Maintenance Work Zone Safety

Pocket Guide of MUTCD Guidance on Temporary Traffic Control

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Purpose

This pocket guide is designed to serve as a field reference on established traffic control guidelines for maintenance activities and other short-term operations. This guide is intended for a broad audience that includes maintenance crews, utility crews, construction inspectors, construction personnel, survey crews, and state and local agency staff who will be in or near highway rights-of-way.

Maintenance Activities

Maintenance activities include a variety of jobs in which workers are laboring in close proximity to traffic. Types of maintenance activities include, but are not limited to:

- Pavement marking installation.
- Raised pavement markers (e.g., lens replacement).
- Pavement sweeping.
- Pavement sampling.
- Pavement repairs limited in scope (e.g., pothole patching and other small repairs).
- Debris cleanup (e.g., both routine cleanup and removal of debris and emergency removal of storm debris and spilled material).
- Vegetation control (e.g., application of herbicides adjacent to shoulders).
- Traffic signal repairs (e.g., routine lamp replacement and emergency repairs).
- Post mounted delineators (e.g., repair and replacement).
- Small roadside signs (e.g., repair and replacement).
- Cleaning drainage facilities (e.g., catch basins, drop inlets, etc).
- Emergency repairs (e.g., miscellaneous operation necessary to restore safe highway operation that can be completed within a few minutes.)

- Mowing in the highway right-of-way (ROW).
- Snow removal.

Seven Principles of Temporary Traffic Control

The primary function of temporary traffic control (TTC) is to provide for the reasonably safe and efficient movement of road users through or around TTC zones while reasonably protecting workers, responders to traffic incidents, and equipment. The *Manual on Uniform Traffic Control Devices* (MUTCD) guidance on TTC includes seven fundamental principles that should be taken into account on every maintenance project, no matter how small the task. These include:

1. Planning for traffic safety.
   a. Road user and worker safety are a high priority element from planning through design and construction.
   b. The needs of all road users including persons with disabilities should be addressed.
   c. Always plan to minimize traffic delays.
2. Minimize interference with traffic flow, including vehicular, bicycle, and pedestrian traffic.
   a. Do not make abrupt changes to traffic patterns that would require rapid vehicle maneuvers.
   b. Road user movement should be inhibited as little as practical.
3. Providing clear and positive guidance on how to get through the TTC zone.
   a. Give adequate advance warning to drivers, bicyclists, and pedestrians of the upcoming TTC zone.
   b. Use appropriate traffic control devices such as cones or portable sign supports.
   c. Remove/cover any conflicting signing.
   d. Use flaggers when necessary.

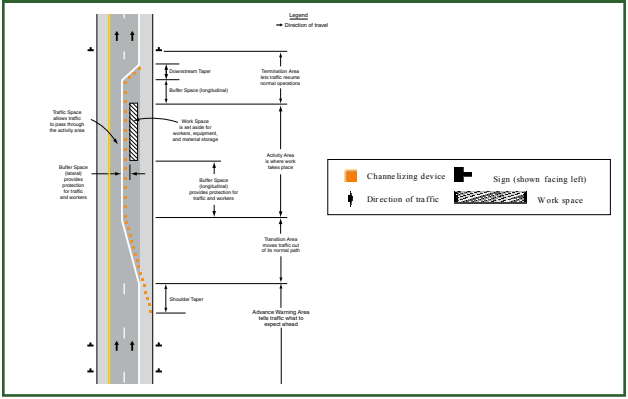
4. Performing continuous inspection and maintenance of TTC devices.
   a. Inspections should be performed by someone who is appropriately trained.
   b. Repair or replace devices as necessary.
   c. Monitor and modify work zone as project progresses.
5. Maintaining roadside safety throughout the project.
   a. Provide a recovery area for errant vehicles.
   b. Store equipment and materials where they won't get hit.
6. Making sure workers receive the training that is required.
   a. All those who are involved with planning, design, construction, and maintenance of a TTC Zone should have the appropriate safety training.
7. Maintaining good public relations.
   a. Provide appropriate advance notice and cooperate with various news media in publicizing TTC zone.
   b. Address the needs of abutting property and business owners.
   c. Address the needs of all emergency service providers.

