

## **CHALLENGES IN ENSURING WORKER SAFETY IN ACTIVE ROADWAY WORK ZONES**

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### **ABSTRACT**

With highway infrastructure getting older and requiring regular maintenance, temporary work zones are a necessary part of upgrading our aging transportation infrastructure to meet today's needs. Effective work zone management involves carefully balancing safety and mobility. It is necessary to ensure that the detrimental impacts on traffic flows are minimized and unnecessary congestion is avoided, but also to make sure that the safety of motorists and workers is not compromised.

Short duration work zone traffic control poses unique challenges. Although the most advanced traffic control procedures are generally impractical in these situations, well-developed traffic control procedures exist for these situations, and when well-executed, will ensure the safety of both the workers and the travelling public, allowing the necessary roadwork to be completed successfully without incident.

The paper defines short duration work activities, identifies the state-of-the-practice for short duration work zone safety standards, presents the challenges associated with short duration work zone safety and identifies best practices, including specific technologies and processes, for improving safety and maximizing mobility, in order to protect both workers and the travelling public.

## **CHALLENGES IN ENSURING WORKER SAFETY IN ACTIVE ROADWAY WORK ZONES**

### **1. INTRODUCTION**

With highway infrastructure getting older and requiring regular maintenance, temporary work zones are a necessary part of upgrading our aging transportation infrastructure to meet today's needs. Effective work zone management involves carefully balancing safety and mobility. It is necessary to ensure that the detrimental impacts on traffic flows are minimized and unnecessary congestion is avoided, but also to make sure that the safety of motorists and workers is not compromised.

Work zone safety is of paramount importance to transportation agencies and the companies engaged in the work. Contractors, construction & maintenance workers, transportation engineers and designers, law enforcement personnel, and road users are all important stakeholders in work zone safety.

When the normal function of a roadway is interrupted by highway construction, maintenance, utility or engineering work activities, temporary traffic control setups are required to ensure safe passage of motorists thorough the work zone. These areas are generally marked by signs, channelizing devices, barriers, pavement markings and work vehicles. Many variables, such as type of work, location of the work, road type, road geometry, and traffic volumes, determine the traffic control needs at each work zone. Of these factors, the anticipated duration of the work is a major determinant of the specific traffic control requirements. Short duration work zones have unique challenges, since it is often impractical to apply state-of-the-art traffic control processes and procedures that take longer to setup and dismantle than carry out the planned work.

The objective of this paper is to define short duration work activities, identify the state-of-the-practice for short duration work zone safety standards, present the challenges associated with short duration work zone safety and identify best practices, including technologies and processes, for improving safety and maximizing mobility, in order to protect both workers and the travelling public. A particular emphasis is placed on short duration work activities occurring on high speed, high volume roadways, i.e. freeways.

### **2. TRAFFIC CONTROL STANDARDS**

Various standards and guidelines establish the requirements for work zone traffic control. The U.S. Federal Highway Administration's Manual on Uniform Traffic Control Devices (MUTCD) (1), and the Canadian version, distributed by the Transportation Association of Canada (2) detail the basic principles of design and the use of traffic control devices for all streets and highways. In

both Canada and the United States, most provincial transportation agencies and state departments of transportation complement or supplement the MUTCD with their own published requirements (3). In the province of Ontario, the seventh book of the Ontario Traffic Manual, entitled Temporary Conditions (OTM Book 7) governs temporary traffic control procedures (4).

The goal of temporary traffic control activities is to provide for the safe and efficient movement of road users, e.g. vehicles, bicyclists, and pedestrians through or around work zones while providing a reasonable level of protection to workers and equipment. The purpose of the OTM is to promote "safe driving behaviour, achieved by a predictable roadway environment through the consistent, appropriate application of traffic control devices". The OTM, for example, outlines six fundamental principles of work zone design:

- Worker safety;
- Road user safety (e.g. motorist, pedestrian, cyclist, others);
- Road user mobility;
- Advance warning to road users that they are approaching a work zone;
- Clear identification of work zone area;
- Positive guidance while approaching and travelling through work zone. (4)

Health and safety regulations also play a role in determining traffic control requirements. In many cases, these laws and statutes override the traffic control guidelines in publications such as MUTCD or OTM. For example, in Ontario, the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects override the OTM, including Book 7 (4). The Act and Regulations outline requirements for the protection of all workers, and include specific requirements for traffic control persons (TCPs).

