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PUBLIC TRANSPORTATION

COOPERATIVE
RESEARCH

**PORTABLE CHANGEABLE
MESSAGE SIGNS
AT WORK ZONES**

in cooperation with the
Department of Transportation
Federal Highway Administration

**RESEARCH REPORT 292-4
STUDY 2-18-81-292
TRAFFIC AT WORK ZONES**

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16. Abstract This report contains several guidelines concerning the use and operation of changeable message signs at highway construction and maintenance work zones. Operational, design, and message considerations are summarized. The report is intended as a quick reference for individuals responsible for the installation and operation of changeable message signs at work zones.					
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Benjamin W. Bohuslav, Supervising Maintenance Engineer, District 13
Walter Collier, District Maintenance Engineer, District 15
Billie E. Davis, District Maintenance Engineer, District 2
Milton Dietert, Assistant Chief Engineer of Safety and Maintenance Operations, D-18
Herman Gadeke, District Traffic Engineer, District 15
Hunter Garrison, District Maintenance Engineer, District 12
Henry Grann, Supervisory Traffic Engineer, District 18 (Retired)
Herman Haenel, Supervisory Traffic Engineer, D-18T
Bobby Hodge, Supervisory Traffic Engineer, District 2
Steve Levine, Traffic Management Supervisor, District 12
Blair Marsden, Senior Traffic Engineer, D-18T
Silas M. Prince, District Maintenance Engineer, District 11
Lewis Rhodes, Senior Traffic Engineer, D-18T
Russell G. Taylor, Engineering Technician V, District 14
Milton Watkins, District Maintenance Engineer, District 18
John Wilder, District Maintenance Engineer, District 14

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1. INTRODUCTION

Changeable Message Signs

Highway signing can be divided into two broad types: static signs, where the message is fixed on the sign, and changeable message signs (CMSs), where the message can be changed to meet changing conditions. Static signs include conventional regulatory, guide and warning signs. Types of CMSs include: bulb matrix, disk matrix, rotating drum, tri-color and scroll.

CMSs can perform a critical role on high-speed highways by furnishing drivers with real-time information that advises them of problems and unexpected conditions, and telling them the best course of action. CMSs can be particularly useful at highway construction and maintenance work sites which often present drivers with unexpected traffic or detour situations. In recent years, CMSs have been placed on trailers or pickup trucks to make them portable. Portable CMSs provide the flexibility for moving the signs to various locations and allow one to display highlighted information at critical locations in work zones.

Applications of CMSs

There are a variety of applications for CMSs at urban freeway construction and maintenance work zones. However, because of their flexibility and capability, they are sometimes incorrectly used, thus reducing their effectiveness. The primary purpose of CMSs in work zones is to advise the driver of unexpected traffic and routing situations. Repeat drivers (i.e., familiar drivers) become accustomed to the situation after a period of time and will begin to ignore the sign. When the message is later changed for a new situation, the repeat drivers may not read the message. Prolonged use of a CMS at one location and for one purpose may, therefore reduce the effectiveness of the sign. Thus CMSs should generally be used for short periods of time (e.g. one to two weeks) and for special applications. Examples of special applications where CMSs can be effective in urban freeway work zones include:

1. New detours
2. Change in detours
3. Introduction of a lane drop where a continuous lane once existed
4. Special speed control measures
5. Periodic use of flaggers, and
6. Location where sight distance is restricted and congestion occurs due to a lane closure.

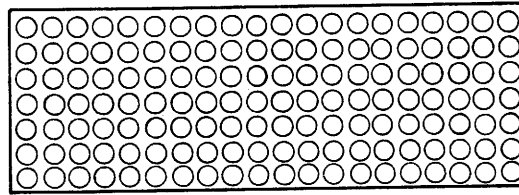
Characteristics of Bulb Matrix CMSs

Bulb matrix is currently the most commonly used CMS in work zones. Thus, this report focuses on the operation of bulb matrix signs.

