Portable Positive Protection:

A Guide for Short Duration and Short Term Work Zones

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Updated by Mobile Barriers LLC based on Material Developed by ATSSA for the FHWA Work Zone Safety Grant Program

Note: This document cites specific products solely to illustrate the concept of portable positive protection, not as an endorsement of any manufacturer's products over others that may or may not be mentioned. Trade or manufacturer names appear herein solely because they are considered essential to the objectives of this guide. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of those of the Federal Highway Administration.

ATSSA
SAFER ROADS SAVE LIVES
American Traffic Safety Services Association

U.S. Department of Transportation
Federal Highway Administration



The Need for Portable Positive Protection

Transportation agencies, contractors, researchers, and private vendors are actively looking for new methods and devices to help make construction and maintenance work zones safer while maximizing mobility. Short-term and short-duration work zones are no exception, especially as fewer devices can be used in a practical way than in long- term work zones due to the limited installation time available. Practitioners commonly cite the challenge of using traditional devices for protection, as installation costs are high relative to the project and it may take longer to install the devices than perform the planned activities. This situation creates the need for more portable positive protection devices in lieu of traditional devices (such as temporary concrete barrier or "TCB") that are commonly used on long-term projects, but can't be repositioned easily.

So what do we mean by "portable positive protection?" For purposes of this guide, this label applies to highly mobile and movable steel barriers that provide acceptable crashworthy levels of protection – like that of temporary concrete barrier – but are much more portable and relatively quick to install and remove when compared to more traditional devices. While temporary concrete barrier is generally considered a device for use on long term projects (those lasting more than 3 days), the definition of portable for the purposes of this guide is a device that is feasible for shorter work operations. Portable devices are available that can be easily placed and removed (or moved from the travel way) to provide protection for short-term and short-duration operations. Portable devices mentioned in this guide may be used on long-term projects as well since many of the work zones in use could vary from short to long duration.

> Concrete barrier requires heavy equipment to install, move and remove. Highly mobile and movable steel barrier, however, can be easily moved on and off the roadway, so that crews can complete their work as safely and quickly as possible and reopen the roadway to normal traffic flow.

Why Should Portable Positive Protection Be Used?

Accidents Happen!

Every year more than 40,000 people are injured as a result of accidents in work zones.[1] Work zone traffic related fatalities rose significantly in 2015. Workers, who sometimes work in unprotected work space and are struck by motorists, comprise approximately 10 to 15 percent of these fatalities each year. Supported by the Temporary Traffic Control Devices Rule ("Subpart K"),[2] which requires consideration of positive protection on projects, there continues to be an increased focus on using positive protection—or devices that ensure protection for workers by physically separating workers and traffic—in work zones. Portable positive protection protects road users as well as workers.

[1] Occupational Safety and Health Administration, "Intro to Work Zone Safety," (2009). Available at https://www.osha.gov. See also American Association of State Highway and Transportation Officials, "Safety Week Campaign Comes as Toll Rises from Highway Work Zone Crashes" at http://www.aashtojournal.org/Pages/040816wzweek.aspx.
[2] "Subpart K," 23 C.F.R. 630.1102-.1110.



Work activities that can benefit from the safety of portable positive protection include:

- Bridge deck and joint repairs
- Guardrail repairs
- Overhead work and lamping
- Pothole and shoulder work
- Slab replacement
- Culvert and drainage work
- ITS and utility work
- Work in areas with limited escape routes

There are several positive protection solutions for short-duration and short- term work zones. Primarily, industry has followed the American Association of State Highway and Transportation Officials (AASHTO) *Roadside Design Guide* and the Federal Highway Administration's (FHWA) *Manual on Uniform Traffic Control Devices* (MUTCD) by using shadow vehicles with truck- or trailer-mounted attenuators (TMA) for protection on projects where the work space is small and the project duration rules out the use of positive protection devices such as portable concrete barrier because it would take longer to install the barrier than to conduct the work. While lanes can be safely closed for short periods of time with shadow vehicles, there may still be some exposure for workers due to the need for roll-ahead distance in advance of the work operation. In addition, while shadow vehicles protect workers from being struck from behind (longitudinal protection), they may still be exposed to errant vehicles in the adjacent lane that could strike them from the side (lateral exposure).