Component Parts of a Temporary Traffic Control Zone

The TTC Zone is the entire section of roadway between the first warning sign or high-intensity rotating, flashing, oscillating, or strobe lights on a vehicle to the END ROAD WORK sign or the last TTC device.[1] A TTC Zone is subdivided into four main parts: advance warning area, transition area, activity area, and termination area. Figure 6C-1 shows a layout and the various component parts of a TTC zone.

[1] Chapter 6C.02 of the MUTCD

Figure 6C-1: Component Parts of a Temporary Traffic Control Zone



Advance warning area. The advance warning area is the section of highway where road users are informed about the upcoming work zone or incident area. This area provides a warning, information, and the appropriate action to take in advance of the TTC zone. A single sign or a series of signs informs drivers what to expect. Suggested advance warning sign spacing is listed in Table 1.

Road Type	Distance Between Signs in feet (meters)		
	A	B	C
Urban (low speed)	100 (30)	100 (30)	100 (30)
Urban (high speed)	350 (100)	350 (100)	350 (100)
Rural	500 (150)	500(150)	500 (150)
Expressway/Freeway	1,000 (300)	1,500 (450)	2,640 (800)

Note: low speed is determined by local highway agency.
A is the distance between the transition and the first sign.
B is the distance between the first and second sign.
C is the distance between the second sign and the third sign. The third sign is the first sign in a three-sign series encountered by a driver approaching the TTC zone.

Transition area. The transition area is that section of highway where road users are redirected out of their normal path. Transition areas usually involve strategic use of tapers with channelizing devices. There are five types of taper used in TTC zones and they are listed in Table 2 along with the taper lengths associated with each type of taper. The length of the taper is based on the speed of the traffic and the width traffic is being offset; i.e., moved laterally from the traffic lane's original alignment. The formulas for the calculating taper lengths can be found in Table 3. Tables 4 and 5 may be used as a quick reference for the taper formulas in Table 3, and these show the calculations of the taper formulas for various conditions.

Table 2 – Taper Lengths

Type of Taper	Taper Length
Merging Taper	L Minimum
Shifting Taper	1/2 L Minimum
Shoulder Taper	1/3 L Minimum
Two-Way Traffic Taper	100 feet (30 m) Maximum
Downstream Taper (optional)	100 feet (30 m) per lane Minimum

Table 3 – Taper Formula

Speed Limit	Formula	
	English	Metric
40 mph or less	$L = \frac{W * S^2}{60}$	$L = \frac{W * S^2}{155}$
45 mph or greater	$L = W * S$	$L = \frac{W * S}{1.6}$

L=Taper Length in feet or meters.
W=Width of offset in feet or meters.
S=Typically posted speed in mph or km/h.

Table 4-Taper Calculations (feet)					
S MPH	**9'**	**10'**	**11'**	**12'**	**Buffer**
25	95	105	115	125	155
30	135	150	165	180	200
35	185	205	225	245	250
40	240	270	295	320	305
45	405	450	495	540	360
50	450	500	550	600	425
55	495	550	605	660	495
60	540	600	660	720	570
65	585	650	715	780	645
70	630	700	770	840	730
75	675	750	825	900	820

Table 5-Calculations for 12 foot lane (feet)				
S MPH	**L**	**1/2 L**	**1/3 L**	**Buffer**
25	125	63	42	155
30	180	90	60	200
35	245	123	82	250
40	320	160	107	305
45	540	270	180	360
50	600	300	200	425
55	660	330	220	495
60	720	360	240	570
65	780	390	260	645
70	840	420	280	730
75	900	450	300	820

Activity area. The activity area is the section of highway where the work takes place and consists of a work space, buffer space, and traffic space.