The duration of the work is an important factor in determining the traffic control needs for a particular project. In general terms, work duration can be classified as long duration or short duration. However, the definitions of long and short duration is not consistent and varies by agency. The U.S. MUTCD identifies five work duration classes and OTM Book 7 identifies three, as shown in TABLE 1. According to Book 7, in Ontario, long duration work exceeds 24 hours in duration and short duration work lasts less than 24 hours (4). The OTM definition is used in this paper.

**TABLE 1 Comparison of MUTCD and OTM Work Zone Duration Definitions.**

| <b>U.S. MUTCD (1)</b> |  | <b>OTM Book 7 (4)</b>          |   |
|-----------------------|--|--------------------------------|---|
| Work Duration         | Definition                                     | Work Duration                  | Definition  |
| Mobile                | Work that moves intermittently or continuously | Mobile Operations              | Work that is done while continuously moving, usually at low speeds (5 to 30 km/h) |
| Short Duration        | Work that occupies a location up to one hour   | Very Short Duration (VSD) work | Work that occupies a fixed location for 30 minutes or less                        |
| Short-term Stationary | Daytime work that                              | Short Duration (SD)            | Work that occupies a  |

|                              |  |                         |   |
|------------------------------|--|-------------------------|---|
|                              | occupies a location from one to 12 hours   | work                    | location for more than 30 minutes, but less than one 24-hour period |
| Intermediate-term Stationary | Work that occupies a location more than one daylight period up to three days, or nighttime work lasting more than one hour | Long Duration (LD) work | Activities which require a work area for longer than 24 hours.      |
| Long-term Stationary         | Work that occupies a location more than three days   |                         |   |

Work zone duration can be more easily defined by the type of work being completed. Long duration work typically includes major highway construction, e.g. highway widening, pavement reconstruction, or bridge rehabilitation. Short duration work, conversely, includes various stationary or mobile maintenance and engineering activities, including, but not limited to, pothole repair, guiderail repair, trash pickup, landscaping activities, installation of pavement markings, pavement sweeping, utility repairs, pavement/geotechnical investigations, surveying, and bridge condition surveys.

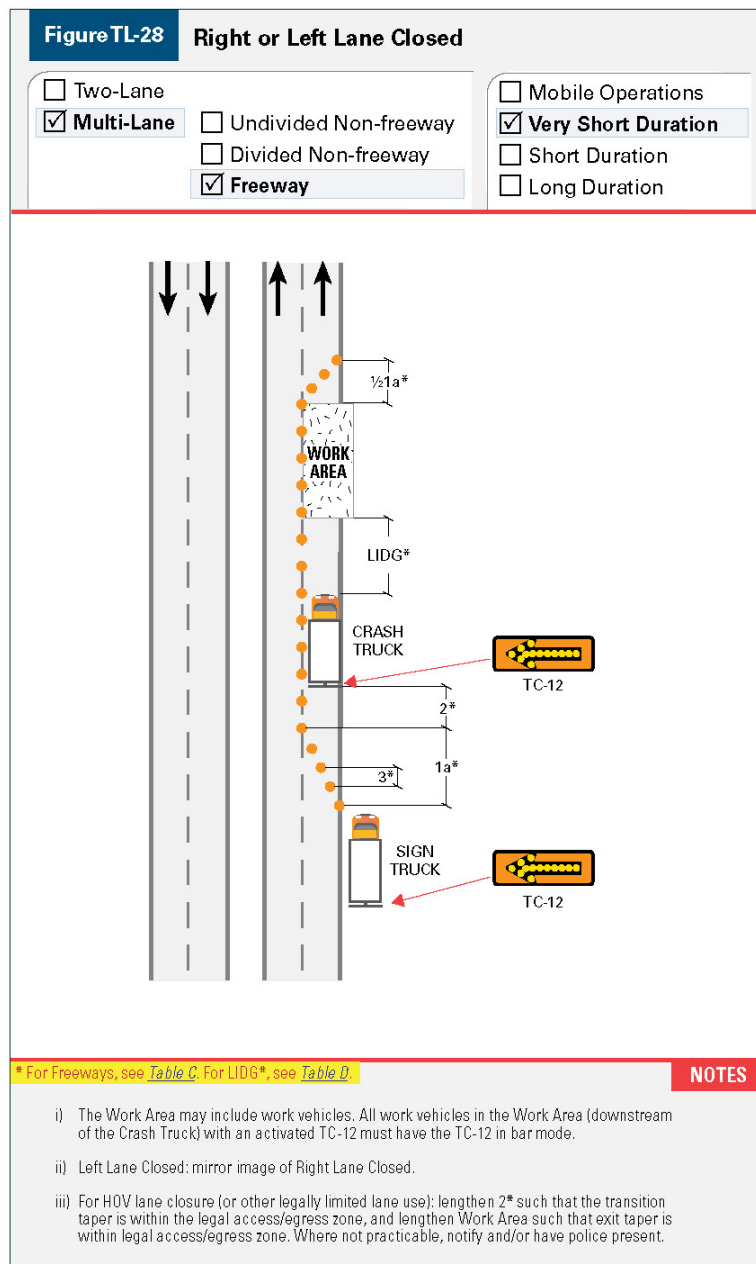
It should be noted that most available guidelines for temporary traffic control, including MUTCD and OTM Book 7, are intentionally general in nature. These traffic control manuals provide typical layouts that are appropriate for most situations. As an example, Figure 1 shows the typical layout for a very short duration single lane freeway closure from OTM Book 7. However, depending on actual road geometrics, location of work, work activity, duration of work, traffic volumes, and traffic speeds may warrant adjustment of the traffic control plans to actual field conditions in order to provide the level of protection and/or mobility required. The distances shown on the traffic control plans are desirable minimum requirements. Device spacing, buffer space, and sign spacing might require adjustments to meet project-specific requirements.