Portable positive protection may also be useful for work zones where traffic congestion is anticipated since they can be moved to reopen traffic lanes quickly as needed. Additionally, portable positive protection may be less intrusive than traditional methods and thus may reduce congestion and delay relative to other devices and configurations. Motorists also need to be protected from hazards they may encounter by inadvertently intruding into the work space. Crashworthiness is another feature of portable positive protection devices that must be considered.

Improved work productivity is often a benefit of portable positive protection since workers recognize they are less exposed to traffic hazards and can focus on the work without distractions. This can reduce the overall work time and improve efficiency, thus helping to offset the portable positive protection installation time.

Related Industry Terminology

This Guide focuses on portable devices for short work operations and uses terminology related to but different from that more generally used in the MUTCD and other FHWA materials. Some terms are highlighted here for clarification.

Portable Positive Protection – An easily transportable device that provides both longitudinal and lateral protection for road workers and crash protection for road users. Positive protection is defined in FHWA regulations as devices which contain and/or redirect vehicles and meet applicable crash standards (such as crashworthy movable barrier).[3] Movable barrier includes movable concrete, movable steel, and highly mobile barriers such as the one shown on the right. Highly mobile and movable steel barrier are described in more detail later in this guide. Movable concrete barrier is discussed below.

Highly Mobile Barrier

[3] Ibid, at 630.1104 Definitions - "Positive Protection."



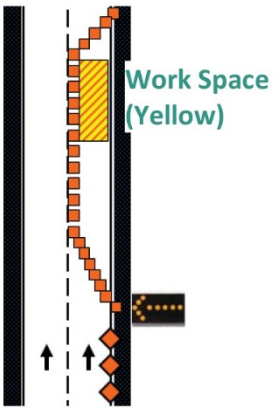
Movable Concrete Barrier – This is referenced here for the purpose of drawing a comparison to portable positive protection. Different from this guide's definition of portable positive protection, this type of positive protection is used where lengthy sections of lanes are opened and closed on a daily or nightly basis or where the work zone is reconfigured daily. A barrier transfer machine (as shown on the right) moves sections of concrete barrier and repositions them from one side of a lane to the other, or from a lane to the shoulder. While this system also provides positive protection, it is important to note the difference between movable and portable in this context. Such movable concrete barrier has higher costs and longer setup time, making it easier to justify on larger, long-term construction projects for providing temporary traffic control and protection, and maximizing traffic flow. Sections of movable concrete barrier can be opened for ingress/egress and/or the same can be used with special gating.

Movable Concrete Barrier & Transfer Machine

As with short-work operations, a long-term project could have a series of short duration closures (closed nightly and opened daily), making it ideal for portable positive protection that can easily be moved into place and removed daily.

Work Space – For mobile or stationary operations, the "work space" is the area where work is taking place. The work space may include the portable positive protection device along with any protective vehicles providing protection from behind and their associated roll-ahead distance.

Protected Space – For the purposes of this document, the area behind a portable device that provides positive protection for workers where the risk of any longitudinal and/or lateral impact from traffic is minimized or significantly reduced.



Protected Space

Protective Vehicles – In contrast to portable positive protection, protective vehicles do not provide lateral protection but they can help protect against rear (longitudinal) impacts and can be used with other barriers to provide extra protection. Protective vehicles, as referenced herein, may include vehicles with or without TMAs attached.

Short-Duration Operation (MUTCD Definition) – Work that occupies a location for up to one hour.

Short-Term Operation (MUTCD Definition) – Work that occupies a location for more than one hour per day.

Mobile Operation (MUTCD Definition) – Work that moves intermittently or continuously.



Portable Positive Protection & Protective Vehicles

There are several types of portable positive protection and protective vehicles. The following describes some of the features and applications of each.