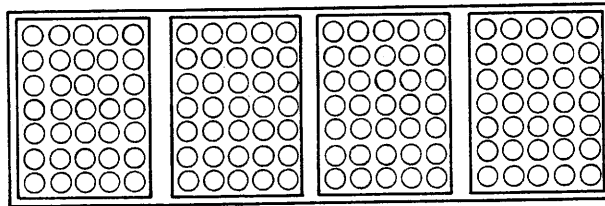
The viewing face of a bulb matrix sign is formed by rectangular arrays of incandescent light bulbs mounted on sign panels. The lamp arrays used to form character lines can either be a continuous field of lamps or a fixed number of rectangular matrix modules--small banks of lamps separated by "lampless" areas (Figure 1). Each character in a message is formed by illuminating the relevant lamps from a matrix of 7 lamp rows and 4 or 5 lamp columns. Typically, the bulb-matrix signs used in work zones are capable of displaying up to about 7 characters per line of message.

Currently one-line and three-line portable CMSs (Figure 2) are commercially available. One-line signs are well suited where messages containing 4 words or less will be displayed. Three-line signs allow the user to display more information to drivers, and therefore have greater flexibility and utility.

Bulb matrix signs are visible farther in advance than static signs and tend to attract the driver's attention when properly positioned with respect to the driver's line of sight.



Continuous Array



Modular Array (5 x 7 Rectangular Modules)

Figure 1. Bulb-Matrix Arrays

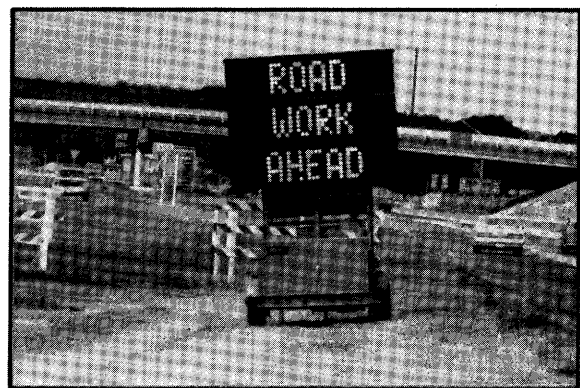
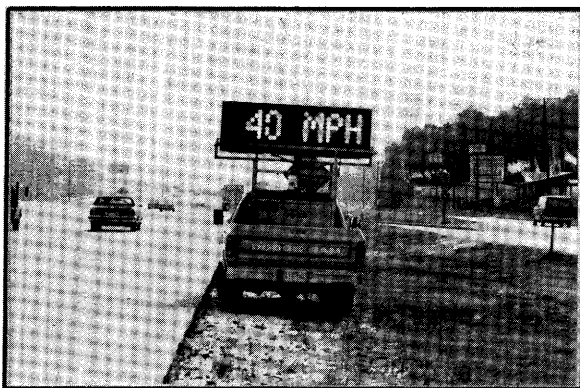


Figure 2. Portable Changeable Message Signs

2. OPERATIONAL AND DESIGN CONSIDERATIONS

Operating CMSs

When CMSs are used at a work site, a driver views the signs as furnishing reliable, accurate, and up-to-date information. All precautions must be taken to insure that these expectations are met. This means that considerable effort will be required in operating the signs.

Operating CMSs requires extra care and time to insure the right messages are displayed at the proper time. Drivers will have negative attitudes about signs that display information that is contrary to existing conditions, display information that is not easily understood or read in ample time to make the appropriate maneuvers, or tell drivers something they already know. Once drivers lose faith in the sign, do not expect them to accept the message the next time. Thus, money may be spent operating signs that are no longer doing the job.

Character Size and Legibility

The characters on a bulb CMS used at freeway work zones should be about 18 inches high. Such a sign will allow approximately 85% of the drivers to begin reading the message approximately 650 feet from the sign provided there are no obstructions (e.g. trucks) in the drivers' line of sight.

Roadside Placement of CMSs

As a general rule, CMSs should be placed only on one side of the freeway -- either left or right depending upon the need. CMSs should never be placed and operated simultaneously on both the right and left sides of the freeway. Two signs operating simultaneously on both sides tend to be distracting and confusing. Drivers are never sure which sign to look at, and chances are, they will fail to read the message. When two signs are needed, they should be placed on the same side of the roadway and should be separated by at least 1,000 feet.