### 3. CHALLENGES WITH SHORT DURATION TRAFFIC PROTECTION

Short duration work zone traffic control often poses some unique challenges due to the transient and unpredictable nature of work. Ideal temporary traffic control measures on freeways include temporary traffic barriers, temporary pavement markings, signed detours and variable message signs. These traffic control best practices provide positive protection of workers, positive guidance through and/or around the work zone, and advanced warning of changes to the road configuration. Although equally desirable in short duration work scenarios, these procedures, however, are generally best suited for long duration activities. It is generally impractical and cost-prohibitive to apply the above-mentioned examples of work zone protection strategies and advanced traffic control approaches to short duration work zones.

The time required to setup traffic control devices can easily exceed the amount of time required to do the work.

Agencies, companies and contractors, therefore, must instead employ simplified policies, procedures and standards for work zone traffic control that achieve a delicate balance between achieving a desirable level of safety, while maintaining an acceptable level of mobility. This, however, does not suggest that the safety of short duration operations should not be compromised by using less traffic control equipment simply because the duration is shorter. Shortcuts, cutting corners or rushing are unacceptable practices.



**FIGURE 1 Sample Typical Layout drawing from OTM Book 7 (4).**

#### 4. WORK ZONE DESIGN AND TYPICAL DRIVER BEHAVIOUR

The Ontario Traffic Manual, Book 7 identifies six component areas of a well-designed work zone (4). These areas and their definitions are highlighted in Table 2, and shown in Figure 2.

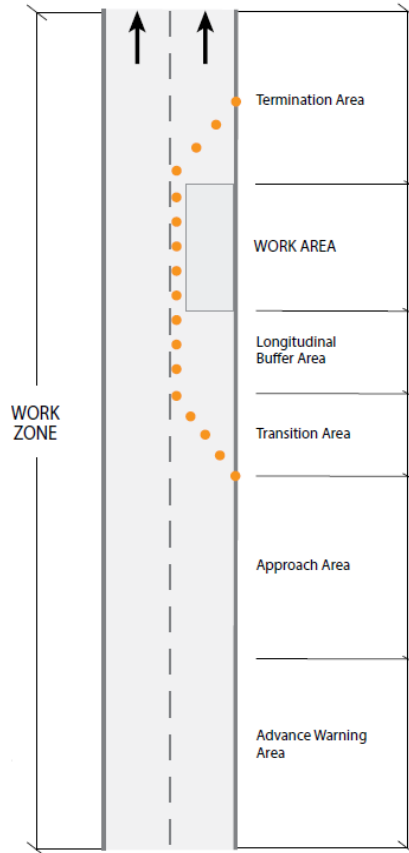
**TABLE 2 OTM Book 7 Work Zone Component Areas (4).**

| <b>Component Area</b>    | <b>Definition</b>  |
|--------------------------|--|
| Advance Warning Area     | Length of roadway used to alert road users of work ahead   |
| Approach Area            | Area used to inform road users of required actions or prohibited actions, e.g. reduced speed limits, required lane changes, passing restrictions |
| Transition Area          | Length of roadway where traffic is channelled from the normal path to the a new path to safely move past the work area                           |
| Longitudinal Buffer Area | Area providing protection for traffic or workers by providing clear space between the transition area and the work area                          |
| Work Area                | Area where the work takes place and/or equipment and material are stored   |
| Termination Area         | Area where traffic transitions back to the normal path of the road   |