Highly Mobile Barriers – Highly mobile barriers such as Mobile Barriers MBT-1 drive down the road like a semi-truck (longitudinally) from site to site for short-duration, short-term and even mobile operations. The barriers are typically used where work can be broken down into increments of 100' (30 m) or less. Multiple barriers can be used together. The barriers drive set up, at speed, and simply pull in place to work. There is little or no time lost to set up or break down. Crews can safely do meaningful work between rush hours (day or night). Upon completion, the barriers simply drive away and the roadway is reopened to normal traffic flows.

Mobile Barriers MBT-1 was introduced in 2008. It has been internationally deployed and has received numerous accolades and awards. It comes with onboard power (120/240 and solar), lights, signage and TMA. It can be set up in 42-102' configurations with 20-80' of work area and 5' high walls. It incorporates storage in and on the decks to carry tools, supplies, materials and other equipment. It is speed appropriate for interstate use. It weighs around 50,000 lbs (22,700 kg). It was independently tested and is FHWA accepted/eligible for TL-3 use under both NCHRP 350 and the new MASH standards. Some have been hit multiple times, even by semi-trucks, and remain in service. The MBT-1 is commercially available for sale, lease or rent. Special versions are available for security/defense and international markets.[4]

Protected Space Example
Mobile Barriers MBT-1

In 2002, Caltrans developed another type of highly mobile barrier called the Balsi Beam. It was smaller and limited to stationary applications where the potential for impact not exceed 43 mph. It was not for use in mobile operations. Rotating beams required on-site set up on arrival and departure to deploy jack stands, stabilize the unit and rotate. It could be set up in 42-52' configurations with 20-30' of work area and 3' high walls. It had no lights, power or signage and could not carry loads (it needed to remain balanced to avoid locking up). It weighed around 28,000 lbs (12,700 kg). It was only ever internally tested to reported TL-2/350 levels (at 13 and 44% the severity of impact to which FHWA's Office of Safety recommended Mobile Barriers MBT-1 test). It was never independently tested and has no FHWA acceptance/eligibility letter. Only a few were made. As of 2014-2015, half were out of service or not being used and the other two were seeing limited use. They were never used outside of California and are not commercially available.[5]

[4] See www.mobilebarriers.com.

[5] Mobile Barriers, LLC, "Developmental Progression of Highly Mobile Barriers," (2016). Available at https://www.workzonesafety.org/data-resources/mobile-barriers/.



Movable Steel Barrier is another type of positive protection device that provides additional portability relative to that of a traditional concrete barrier. It is typically moved from the shoulder or one side of a lane to the other (laterally) and used for long lengths of need and contra flow arrangements. While steel barrier requires heavy equipment to unload it from a truck onto the roadway, once unloaded it is moved relatively easily and can be towed or pushed into place on the ground. Steel barrier may be used for long term projects which span weeks or months, but involve short-term activity locations where the barrier must be placed and removed on a daily basis to avoid peak hour traffic impacts.

Movable Steel Barrier

As an example, when a lane is closed for a short-term work zone at night for overhead bridge painting, workers may be behind a tarp without good visibility and exposed to approaching traffic. Steel barrier sections can be staged on the shoulder, and, depending on whether the product is equipped with wheels, workers can easily roll sections into place for protection. The barrier can then be rolled to the shoulder by workers to open the lane to traffic during daytime hours. Steel barrier placement time generally exceeds the window of time needed for short-term or stationary operations that last less than six hours; therefore, another form of positive protection such as highly mobile barriers may be used for activities that meet these time frames.

Steel Barrier Installation

Depending on the product, steel barrier may include wheels for ease of rolling into place by hand. When in place, the barrier sections may be lowered to where high friction pads come into contact with the roadway surface to provide additional stability when impacted. These rubber pads may also add up to 0.5 inches between the pavement and the barrier, allowing for water drainage. Steel barrier sections weigh approximately 3,000 lbs (for 50-foot lengths) and approximately 750 feet of barrier can be transported by semi-truck and trailer in one load. One manufacturer provides 13-, 26-, or 40-foot sections. Barrier sections can be towed into place, moved with a forklift, or moved by hand when on wheels.