Work space. The work space is that portion of the highway closed to road users and set aside for workers, equipment, and material, and a shadow vehicle if one is used upstream. This is the area where the work actually takes place. If using a shadow vehicle, the shadow vehicle shall be placed in the work space and not in the buffer space.

Buffer space. The buffer space is a lateral and/or longitudinal area that separates road user flow from the work space or an unsafe area, and might provide some recovery space for an errant vehicle. Buffer spaces are highly recommended. A longitudinal buffer area may be placed in advance of a work area. Neither work activity nor storage of equipment, vehicles, or material should occur within a buffer area. Table 6 shows typical longitudinal buffer space lengths based on traffic speed. The traffic speed used is based on the posted speed, off-peak 85th percentile speed prior to work starting, or the anticipated operating speed depending on the available data. When no data is available, typically the posted speed is used to determine the longitudinal buffer space.

Traffic space. The traffic space is the portion of road in which road users are routed through the activity area.

Termination Area. The termination area is used to return traffic to the normal path. The termination area extends from the downstream end of the work area to the last TTC device, such as End Road Work signs, if posted.

Table 6–Buffer Space Recommendations	
Speed	**Minimum Recommended Buffer Space (feet)**
20	115
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645
70	730

Approximating Distances in the Field

To approximate a distance in the field, two methods are available:

- Pacing Method: In advance, determine the length of your stride and how many paces it would take you to cover the distances needed.
- Skip-Line Method: Upon arrival at the scene, determine the pattern and measure the length of the skip lines. Most skip lines are on a "10-30" pattern. This means that the painted lines are 10 feet long and the gap between them is 30 feet long, resulting in a distance of 40 feet from the beginning of one line to the beginning of the next line.

Traffic Control Devices

Different types of traffic control devices are more appropriate for maintenance operations than for longer term stationary operations. Traffic cones are often used for maintenance projects because of the ease in setting up the TTC zone. They are used for shorter duration projects when they can be attended at all times to ensure that they can be reset if struck by a vehicle. The MUTCD states:

"Cones shall be predominantly orange and shall be made of a material that can be struck without causing damage to the impacting vehicle. For daytime and low-speed roadways, cones shall be not less than 18 inches in height. When cones are used on freeways and other high-speed highways or at night on all highways, or when more conspicuous guidance is needed, cones shall be a minimum of 28 inches in height.

For nighttime use, cones shall be retroreflectorized or equipped with lighting devices for maximum visibility. Retroreflectorization of cones that are 28 to 36 inches in height shall be provided by a 6 inch wide white band located 3 to 4 inches from the top of the cone and an additional 4 inches wide white band located approximately 2 inches below the 6 inch band.

Retroreflectorization of cones that are more than 36 inches in height shall be provided by horizontal, circumferential, alternating orange and white retroreflective stripes that are 4 to 6 inches wide. Each cone shall have a minimum of two orange and two white stripes with the top stripe being orange. Any nonretroreflective spaces between the orange and white stripes shall not exceed 3 inches in width."

Since most cones are fairly light weight and may be easily over turned, cones should be given ballast (i.e., weighted down) using weighted rings or by double stacking the cones. The ballast should be kept to the minimum amount needed to prevent over turn from large wind gusts, such as the wind from a heavy truck passing. Check local standards and guidelines for your state's or local jurisdiction's preferences on the use of cones and cone ballast.

Work Duration

Work duration is a key element in identifying the number and types of devices used in the TTC zone. Work durations for maintenance work typically fall into three categories: short-term stationary, short duration, and mobile.

- **Short-term stationary** work occurs during the daytime and occupies a location for more than one hour within a single daylight period. Some maintenance and utility operations are short-term stationary work. The installation and removal of traffic control can be carried along with this type of work. Also during this situation, a crew is present to maintain and monitor TTC. Cones and portable sign supports are a feasible option for traffic control devices.