Despite well-documented work zone design procedures and carefully implemented traffic control procedures, collisions, injuries and deaths in work zones remain all too common. In the United States, 1,000 fatalities and 40,000 injuries related to work zone crashes occur every year (5).

Some of the primary causes of work zone related collisions include driver inattention, congestion (traffic slowing/stopping), speeding motorists, inconsiderate / impatient drivers, limited sight distance, inadequate or confusing traffic control setup, inclement weather conditions, work vehicle movements (e.g. entering/exiting work zone), encroachment into buffer zones and unauthorized entry into work zone.

Drivers generally do not expect highway work zones to suddenly appear without warning. Work areas are generally unexpected and disruptive to traffic flows. This is particularly true on controlled access facilities, such as freeways, where interruptions are not expected. Although good traffic control practices should not be ignored, regular trips through long duration work zones give drivers an opportunity to familiarize themselves with temporary traffic control measures. This opportunity is not available for short duration work zones, and as a result, the work area must be designed in a way to provide the driver with the information they need in order to travel through safely.



**FIGURE 2 Work zone component areas (4).**

The task of driving requires the continuous gathering and processing of information from various roadway and roadside features, such as traffic signs, pavement markings, channelizing devices and other visual information provided along the roadway. However, the driver is always prioritizing information and cues received while driving, since he can only handle one source of visual information at a time. As a result, drivers are also continuously discarding information that seems less important or irrelevant, before moving onto the next piece of information. Based on the information received, decisions are made in order to react appropriately to potential hazards. Nighttime driving is particularly cognitively demanding.

Drivers should only be given information they need so that they can gather the information and correctly react. If a driver is overloaded with information, they may become confused and miss information that may have been important for safe operation of their vehicle through a complicated work zone driving environment. The amount of information that is given to a driver should be adequate to help the driver perform their task of driving without causing confusion. These human factors necessitate a clear, logical layout of the work zone signage and traffic control devices. Good traffic control procedures avoid abrupt changes to traffic patterns that would require rapid vehicle maneuvers. In fact, road user movement should be inhibited as little as practical. That being said, very rarely will drivers slow down unless they clearly perceive a



need to do so. Good traffic control procedures will encourage speed reduction, but also provide protection from any errant vehicles.

A number of work zone best practices that are able to mitigate the risk to drivers, as well as workers are available. Some examples of these best practices are presented in the following section.

## **5. BEST PRACTICES**

This section outlines a number of best practices relating to short duration work on roads and highways. The examples provided are generally considered cost-effective for short duration projects. Some practices are mandated by local regulations and statutes. Others are simply considered advisable based on experience of the authors. Not all practices may be applicable to each scenario or project. It should be ensured that all local laws and regulations relating to traffic control and health and safety are observed at all times. Many of these practices are complementary or supplementary to local requirements.

### **a. Training**

All workers, whether or not they are involved in traffic control activities, should be trained in how to work next to traffic in a way that minimizes their vulnerability. Routinely working near traffic for extended periods of time can lead to workers becoming complacent to the danger around them. Every worker must take responsibility for their own safety and a safety-conscious attitude will make a great impact on the overall safety of the work crew. Examples of good behaviours include avoid turning your back to oncoming traffic, if possible, and avoid placing yourself in a location that may surprise passing motorists.

Tailgate safety meetings prior to beginning any work operation provide an opportunity to ensure everyone is aware of the task to be performed and best practices to protect themselves adjacent to live traffic.

In addition, only those individuals who are formally trained in proper temporary traffic control practices and have a basic understanding of traffic control principles should be permitted to partake in the development of traffic control plans and/or the setup, takedown and maintenance of traffic control equipment. Well-trained traffic control personnel are not only capable of setup and takedown, but vigilantly ensure that all devices correctly remain in place throughout the closure, especially in the case of adverse conditions, such as high winds.

