System Requirements

Truck Rollover Warning System (TROWS)

Minnesota Department of Transportation
MnDOT Contract No. 02200

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# System Requirements

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1. **Project Description**

1.1. 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 iSINC™ 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.

1.2. The project will follow traditional systems engineering principles to provide for stakeholder input, requirements definition, detailed system design, factory testing and field operational testing phases. A multi-organizational project team will provide input throughout the project. The project will be delivered over a 17 month time frame from February 2013 to July 2014. System installations are anticipated to occur during the summer of 2013. A project evaluation may be conducted to capture data on the effectiveness of the system.

1.3. An integral part of the development process for the TROWS is the creation of System Requirements. The System Requirements listed below along with the Concept of Operations document will provide the basis for the Detailed System Design effort for the project.

2. **Functional Requirements**

2.1. The system shall use WIM detection devices to detect vehicle classification, weight, speed, and rate of deceleration in the vicinity of the exit ramp entrance.

2.2. The system shall use a configurable detection device to detect a wet, ice, snow, or frost road surface condition at one location on the exit ramp.

2.3. The detection information shall be communicated to a local controller that will activate dynamic warnings.

2.4. A warning sign shall be present to provide active real-time dynamic warning to truck drivers that are entering the exit curve at too high a rate of speed. The intent and meaning of the warning sign and dynamic warning will be intuitive to the driver.

2.5. The same sign or a second warning sign shall provide active real-time dynamic warning to truck drivers or all drivers that the road surface condition is adverse.

2.6. The warning signs and dynamic warnings shall be approved by MnDOT and should conform to the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD).
3. **Performance Requirements**

3.1. Expandability: The system shall be deployed at one site. The system shall operate as one system with both WIM and road surface detection. However, the WIM and road surface detection could be installed individually.

3.2. Speed: System should determine rollover potential and activate dynamic warning prior to vehicle reaching the dynamic warning viewing zone.

3.3. Safety: The system shall not obscure or detract from any in place signing. The system shall be able to meet breakaway standards used by MnDOT.

3.4. Reliability: The system shall detect approaching truck traffic with less than a 2.5% error. The surface detection system shall have the following requirements:

3.4.1. Pavement surface temperature. -40°C to +75°C with an accuracy of ±0.2°C from -15°C to +10°C, otherwise ±0.8°C.

3.4.2. Water film thickness. 0 mm to 10 mm with an accuracy of ±30% from 0.2 mm to 3 mm.

3.4.3. Freezing point temperature. -30°C to 0°C with an accuracy of ±0.5°C from -2.5°C to 0°C, otherwise ±20%.

3.5. Availability: The system is intended for 24 hour per day, 7 day per week continuous operation. The system shall function with a 99% up-time when AC power is present.

3.6. Maintainability:

3.6.1. Hardware Maintenance: All system hardware components shall be self-contained commercial off the shelf (COTS) modules housed in weather proof, NEMA 3R or better rated enclosures suitable for outdoor use. Manual settings or adjustments can be done to install, maintain, and adjust the system. Maintenance shall consist of module-level replacement and shall not require circuit board level or component-level adjustment, replacement or repair.

3.6.2. Software Set Up, Programming and Diagnostics: The system shall be user programmable through the use the individual component or a laptop computer and shall allow for diagnostics, data download and programming of system parameters. The system shall allow operations staff to perform diagnostics at the site via the individual component or a laptop connection, or remotely through a cellular modem.

3.7. Failsafe mode: The failed system should not present a more dangerous situation than if the system was not present.

3.8. Fault detection: The system shall have diagnostic outputs to be used to detect operational failure by trained personnel.
4. Operational Requirements / Operational Modes

4.1. Normal Operation: During normal operating conditions the system shall actively detect the presence, classification, weight, speed, and deceleration of truck traffic approaching the exit ramp and the pavement condition on the exit ramp.

This information, except for the pavement condition, will be used to calculate the maximum safe speed for trucks at the upcoming point of curvature and the predicted speed at that point. If the predicted speed exceeds the calculated maximum safe speed, or an absolute maximum safe speed (determined by MnDOT), the system will activate a dynamic warning with a sign, which is viewed by the truck driver, advising the driver to slow down. The calculated maximum safe speed shall be configurable and is based on vehicle weight and FHWA algorithms. The absolute safe speed shall be user configurable without software or hardware changes. The dynamic warning will be displayed until the vehicle has been detected to have passed the optimum sign viewing area. When no trucks are detected that are exceeding the maximum safe speed, the system shall remain in its normal unactivated state, with no dynamic warning indication being given.