- **Short duration** work occupies a location for up to one hour during either daylight or nighttime. Portable traffic control devices are an option for TTC, but safety should not be sacrificed by using fewer devices because the operation may frequently change its location. Vehicles with high intensity rotation flashing, oscillating, or strobe lights may be used in place of signs and channelizing devices. These vehicles may be equipped with signs or arrow panels to assist TTC. The use of shadow vehicles may be used to assist with the safety of workers.
- **Mobile** work moves intermittently or continuously. Intermittent operations typically consist of mowing, trash pickup, or survey crews, whereas continuous operations are constantly moving at a slow rate of speed like installing pavement markings or installing rumble strips. The same devices and vehicles apply to mobile work as previously mentioned in short duration operations.

When using mobile operations, an important consideration is moving the traffic control devices at the same pace as the work operation. Mobile operation minimizes interference with traffic; however, traffic control devices must be easily movable or mounted on the work vehicles to ensure the safety of the work operation.

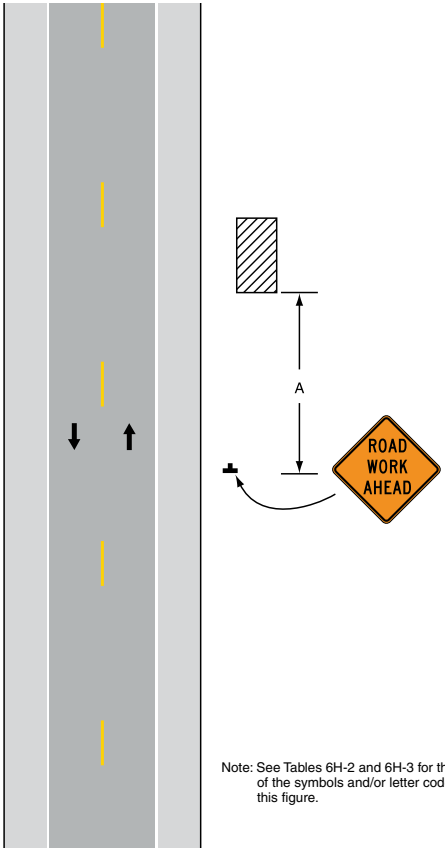
Typical Applications

The following pages represent a few of the typical applications that can be found in the MUTCD and the *Traffic Control Handbook for Mobile Operations at Night.*[1] Typical applications 1, 4, 17, and 35 may be found in the Part 6 of the MUTCD. These applications imply minimum, daytime solutions; whereas the *Traffic Control Handbook for Mobile Operations at Night* provides typical applications specifically for nighttime operations. The Typical Applications labeled NMTA-1 and NMTA-2 take into account nighttime conditions and may be used in this situation.

When designing or setting up a TTC zone, the following information can be used as a guide for situations commonly encountered in the field. These typical applications are a selected few of the common applications for short-term stationary, short duration, and maintenance that can be used. More information can be found in either the MUTCD or the *Traffic Control Handbook for Mobile Operations at Night.*

[1] *Traffic Control Handbook for Mobile Operations at Night*. Federal Highway Administration, Washington DC (August 2003).

Figure 6H-1: Work Beyond the Shoulder (TA-1)



Note: See Tables 6H-2 and 6H-3 for the meaning of the symbols and/or letter codes used in this figure.

Typical Application 1

Notes for Figure 6H-1, Typical Application 1—Source: Part 6, MUTCD

Guidance:

1. If the work space is in the median of a divided highway, an advance warning sign should also be placed on the left side of the directional roadway.