### **b. Attire**

Most provinces' Occupational Health and Safety Acts outline the minimum requirements for the attire of individuals working on roadways. Workers shall be attired in bright, highly visible clothing such as vests or jackets. These garments shall be orange, yellow or yellow-green and retroreflective, as required by CAN/CSA Z96-09 (6). Clothing must be kept clean to provide protection for the worker through better visibility to the motorist at all angles. Vests are

generally considered to be the minimum requirement, but more conspicuous clothing such as fluorescent jackets and pants further improve visibility to motorists.

### **c. Work vehicle lighting**

The work vehicle serves as a protective and warning device. Amber warning lights are typically required. The public generally associates flashing amber lighting with work vehicles. Modern flashing Light Emitting Diode (LED) lights have been found to be much brighter than conventional incandescent or halogen strobes. Brighter lights allows motorists to identify a potential hazard from further back and take avoidance action earlier. Reflective markings, e.g. reflective red-silver adhesive tape, has been found to increase conspicuity of work vehicles on the highway.

### **d. Blocker vehicles or shadow vehicles**

Generally required on high speed roadways, such as freeways, a truck mounted attenuator (TMA) is a portable impact attenuator attached to the rear of a truck with a minimum weight requirements. Ballast is often added to the truck to minimize the roll-ahead distance when impacted by a vehicle. The TMA is used as a shield to prevent errant vehicles from entering the work zone. It should be ensured that the TMA operator follows any moving operations (continuous or intermittent) carefully in order to maintain a safe longitudinal gap to prevent any vehicles from entering the work zone laterally.

Even if not required, some sort of blocker vehicle is useful to inform upstream traffic of work activities ahead and provide motorists with ample opportunity to slow down and/or change lanes.

### **e. Buffer space**

Buffer space around the work area is very desirable to separate workers from live traffic. Buffer space should be provided laterally and longitudinally if possible. A lateral buffer zone separates traffic flow from the work zone, and may provide some recovery space for an errant vehicle. If possible, it is recommended that the lane adjacent to the one being worked in be closed in order to provide a comfortable lateral buffer space. This full lane width provides additional clearance between travelling vehicles and workers. It also avoids the impression that the work zone activity may encroach on the driving lane, which can cause sudden corrective action from passing drivers.

Longitudinally, workers on foot must remain mindful of their positions in relation to shadow and work vehicles during work operations. The goal is to remain beyond the potential roll-ahead distance of the trailing vehicle if it is struck from behind, but not too far beyond in case a passing vehicle incorrectly tries to enter the work area laterally.

### **f. Variable message signs (VMS)**

Variable message signs (VMS), whether permanent or portable, are an excellent tool to provide motorists with valuable information regarding the temporary conditions downstream. Upstream of a work zone, VMS can provide motorists with an opportunity/time to avoid an

incident, prepare for delays, and given travel directions or guidance. For example, on a core-collector facility, the message "1 right lane blocked in collector lanes" may allow motorists to transfer to the express lanes at the upstream transfer or move to the left lane well in advance of the work area. For all information displayed, the goal is to have a positive impact on the motorist's travel behavior, which will in turn, help improve traffic flow, safety and operations. In Ontario, the Ministry of Transportation's COMPASS Traffic Operations Centre will display useful information about downstream lane closures in order to provide drivers with advance warning and an opportunity for pre-emptive actions, e.g. switching from express lanes to collector lanes, exiting from the highway completely, etc.

#### **g. Traffic Control Equipment**

Traffic control devices are used to visually guide drivers through work zones. Signage, channelizing devices (cones, drums, barrels), and arrow boards all provide a message to the driver. In order to do so, equipment must be well-maintained in order to remain visible and provide the expected positive guidance to the motorists. Signs that are illegible, worn or no longer retroreflective must be replaced. Improper equipment can send incorrect messages to the driver, which can cause confusion, safety concerns or collisions. Barrel/drum type channelizers are preferred for high speed, high volume facilities, if not mandated, because they provide improved conspicuity than most cones.

#### **h. Work hours**

Off-peak work hours are now commonplace for most freeway facilities across the country in order to minimize work zone impacts on motorists. By requiring work to take place at night, highway capacity is maintained during peak periods and this reduces delays. The benefits of nighttime work hours are lower traffic flows, which make lane closures easier to execute and reduce the possibility of queuing. However, there are some additional risks associated with working at night, such as driver fatigue, impaired drivers, reduced visibility, and higher speeds resulting from low traffic volumes. Choosing to work at night, however, can improve productivity, particularly for mobile operations and satisfy the traffic control objective of minimizing delay and disruption.