One advantage of steel barrier relative to traditional concrete is that it can be easily removed if work activities are suspended due to unforeseen high traffic impacts – providing flexibility in managing the work zone. Speed joints and rigid dovetail joints may be used to connect sections together, while anchoring pockets may be used to attach the section to the pavement for minimal deflection. Steel barrier can easily be aligned to curves compared with traditional concrete barrier.



Protective Vehicles - The AASHTO *Roadside Design Guide* specifies three types of protective vehicles – advance warning, shadow, and barrier vehicles. Similar to a shadow vehicle, a barrier vehicle can also be used to provide worker protection. The difference between a shadow vehicle and barrier vehicle is that a barrier vehicle does not have a driver at all times. Caltrans' for example outlines a description of a barrier vehicle as follows:

Protective Vehicles with TMAs Provide Rear (Longitudinal) Protection

"A barrier vehicle is an unoccupied vehicle or piece of equipment used to protect workers from errant motorists. Any vehicle at a work site can be used as a barrier. However, workers shall use the heaviest vehicle reasonably available. In certain instances, more than one (1) barrier vehicle may be needed. A barrier vehicle does not require a TMA. However, if a TMA is available, it should be used.

Any vehicle that is used should be parked upstream from the work site between approaching traffic and the workers. It should be parked where it will provide the best protection; not too close to the workers, not too far back. It shall be carefully positioned so that it will intercept errant vehicles, but will not roll ahead into the work area. Always park the barrier vehicle with the emergency brake set and lower any attachments to the ground. Channelization devices are recommended to delineate and separate traffic from the barrier vehicle during short term work.

A barrier vehicle without a TMA can be parked a number of ways. It can be parked at an angle or even straight across the lane. If it is parked at an angle, the front of the vehicle should be pointed away from traffic. The wheels shall be turned away from the work zone. If possible, the wheels should be turned away from traffic. This will avoid motorist panic and prevent secondary collisions if the barrier vehicle is hit and pushed ahead. A barrier vehicle with a TMA should normally be parked parallel with the direction of traffic."

Illustration of In-Lane Barrier Vehicle used with MBT-1

Barrier vehicles can be effectively used with other types of portable positive protection like highly mobile barriers shown at the right. Where heavy commercial vehicles comprise a high proportion of prevailing traffic, some recommend use of heavy barrier vehicles (such as a 50,000 lbs dump truck with signage and TMA) positioned in-lane sufficiently upstream of the work space to allow for skid forward and better protect against a direct rear impact by a heavy commercial vehicle.[6]

[6] Ullman, G., Alberson, D., & Groeneweg, K., "Shadow Stretching: New Attenuator Research Adjusts to Heavier Traffic," Roads and Bridges Safety Edition: June 2016: 12-14. Available at http://editiondigital.net/publication/?i=308316&p=12#{"page":12,"issue_id":308316}.



When Is It Appropriate to Use Portable Positive Protection?

Improved road-user and worker safety is the proven benefit from using portable positive protection. Projects in most short-term, short-response-time, high-traffic-volume work zones place the priority on getting the work done as quickly and safely as possible. These devices protect workers and provide them with a true feeling of safety, which lets them focus on their work, promoting productivity. Devices must be crashworthy and speed appropriate for anticipated conditions (see Crashworthy Devices).