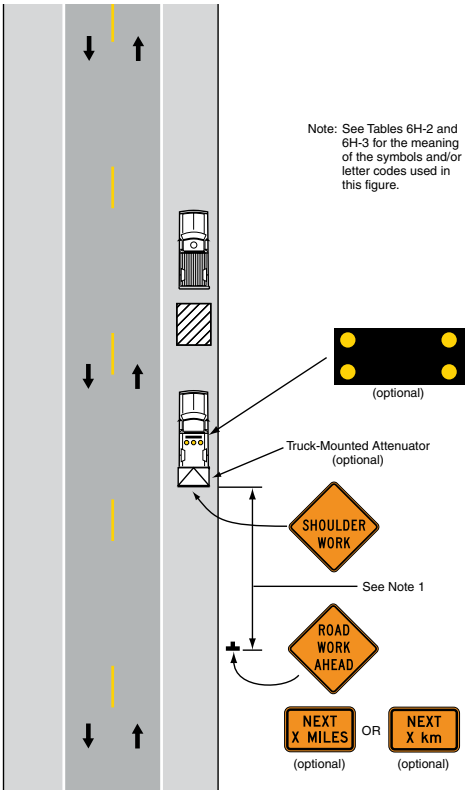
Option

2. The ROAD WORK AHEAD sign may be replaced with other appropriate signs such as the SHOULDER WORK sign. The SHOULDER WORK sign may be used for work adjacent to the shoulder.
3. The ROAD WORK AHEAD sign may be omitted where the work space is behind a barrier, more than 24 inches behind the curb, or 15 feet or more from the edge of any roadway.
4. For short-term, short-duration or mobile operation, all signs and channelizing devices may be eliminated if a vehicle with activated rotating lights or strobe lights is used.
5. Vehicle hazard warning signals may be used to supplement rotating lights or strobe lights.

Standard

6. Vehicle hazard warning signals should not be used instead of the vehicle's rotating lights or strobe lights.

Figure 6H-4: Short Duration or Mobile Operations on Shoulder (TA-4)



Typical Application 4

Notes for Figure 6H-4, Typical Application 4—Source: Part 6, MUTCD

Guidance:

1. In those situations where multiple work locations within a limited distance make it practical to place stationary signs, the distance between the advance warning sign and the work should not exceed 5 miles.
2. In those situations where the distance between the advance signs and the work is 2 miles to 5 miles, a Supplemental Distance plaque should be used with the ROAD WORK AHEAD sign.

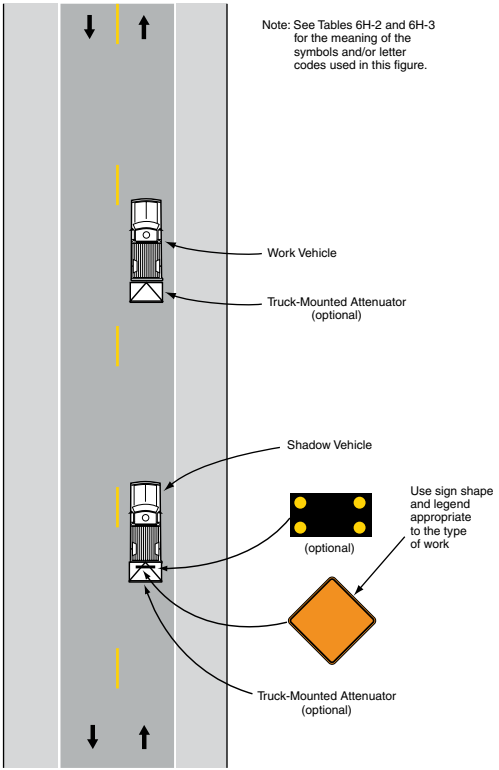
Option:

3. The ROAD WORK NEXT XX mi. sign may be used instead of the ROAD WORK AHEAD sign if the work locations occur over a distance of more than 2 miles.
4. Warning signs may be omitted when the work vehicle displays rotating lights or strobe lights if the distance between work locations is 1 mile or more, and if the work vehicle travels at vehicular traffic speeds between locations.
5. Vehicle hazard warning signals may be used to supplement rotating lights or strobe lights.