Lamp Dimming at Night

Bulb matrix CMSs are highly visible during the day because of the relative intensity of the lamps with respect to the surrounding area. There is a need for high intensity during the day to create enough contrast so that a driver can read the message. However, the intense brightness can create problems at night or during cloudy periods. The light intensity must be reduced at night and during periods of reduced light levels, otherwise the message will be too bright for drivers to read. In some cases the signs may become a potential hazard by distracting or "blinding" drivers.

Many signs are equipped with a photocell which automatically adjusts the intensity of the lamps. Some signs must be adjusted manually. The CMSs should be inspected during nighttime operation to insure that the appropriate light intensity is in effect.

Bulb Replacement

When light bulbs burn out on the sign, readability is affected. Messages generally become difficult to read when more than 10% of the bulbs are burned out. It is not always possible to replace defective bulbs as soon as they are noticed; however, a routine inspection and bulb replacement program will minimize the problem of poor readability.

3. MESSAGE DESIGN AND DISPLAY CONSIDERATIONS

Information Unit

An **information unit** refers to each separate information item given in a message which a motorist could recall and which could be a basis for making a decision. Consider the message **ROADWORK AT MILFORD, UTOPIA TRAFFIC USE WILLIAMS STREET**. This message has four units of information as follows:

<u>Question</u>	<u>Info. Unit Required</u>
1. What happened?	Roadwork
2. Where?	At Milford
3. Who is the advisory intended for?	Utopia Traffic
4. What is advised?	Use Williams Street

Typically, a unit of information is two words, but a unit could contain one to four words. A unit of information provides an answer to a question which a driver may pose. For example, **ROADWORK** is a one-word information unit; **AT MILFORD** is a two-word unit; **USE WILLIAMS STREET** is a three-word unit.

Message Length

Message length refers to the number of words or characters in a message. There are certain guidelines that must be followed to make sure the messages are displayed (exposed) to a driver long enough so that he can read the message in the few seconds he has while traveling at normal freeway speeds. The message must be short enough so he can read the entire message.

A good rule of thumb is that a driver will need at least one second per short word (up to eight characters) not counting prepositions, or two seconds per unit of information to read and recall a well designed message.

As mentioned earlier, most drivers (85%) can begin reading a bulb matrix CMS with 18-inch high characters approximately 650 feet upstream of the sign. Thus, while traveling at 55 mph (80.67 ft/sec) a driver has only about 8 seconds to read the message. ($650 \text{ ft} / 80.67 \text{ ft/sec} = 8 \text{ sec}$)

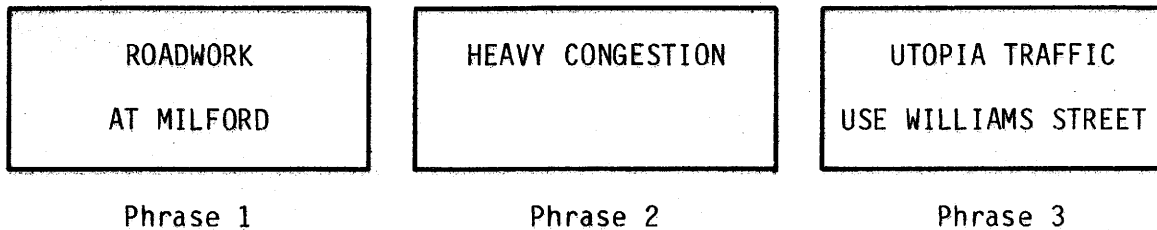
The requirements of one second per word and two seconds per information unit means that a message should not be longer than 8 words or 4 units of information for drivers traveling at 55 mph.

Flashing Operations

It may sometimes be desirable to flash certain words, phrases, or the entire message to emphasize the urgency of a message. Flashing is also used to attract the driver's attention to the sign when the sign may be affected by surrounding commercial development.