Crashworthy Devices: TL-2 devices are designed and tested for impacts not exceeding 43 mph (70 km/h). TL-3 devices are designed and tested for higher speeds and generally considered more speed appropriate for interstate and other high speed uses.[7]

Using portable positive protection may be appropriate when the following factors are in place:

- There is limited time as it relates to work hour restrictions, setup and removal, productivity, work area access, transportation routes, and removal and storage of the device.
- Using other exposure control measures may increase worker and road user hazards.
- There are limited escape areas, such as in tunnels and on bridges.
- There is a need for positive protection for exposed work hazards or during night work.
- Where deflection can be accommodated – steel barrier deflects over 5 feet if anchored at the ends only, and minimal deflection can be achieved for at least one type of system where the steel barrier is anchored approximately every 33 feet. Generally, deflection may occur in the range of 6 to 8 feet when impacted by a full size pick-up truck. Steel barrier is more practical for short-term projects than for short-duration work zones. Highly mobile barriers typically experience minimal deflection.

Resource Charts: The FHWA Office of Safety has compiled Convenient quick guides of movable (including highly mobile) and steel barrier.[8]

FHWA and device manufacturers have developed Resource Charts regarding crashworthy devices and work zone applications that should also be referenced when deciding if and when to use portable positive protection. (See Resource Charts.)

[7] Federal Highway Administration, "Longitudinal Barriers," (Sept. 2015). Available at http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/.

[8] Federal Highway Administration, "Resource Charts," (Feb. 2016).
- Movable Barrier: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/resource_charts/wzb_moveable_barrier.pdf
- Steel Barrier: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/resource_charts/wzb_steel.pdf.



Cost Benefits?

Cost is always a consideration and may be relatively high in initial investment depending on the type of device used, but portable positive protection can provide valuable safety and efficiency benefits that can be used to justify the cost, especially given the potential for greatly reducing exposure to workers.

An estimate of the economic value of a statistical life for use in benefit-cost analysis was $9.1 million in 2013[9] making the overall benefit-cost ratio very high (even for a several hundred thousand dollar device investment) for saving just one life over the useful life of the barrier (which can be 20 years or more).[10]

One study sponsored by Caltrans showed that the cost of portable positive protection could be offset in less than 1 year, with an expected yearly average benefit of $1.9 million per year with the use of highly mobile barrier.[11]

Renting, leasing, purchasing, developing a contract bid item, agency- provided contract item, or other payment means are some of the payment methods that may be appropriate for your use of portable positive protection devices on a project.

Future ownership of the devices in use after the contract term expires should be a consideration for making the device a contract bid item. Including a requirement in the contract for future reimbursement to the agency for the assessed value of the equipment after contract expiration may also be an option.

Agencies may want to specify portable positive protection as part of a contract and list examples that will allow contractors to select the most appropriate type to use, consistent with the contract plans and specifications.

Portable positive protection can be procured in a number of ways including:

- Renting
- Leasing
- Purchasing
- Specifying a Contract Bid Item
- Including an Agency-Provided Contract Item

State and local agencies may benefit substantially from cost participation by FHWA on Federal Aid contracts.

[9] U.S. Department of Transportation, "Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses," (June 2014).

[10] Colorado Department of Transportation, "Deployment and Evaluation of Mobile Barrier in CDOT Research Branch," (March 2012). Available at https://www.workzonesafety.org/data-resources/mobile-barriers/, Attachment 1.

[11] UC Davis/AHMCT, "A Risk Assessment and Cost Benefit Analysis for [Highly Mobile Barriers]," Technical Report Number UCD-ARR-08-09-30-01, (2008). Ibid, Attachment 3.



Ten Suggested Steps to Take When Planning to Use Portable Positive Protection

The following list shows a collection of steps to follow in implementing portable positive protection. This list can be applied to either highly mobile or movable steel barrier sections already staged on the roadside for future use. Many strategies are possible and those that are intended should be defined in the contract plans and provisions or as well detailed temporary traffic control plans (TTCP).