Standard:

6. Vehicle hazard warning signals should not be used instead of the vehicle's high-intensity rotating, flashing, oscillating, or strobe lights.
7. If an arrow panel is used for an operation on the shoulder, the caution mode should be used.

Figure 6H-17: Mobile Operations on Two-Lane Road (TA-17)



Typical Application 17

Notes for Figure 6H-17, Typical Application 17—Source: Part 6, MUTCD

Standard:

1. Vehicle -mounted signs should be mounted in a manner such that they are not obscured by equipment or supplies. Sign legends on vehicle-mounted signs should be covered or turned from view when work is not in progress.
2. Shadow and work vehicles should display high-intensity rotating, flashing, oscillating, or strobe lights.
3. If an arrow panel is used, it should be used in the caution mode.

Guidance:

4. Where practical and when needed, the work and shadow vehicles should pull over periodically to allow vehicular traffic to pass.
5. Whenever adequate stopping sight distance exists to the rear, the shadow vehicle should maintain the minimum distance from the work vehicle and proceed at the same speed. The shadow vehicle should slow down in advance of vertical or horizontal curves that restrict sight distance.
6. The shadow vehicles should also be equipped with two high-intensity flashing lights mounted on the rear, adjacent to the sign.

Option:

7. The distance between the work and shadow vehicles may vary according to terrain, paint drying time, and other factors.
8. Additional shadow vehicles to warn and reduce the speed of oncoming or opposing vehicular traffic may be used. Law enforcement vehicles may be used for this purpose.
9. A truck-mounted attenuator may be used on the shadow vehicle or on the work vehicle.
10. If the work and shadow vehicles cannot pull over to allow vehicular traffic to pass frequently, a DO NOT PASS sign may be placed on the rear of the vehicle blocking the lane.

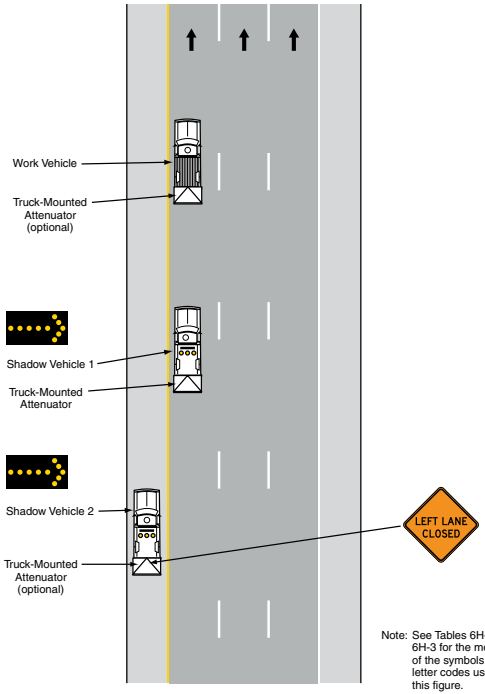
Support:

11. Shadow vehicles are used to warn motor vehicle traffic of the operation ahead.

Standard:

Vehicle hazard warning signals should not be used instead of the vehicle's high-intensity rotating, flashing, oscillating, or strobe lights.

Figure 6H-35: Mobile Operations on Mulit-Lane Road (TA-35)



Note: See Tables 6H-2 and 6H-3 for the meaning of the symbols and/or letter codes used in this figure.