#### **i. Police assistance**

The use of paid duty police services as part of the traffic control plan has a premium cost above and beyond conventional traffic control services. However, police presence in or near the work zone can be an effective speed control measure. Motorists recognize the red-blue flashing lights of police vehicles reduce their speed through the work zone, improving safety. Police can also assist with closing the setup of complex lane closures, e.g. back to back transfer lanes, converging ramps, and assist with rolling closures.

#### **j. Advocating for better work zone timing restrictions**

Although most freeway closure restrictions are already limited to the overnight hours, opportunities to advocate for improved restrictions remain, in an effort for improved safety and/or efficiency. Although already limited to a period of reduced traffic volumes, the traffic restrictions are generally developed in a way to maintain a minimum level of mobility at all

times, wherever possible. In Ontario, this may include limiting ramp closures from midnight to 5:00am and maintaining one ramp lane open on multi-lane ramps and one lane open on the highway at all times.

However, short term work is generally not recurring. Longer work windows and full closures will allow work activities to be completed more efficiently and in one go, instead of requiring traffic control equipment to be removed from one half of the road or ramp, in order to set it up again on the other side, on the same night or on multiple nights.

Requesting full roadway closures for the duration of the work activity is a strategy that eliminates the exposure of motorists to work zones and workers to traffic. This strategy often allows for the faster completion of the work by allowing the work crew full access to the work area and for efficiencies in construction methods. The ability to detour traffic adequately onto adjacent roads is necessary, and must be considered.

The request for longer or full closures may inconvenience a few more individuals, but overnight traffic volumes are generally low enough. When presented to agency officials, a well-formed argument about improved efficiency and safety is often successful.

## **6. ADVANCEMENTS IN TRAFFIC CONTROL TECHNOLOGIES**

Traffic protection policies and procedures are continuously evolving through ongoing research and the introduction of new equipment to the market. Some new technologies may very appropriate for short duration work zones. The feasibility of these new technologies can be determined by evaluating their applicability and cost-benefit ratio. Any implementation of new technologies will require some capital investment, but the notable improvement to worker and driver safety, as well more efficient take-down and set-up of traffic control equipment may reveal a short payback period for the initial investment.

Some examples of applicable new traffic control technologies are presented below:

### **a. Intrusion alarms**

This device, mounted on cones, drum or other channelizers, warns work crews of errant drivers entering the work zone (7). Triggered by the impact of a channelizer being knocked over by a vehicle, a loud horn is sounded to warn workers, giving them time to react and to move out of harm's way, in order to avoid injury or death. This is fairly low cost backup to workers' self-awareness in the work zone.



**FIGURE 3 Work zone intrusion alarm (7).**

**b. Mobile barriers**

The mobile barrier trailer is an innovative work zone barrier, towed by standard truck tractor (8). This system allows workers to complete their activities behind the protection of a highly mobile positive protection barrier in all types of work zones. It is bright in colour to improve conspicuity and is equipped with an approved energy attenuator, meeting the same requirements as TMAs. The trailer can be customized with a portable variable message sign, speed detection device, lighting and a privacy barrier. This technology has the benefit of quick work zone setup, while providing the same benefits as traditional temporary concrete barrier wall.



**FIGURE 4 Mobile barrier trailer (8).**

**c. Automatic cone setter/retriever**

The automatic cone setter and automatic cone retriever are customized vehicles that have been designed and built to automate the placement of traffic control devices, as well as their retrieval (9). As a result, a worker does not need to hang off the side of the truck and jump on and off to set and retrieve tipped cones. The placement and removal of traffic control devices is generally the most vulnerable activity and these vehicles greatly reduce the traffic control personnel's exposure to traffic.



**FIGURE 5 Automatic cone setter (9).**

**7. CONCLUSION**

Short duration work zone traffic control poses unique challenges. Although the most advanced traffic control procedures are generally impractical in these situations, well-developed traffic control procedures exist for these situations, and when well-executed, will ensure the safety of both the workers and the travelling public, allowing the necessary roadwork to be completed successfully without incident. A number of best practices exist for this type of short duration work, of which several have been presented in this paper. Furthermore, innovation from the commercial sector has resulted in several new technologies on the market. Several examples suitable for use in short term work zones have been presented. Short duration work activities are not a valid excuse for lack of insufficient temporary traffic control. Safety should not be sacrificed.

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