1. Identify crew members who will perform the work and those who will assist with traffic control. A responsible person, such as the Traffic Control Supervisor or Agency Inspector, may be charged with this duty.
2. Organize crew members and meet ahead of the scheduled operation to discuss the deployment. Be sure that manufacturer guidance is reviewed and understood in light of State and local requirements. Some agencies follow a Pre-Activity Safety Plan process, which is a best practice approach and may include an assessment for portable positive protection. TTCPs should be available for all involved and written instructions may be needed for some activities.
3. Ensure that the necessary equipment is available to perform the work activities. The Traffic Control Supervisor and Agency Inspector should refer to the equipment list shown on or in connection with the TTCP.
4. Develop and/or review site-specific TTCPs for location of work, type of work activity, time of day and potential lighting needs, safe stopping locations, positioning of semi-trailers for unloading devices, and other temporary traffic control devices such as signs and arrow boards that will accompany the installation.
5. Review the existing traffic data for the work location and analyze the project's effect on traffic flow, including the potential for queuing, speed variability, and the potential hazards associated with slowing traffic as the device is put into place. The higher the traffic levels, the more benefit in reduced exposure to offset cost of the portable positive protection. Work hours may need to be established to minimize traffic impacts.
6. For a right-lane closure it may be necessary to stop on the shoulder in advance of the work space to find the appropriate gap in traffic where the lane can be closed safely, in keeping with accepted safety practices.
7. For a left lane closure, consider the limited inside shoulder area and how the operation will be initiated, including ground placement of advance warning signs, if applicable. This setup may require a mobile lane closure if the inside shoulder is narrow (especially if a median wall exists) and advance warning signs are placed on the ground instead of or in addition to using vehicle-mounted signing.
8. Consider potential lateral and longitudinal displacement and leave room for lateral deflection if a vehicle strikes the protection device. A lateral buffer space may need to be established, usually one lane width. No lateral buffer is typically required for highly mobile barrier due to its minimal deflection.
9. When using highly mobile barriers, slightly angle the tractor away from the side where traffic will pass. This may help avoid cab/tractor impact from an errant vehicle as it travels down the outside of the barrier in the event of impact. When deployed, ensure that a truck mounted attenuator is lowered.
10. Once the operation is complete, all materials and tools are removed from the site, and all personnel are accounted for in the vehicles, use radio communication from the upstream vehicle (advance warning or shadow vehicle) to determine the appropriate timing for moving the operation back into the flow of traffic and opening the lane. For steel barriers, it may be possible to move the sections to the shoulder prior to reloading onto a removal vehicle.



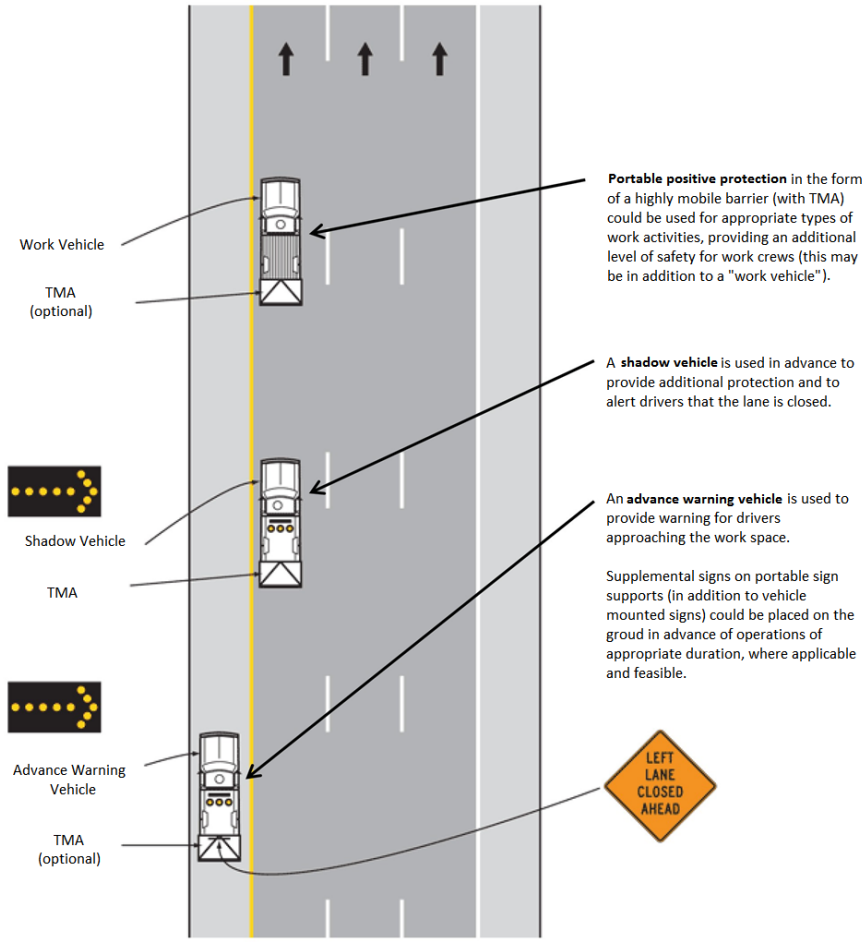
Example of a Typical Application of Portable Positive Protection