Typical Application 35

Notes for Figure 6H-35, Typical Application 35—Source: Part 6, MUTCD

Standard:

1. Arrow panels should, as a minimum, be Type B, with a size of 60 x 30 in.

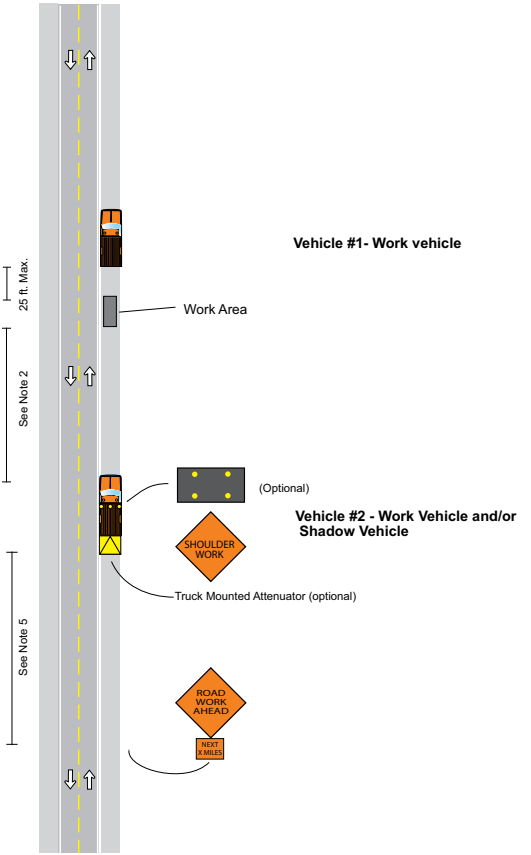
Guidance:

2. Vehicles used for these operations should be made highly visible with appropriate equipment, such as: high-intensity rotating, flashing, oscillating, or strobe lights, flags, signs, or arrow panels.
3. Shadow Vehicle 1 should be equipped with an arrow panel and truck-mounted attenuator.
4. Shadow Vehicle 2 should be equipped with an arrow panel. An appropriate lane closure sign should be placed on Shadow Vehicle 2 so as not to obscure the arrow panel.
5. Shadow Vehicle 2 should travel at a varying distance from the work operation so as to provide adequate sight distance for vehicular traffic approaching from the rear.
6. The spacing between the work vehicles and the shadow vehicles, and between each shadow vehicle, should be minimized to deter road users from driving in between.
7. Work should normally be accomplished during off-peak hours.
8. When the work vehicle occupies an interior lane (a lane other than the far right or far left) of a directional roadway having a right shoulder 10 feet or more in width, Shadow Vehicle 2 should drive the right shoulder with a sign indicating that work is taking place in the interior lane.

Option:

9. A truck-mounted attenuator may be used on Shadow Vehicle 2.
10. On high-speed roadways, a third shadow vehicle (not shown) may be used with Shadow Vehicle 1 in the closed lane, Shadow Vehicle 2 straddling the edge line, and Shadow Vehicle 3 on the shoulder.
11. Where adequate shoulder width is not available, Shadow Vehicle 3 may drive partially in the lane.

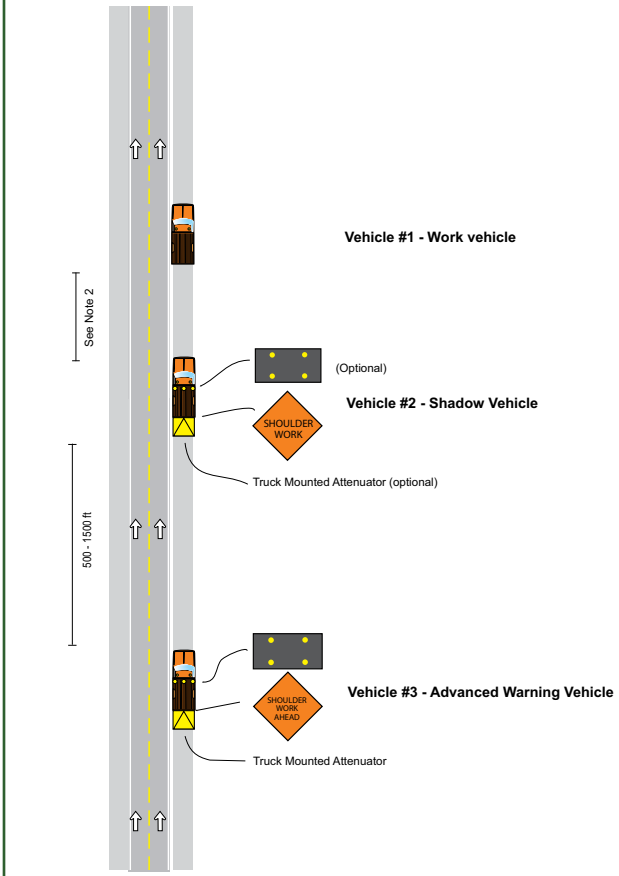
NMTA - 1: Night Mobile Operation on Shoulder of Two-Lane Two-Way Roadway