Splitting (Chunking) and Sequencing Messages

Sometimes roadwork situations dictate the need for longer messages than can be displayed at one time on the CMS. A longer message can be displayed by dividing the message into chunks and sequencing the message chunks on a sign or, if necessary, displaying separate chunks of information on two signs. Chunking must be accomplished by splitting the message into compatible phrases as illustrated below.



Note that the words **HEAVY CONGESTION/UTOPIA TRAFFIC** are not compatible and therefore should not be chunked together. **UTOPIA TRAFFIC/USE WILLIAMS STREET** are compatible in the sense that the action statement refers to the destination group. Collectively, the message elements form a message that will stand alone like a sentence.

Delineating the End of Sequenced Messages

When a message is divided into two parts which are sequenced on the sign, the two information elements are simply alternated on the sign and the driver generally has no difficulty in understanding the message. When a message must be divided into three or more parts, the end of message must be delineated before it begins its next cycle so that a driver understands when the message is repeated. One of the best ways to delineate the end of message is to display a series of stars (asterisks) as shown in Figure 3. The stars should be displayed for approximately one second. Another acceptable way to delineate is to have a blank period of approximately one second to mark the end of the message before it recycles.

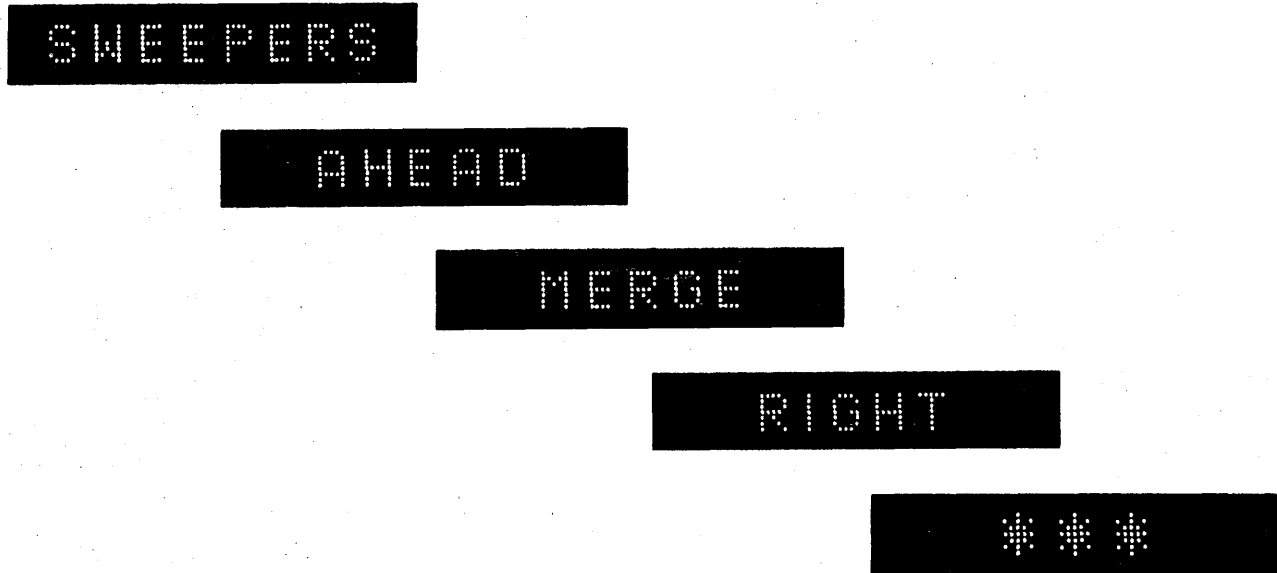


Figure 3. Delineating the End of a Sequenced Message

Lane Blockage (Closure) Messages

It is sometimes necessary to inform drivers of blocked or closed lanes. When this occurs, care in the choice of words is essential so that drivers fully understand which lanes are blocked or closed.