An example of a traffic control configuration for a mobile lane closure can be found in the MUTCD section 6H and is shown in the Figure 6H-35 from the MUTCD. A similar configuration can be used for portable positive protection as shown in the typical application.[12] This configuration could also be reversed for a right lane closure.

These suggestions are not meant for use in place of the typical application, but are shown using an MUTCD typical application drawing to relay main points about how to use portable positive protection.

It is important to have advance warning of the mobile lane closure using an advance warning vehicle with appropriate signing to warn drivers of the lane closure. The typical application diagram includes a potential approach to executing this mobile lane closure when using portable positive protection. While this approach reflects the MUTCD typical application for mobile operations, other deployments may or may not include the shadow vehicles. In either case, advance warning for drivers is of utmost importance to the safety of the operation.

Figure 6H-35. Mobile Operation on a Multi-Lane Road (TA-35)



[12] Florida Department of Transportation, "Drawings of Mobile Barriers MBT-1." Available at https://fdotwp1.dot.state.fl.us/ApprovedProductList/Products/Index/4501.



Summary

Protection of workers and road users in work zones is a critical requirement and can usually be accomplished with various work zone strategies. As opposed to workers on foot, drivers and passengers have some level of protection in the relative safety of their vehicles. Protecting workers from errant vehicles can be a more difficult challenge and one that is not always directly addressed. Portable positive protection, such as highly mobile and movable steel barriers, and protective vehicles, fill the need particularly well in short-term and short-duration work zones where using other device types may not be feasible.

Information Sources

Federal Highway Administration Resource Charts

http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/resource_charts/

TX Deployment—"Texas Department of Transportation Rolls out Mobile Barriers MBT-1"

http://mobilebarriers.com/images/TxDOT%20Rolls%20Out%20Mobile%20Barriers%20MBT-1.pdf

Mobile Barriers MBT-1 Cost benefit Analysis—with Analysis from CO, CA and Others

http://mobilebarriers.com/images/docs/Cost%20Benefit%20Analysis%20-%20Mobile%20Barriers%20MBT-1.pdf

Field Guide for the Placement of Shadow Vehicles in Work Zones

https://www.workzonesafety.org/training-resources/fhwa_wz_grant/atssa_field_guide_shadow_vehicles/

Guidelines on the Use of Positive Protection in Temporary Traffic Control Zones

https://www.workzonesafety.org/fhwa_wz_grant/atssa/atssa_positive_protection_guidelines

Manual on Uniform Traffic Control Devices – Part 6 sections 6F and 6G

http://mutcd.fhwa.dot.gov

North Texas Tollway—"Mobile Barriers Protect Workers"

https://www.workzonesafety.org/publication/mobile-barriers-protect-workers/

Washington State Department of Transportation Work Zone Traffic Control Guidelines Book M54-44

http://www.wsdot.wa.gov/Publications/Manuals/M54-44.htm



National Work Zone Safety Clearinghouse

http://www.workzonesafety.org

Developmental History of Highly Mobile Barriers

https://www.workzonesafety.org/data-resources/mobile-barriers/

Mobile Barriers Web Site

www.mobilebarriers.com

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