholder viewpoints. The description assumes the system is deployed. The next section will describe the installation process and operational scenarios associated with the installation and operations of the system.

MnDOT is currently using signing as the means for preventing truck rollover crashes on interchange ramps. The TROWS will provide a dynamic warning for trucks entering the freeway exit ramp at too high a rate of speed and for all vehicles under slippery/icy roadway conditions.

5.1 **Deployment of the Truck Rollover Warning System**

5.1.1 **Location**

The system will be located on the southbound exit ramp of I-694 to eastbound I-94. This interchange incurred the second highest number of truck rollover crashes in the State as published in the American Trucking Research Institute’s (ATRI) “Mapping Large Truck Rollover: Identification and Mitigation through Special Data Analysis” released in May 2012. This particular exit ramp incurred the highest number of truck rollover crashes for this interchange, as determined from MnDOT crash data from 01/01/2007 – 05/03/2013.
MnDOT modified the signing at this exit ramp in September 2012. The signage as it exists with those changes will remain for this project.

5.1.2 System Components
5.1.2.1 Roadside WIM Electronics and Communications
5.1.2.2 Piezoelectric WIM Sensors and Inductive Loops
5.1.2.3 Signing and Dynamic Warnings
5.1.2.4 Road Surface Condition Detector

5.1.3 Description from the viewpoint of the truck driver/carrier.
Truck drivers that are southbound on I-694 may notice two signs on the southbound to eastbound exit ramp, while truck drivers using that ramp will have those two signs in their direct line of sight. The messages on the signs will be determined in the design phase of the project.

If a truck driver is exiting at a speed that is too high for their truck’s weight and the exit geometry, the driver will see a dynamic warning with one of the signs. Truck drivers that are not exiting may also see the dynamic warning.

Truck drivers that are exiting when road surface conditions are potentially slippery and/or icy will see a dynamic warning with the second sign. Truck drivers that are not exiting may also see the dynamic warning.

As part of this project, truck drivers may be surveyed with regard to the operation of the TROWS.

5.1.4 Description from the viewpoint of the other vehicle driver.
Other vehicle drivers that are southbound on I-694 may notice two signs on the southbound to eastbound exit ramp, while other vehicle drivers using that ramp will have those two signs in their direct line of sight. The messages on the signs will be determined in the design phase of the project.

Other vehicle drivers that are exiting will only see two signs on the exit ramp, but will normally not experience any dynamic warning, unless they are in front of or following a truck which activates the warning for a truck going too fast or the dynamic warning is activated on the second sign for potentially slippery and/or icy road conditions.

Other vehicle drivers that are not exiting may also see both dynamic warnings.

5.1.5 Description from the viewpoint of the maintenance worker.
The TROWS installation will be performed by a contractor. The transportation agency field support staff shall assure the installation tasks are performed and inspected.

System maintenance throughout the project will be the responsibility of the SEH team and may include items such as:
- Repairs in the event of system failure.
- Scheduled system diagnostic readings.
- Scheduled preventive maintenance.
If the system is turned over to MnDOT at the conclusion of the project, the maintenance staff will be trained in the maintenance of the TROWS. MnDOT may desire to maintain the systems cellular modem for remote monitoring of the system operation.

5.1.6 **Description from the viewpoint of the transportation engineer.**

In general the transportation engineer will identify locations in need of safety improvements through traditional means such as crash data, public comment, safety audits, and professional judgment. The transportation engineer will evaluate the viability of a TROWS by reviewing the current signage and evaluating cost and performance criteria.

In cases where the transportation engineer determines that use of a TROWS is needed a plan set will be developed to identify location of system components and other location specific information. Prior to installation of the TROWS, in-place traffic control devices will be inventoried.

There should be no need for additional public education or notice in order for the TROWS to be deployed and operate effectively. However, the installation of the TROWS may serve as an opportunity to provide general traffic safety educational messages to the public. Articles or announcements in local media may be appropriate.

As with any change in traffic control, the transportation engineer may expect questions or comments from the public, media, or elected officials. The transportation engineer should be prepared to address questions by understanding the objectives and intended operation of the TROWS.

The implementation of a TROWS will not constitute an addition of an enforceable traffic control sign. The TROWS is advisory. However, the transportation engineer may choose to advise law enforcement of the addition of the TROWS so they are also able to respond to questions or concerns raised to them by the public.

The transportation engineer may direct installation of the TROWS. The engineer may also be responsible to direct maintenance staff to perform initial system diagnostics and ongoing adjustment and calibration on a scheduled basis. The engineer is also responsible to determine a repair policy of procedure in the event the TROWS fails.

The transportation engineer should conduct periodic review of data from a TROWS to evaluate its effectiveness. The system may be equipped with a cellular modem to be able to obtain data remotely.

5.1.7 **Description from the viewpoint of law enforcement/emergency services.**

The implementation of a TROWS will not constitute the addition of an enforceable traffic control sign, the TROWS is advisory. However, law enforcement should become aware of the placement of the TROWS via notification from the transportation agency or from inquiries by the public.

Law enforcement should have no additional responsibilities or traffic enforcement activity as a result of the TROWS deployment. Law enforcement should become familiar with the objectives of the TROWS, and may choose to use the installation of the TROWS as an opportunity to provide general traffic safety educational messages to the public.

Emergency services will not have any involvement with the installation and presence of a TROWS.
6.0 Concept of Operation – System Operational Description

This concept of operations system operational description is provided to identify the roles and responsibilities of the parties participating in this project. The information in this section may be used to drive the development of the individual system requirements, detailed system design, and system installation. However, the primary objective of this section is to provide guidance and clarity to the specific tasks that each stakeholder will need to take throughout the course of the project in order for the project to be successful.