The in-road surface condition detection sensor shall be configurable to detect a pavement condition of wet, ice, snow, or frost. When the configured condition is detected, the system shall provide a dynamic warning with a sign to drivers of a configurable range of vehicle classes. The dynamic warning will be displayed until the approaching vehicle has proceeded past the sign.

When there is no detection of adverse pavement conditions, the system shall remain in its normal unactivated state, with no dynamic warning indication being given.

4.2. Fault Operation: The system shall provide diagnostic outputs for determining that the system is not operational. Fault conditions may include malfunction of detection and system restarts.

4.3. Diagnostic Operation: The system shall permit operations staff to monitor operation on a daily basis of all system components. This monitoring shall be accessible at a central node or remotely through a cellular modem and shall monitor system operation.

5. Interface and Subsystem Requirements

5.1. Detection: The system shall use detection devices necessary to operate the system. These devices include detection of approaching trucks, speed of trucks, and roadway surface conditions. Truck detectors shall have less than 2.5% error in vehicle volumes and $\pm$ 1.0 mph in truck speeds.

Road surface detection shall be configurable to detect dry, wet, ice, snow, or frost.

5.2. Warning Devices: Warning sign(s) shall be visible to all drivers approaching the exit ramp. The dynamic warning(s) shall be with the sign(s) and also be visible to all drivers approaching the exit ramp. Signs and warnings shall be approved by MnDOT and
should conform to the MN MUTCD. The warning message and dynamic warning given to the driver shall be intuitively obvious to understand. Placement of the warning sign shall be within the driver’s cone of vision and placed to minimize potential for knock down.

5.3. Power: The system shall be powered by the AC power.

5.4. Environmental Requirements: The system shall function to defined requirements in typical Minnesota weather conditions. The Operating Temperature Range shall be: -34° to +74° C.

5.5. Communications: Communication links shall be hard wired except for the cellular modem.

6. **Data Requirements**

6.1. Data Content: The system shall monitor and record system performance. The data shall be retained within the system, on-board for a period of 30 days, or the maximum number of events allowed by the controller. The system shall retain individual events with a time stamped record for each event. The system shall also keep a daily running total (i.e tallies) of system events. Tallied data totals shall be available via wireless laptop access to the system and/or by removal and access of the memory card, and/or via remote cellular modem. The systems shall record system events such as: Truck detected; Speed at time of detection; Time of detection; Pavement condition – dry, wet, ice, snow, or frost; Status – Warning On, Warning Off, and System Restart.

6.2. Data Record Frequency
   6.2.1. For each Event (such as truck detections, warning on, warning off, etc)

6.3. Data Archive and Retrieval: Data shall be maintained and accessible from the local node and remotely via cellular modem during service operations. The system shall continue to operate during data collection and downloading.

6.4. Reporting software will allow for exporting data into a .csv format.

7. **Enabling Requirements**

7.1. Road Geometry: The system shall be suitable for installation on single lane curves/freeway exit ramps.

7.2. Roadway Volume: The system will function with freeway level traffic volumes.

7.3. Installation: Installation of this system shall be similar to a traffic signal installation and will require a lane/ramp closure.
7.4. Parts / Materials / Components: The components of the system shall be standard commercial off the shelf (COTS), field proven devices.

7.5. System Costs: The system costs shall be similar to a traffic signal installation.

8. Test and Evaluation Requirements

8.1. System data shall be provided in a readily usable format.

8.2. System data shall be downloadable.

8.3. System data shall be retained for 30 days or the maximum number of events allowed by the system controller.

8.4. System data shall be individually time stamped. System clocks shall be synchronized to local time and maintained to within +/- 2 seconds.

8.5. System data shall include:
   8.5.1. Fault type
      8.5.1.1. Malfunction of detector nodes
      8.5.1.2. Loss of power
   8.5.2. Vehicle detection
   8.5.3. Vehicle speed
   8.5.4. System activation
   8.5.5. System restart