Notes for NMTA-1—Source: ***Traffic Control Handbook for Mobile Operations at Night.***

1. This plan is appropriate for intermittent moving operations positioned on the shoulder, completely free of or with only minimal intrusion into the travel lane. Such operations stop briefly, typically for 15 minutes or less, at various locations along a highway.
2. The distance between the work vehicle and the shadow vehicle should be based on traffic conditions.
3. Vehicle #1 may be omitted when the size of the work crew does not require two vehicles. If only one vehicle is used, the workspace should be positioned immediately in front of the vehicle.
4. Work lights should be provided on Vehicles 1, 2, or both, depending upon the nature of the work operation. Both vehicles should be equipped with warning lights with 360 degree visibility.
5. When multiple work locations within a limited distance make it practical to place stationary signs, the ROAD WORK AHEAD sign may be placed on the shoulder. The distance from the sign to the work should be kept as short as possible, not to exceed 2 miles.
6. Where sight distance is good and traffic speed and volume are not high, this plan may be adapted to continuously moving operations such as sweeping. Vehicle 1 performs the work and Vehicle 2 serves as the shadow vehicle and advance warning vehicle. Except for work on very short highway segments, it is not normally practical to use stationary signs for continuously moving operations.
7. Refer to TA-4 on page17 and 18 of this document for additional guidance.

NMTA - 2: Night Mobile Operation on Shoulder of High Speed Multi-Lane Highway



Notes for NMTA-2—Source: ***Traffic Control Handbook for Mobile Operations at Night.***

1. This plan is appropriate for continuously moving operations such as sweeping or herbicide application, especially where sight distance is not good or higher traffic speed and volume may be encountered.
2. The distance between the work vehicle and the shadow vehicle should be based on traffic conditions.
3. Where the operation must stop briefly at intermittent locations, a stationary ROAD WORK AHEAD sign may be placed on the shoulder. It should be kept as close as possible to the operation, not to exceed 2 miles.
4. For continuously moving operations, all work is performed from Vehicle 1, with no workers on foot. When intermittent stops require workers to be on the pavement, the work space should be located immediately behind or ahead of Vehicle 1.
5. Work lights should be provided on Vehicle 1 to light the work operation, and may be provided on Vehicles 2 and 3 as needed, depending upon the nature of the operation. All vehicles should be equipped with warning lights with 360 degree visibility.
6. The position of Vehicle 3 should vary based on sight distance, ramps, intersections, shoulder obstructions, etc. A minimum of 500 ft. in advance of Vehicle 2 is desirable; with a maximum of 1,500 ft. Shorter distances may be used for low-speeds.
7. Vehicle 3 may be deleted where speeds are less than 55 mph and sight distance is adequate to provide at least 1,500 ft visibility to Vehicle 2 (1,000 ft. visibility for speeds of 40 mph or less).
8. Refer to TA-4 on page17 and 18 of this document for additional guidance.

SAFER ROADS SAVE LIVES

U.S. Department of Transportation
Federal Highway Administration

Developed by:
The American Traffic Safety Services Association (ATSSA)
15 Riverside Parkway, Suite 100
Fredericksburg, VA 22406-1022
(800) 272-8772

For more information on the MUTCD, visit the following website:
http://mutcd.fhwa.dot.gov/index.htm

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