6.1 Stakeholder Responsibilities.

6.1.1 Development of System Requirements

6.1.1.1 System requirements will encompass a number of detailed descriptions of how the systems will function and to what parameters the systems will perform. They may include functional, performance, interface and data requirements as well as items such as reliability and environmental requirements. Responsible – PMT.

6.1.1.2 All PMT members will be engaged in the development of the functional requirements through the attendance and participation in project meetings. Draft meeting materials should be reviewed prior to attendance at team meetings to enable productive discussion and work during meetings. Responsible – PMT.

6.1.1.3 Each team member should contribute items to the system requirements in general, but also bring forward any specific items to be included in the system requirements that represent your specific discipline or stakeholder group. Responsible – PMT.

6.1.1.4 The Consultant team will be responsible for gathering, drafting, and presenting the System Requirements and will prepare and deliver the final System Requirements document. Responsible – Consultant.

6.1.2 Preliminary Engineering

6.1.2.1 Identify any needed agency approvals. Responsible – MnDOT.

6.1.2.2 Confirm site for system installation. Responsible – MnDOT.

6.1.2.3 Determine availability of AC power at the site. Responsible – MnDOT and Consultant.

6.1.2.4 Prepare site plans. Responsible – Consultant.

6.1.3 Detailed Design

6.1.3.1 The Consultant team will recommend design parameters for review by the stakeholders.

For example, if the calculated speed indicates that the vehicle could travel the curve at 30 miles per hour but the advisory/posted speed of the exit is 25 miles per hour, the advisory/posted value would over-ride the calculated value so that a vehicle is never allowed to exceed the advisory/posted speed without receiving a warning.

Responsible – Consultant

6.1.3.2 The Consultant team will prepare draft and then final designs. Responsible – Consultant.

6.1.3.3 The designs will be reviewed by the PMT subject to their involvement and expertise. Responsible – PMT
6.1.4 **Installation**
- 6.1.4.1 Install system per final design plan. Responsible – Consultant
- 6.1.4.2 Inspect system installation. Responsible – MnDOT

6.1.5 **Testing**
- 6.1.5.1 Prepare factory and field test plan. Responsible – Consultant
- 6.1.5.2 Conduct factory and field/shadow test. Responsible – Consultant

6.1.6 **Training**
- 6.1.6.1 Conduct maintenance training if system remains in place. Responsible – Consultant

6.1.7 **Operation and Maintenance**
- 6.1.7.1 Operate and maintain the system through the project duration. Responsible – Consultant
- 6.1.7.2 Develop a cost report for the procurement, installation and operation of the system. Responsible – Consultant
- 6.1.7.3 Provide data with regard to system operation from the shadow testing and operational periods. Responsible – Consultant
- 6.1.7.4 Decide if a truck drivers survey is needed, if so, provide a survey of system operation for truck drivers. Responsible – PMT

6.2 **Lines of Communication**
- 6.2.1 Email and Phone
- 6.2.2 Project Meetings
- 6.2.3 Meeting Minutes
- 6.2.4 Project Deliverables

6.3 **High-Level Requirements** *(These items will be further specified in the System Requirements task).*

This listing of requirements is intended to establish a base line for the project to build on in the next phase of the project, provide a linkage between Concept of Operations and development of Systems Requirements, and establish a common understanding among the project participants of the high level system requirements.

6.3.1 **Detection**
- 6.3.1.1 The system will use WIM detection devices to identify trucks and their speed approaching the curve. The detection shall be adjustable for number of axles, spacing of axles, length of vehicle, and weight of vehicle.
- 6.3.1.2 The system will use in-road surface condition detection to sense slippery/icy conditions on the curve. The sensor shall detect pavement statuses of dry, wet, ice, snow, or frost.
- 6.3.1.3 Communication – Detector devices shall communicate to the system controller via hardwire.
6.3.2 Signage/Warning
6.3.2.1 A sign and dynamic warning will be used to warn truck drivers if they are exiting at too high of a rate of speed.
6.3.2.2 A sign and dynamic warning will be used to warn all exiting vehicles of slippery/icy pavement conditions.
6.3.2.3 Message
   6.3.2.3.1 The signs will have a dynamic component to assist in communicating the warning.
   6.3.2.3.2 The timing and duration of the warnings may be based on the placement of the signs.

6.3.3 Components
6.3.3.1 The system components shall be combined into a functional system to provide active warning notification.
6.3.3.2 The system components shall be hard wired for communication between system components.

6.3.4 Power
The power for the system shall be AC.

6.3.5 Communications
A cellular modem shall be provided for remote communication.

6.3.6 Performance
The system shall perform with minimal failure. Acceptable failure rate to be established in System Requirements.

6.3.7 Data
6.3.7.1 Data Type – Data collected by the systems shall include type of detection, time of detection, speed at the time of detection, and time and duration of warning.
6.3.7.2 Data Storage – The System Requirements shall determine how long data should be stored and how it should be reported.
6.3.7.3 Data Reliability – The data collected by the system shall be accurate to levels established in the System Requirements.

6.3.8 Fault Notification
The system should have diagnostic outputs to be used to detect operational failure by trained personnel.

6.3.9 Installation
The designed systems shall be assembled and installed by an installation contractor as required in the design and bid documents. The Consultant team will coordinate the installation and install the system components. The MnDOT will provide permits as required.