LANE BLOCKED indicates a temporary blockage due to an accident, stall, etc., whereas **LANE CLOSED** indicates a prolonged closure. Therefore, use **RIGHT (LEFT) LANE BLOCKED** when the obstruction is due to an incident.

The message **FREEWAY BLOCKED AHEAD** is interpreted by drivers to mean the entire freeway is blocked.

CMSs vs. Arrowboard

The arrowboard, not a CMS, is probably the best device for informing drivers of right or left lane closures. An arrowboard has high target value and is well understood by drivers to mean that a lane is closed and drivers should merge into an open lane in the direction indicated by the arrow.

When a right or left lane is closed, an arrowboard should be used. Never use a CMS in place of an arrowboard. However, there may be a few occasions when a CMS might be needed to supplement the arrowboard.

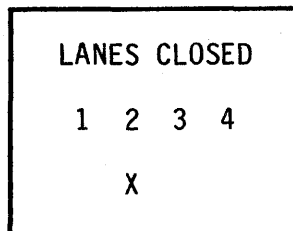
Two-and Three-Lane Freeway Sections

When there are only two or three lanes in a direction, the CMS word message may be either descriptive (**LEFT LANE BLOCKED** or **RIGHT LANE BLOCKED**) or it may be directive (**KEEP RIGHT** or **KEEP LEFT**).

When the center lane is blocked or closed on a three-lane section, a directive message is not recommended. The preferable message is **CENTER LANE BLOCKED (CLOSED)**.

Four or More Lanes

When the freeway section has four or more lanes in one direction, word descriptors like **LEFT**, **CENTER**, and **RIGHT** are ambiguous in designating specific lane blockages to drivers. A semi-symbolic CMS message, as shown below, was found to be well understood by drivers and is recommended on freeway sections with four or more lanes.



Incident Messages

During roadwork, incidents sometimes occur which require displaying special messages to drivers. Examples of incidents for which messages can be displayed on CMSs are:

ACCIDENT
DAMAGED BRIDGE
ICE (ICY BRIDGE)
FLOOD

FOG
SPILLED LOAD
PAVEMENT BROKEN
SNOW

Do not display information on roadwork or incidents off the roadway which can be readily seen by a driver and avoided by lane changing. Examples of minor off-roadway objects are mowing machines, stalled vehicles, trash, or small dead animals.

Describing Roadwork or Incident Location

When a majority of drivers would be unfamiliar with the names of local cross-streets, roadwork and incident locations should be described in distance to the nearest half-mile. Highway travelers are accustomed to seeing distances to cities. However, when a majority of drivers are commuters, roadwork and incident locations should be referenced to the nearest cross-street. Commuters are highly familiar with cross-street names and can relate to the named locations better than to distances. Commuters are poor at estimating distances to major cross-streets. Giving distances does not easily translate in terms of whether the location is upstream or downstream of an exit ramp of interest. When there are no cross-streets in the vicinity, a prominent landmark (factory, water tower, airport, etc.) may be substituted. Examples of incident location messages are shown below.

ROADWORK 2 MILES

Unfamiliar Driver

ROADWORK AT BATES AVE

Familiar Driver

ROADWORK AT VANCE AFB

Note: The word **AHEAD** may be given after **MILES** although it is largely understood.

Delay Information

The duration of the delay is a primary factor in a driver's decision to divert or stay on the freeway. A critical delay time for the average driver is about 20 minutes. If an average driver is informed that his trip will take 20 minutes longer than usual (20 minute delay), he will think seriously about taking another route.

Major Delay implies to the average driver a delay of at least 20 minutes. **Minor Delay** implies to the average driver a delay of not more than 15 minutes.

Abbreviations

Sometimes because of the limitations of the CMS size and the message length requirements, it is necessary to abbreviate words. The following are a set of abbreviations for some frequently used words on CMSs for which at least

85% of the driving public would understand if they appeared on a CMS. These abbreviations will likely be understood independent of the other words in the message.

<u>Word</u>	<u>Abbreviation</u>	<u>Word</u>	<u>Abbreviation</u>
Boulevard	BLVD	Normal	NORM
Center	CNTR	Parking	PKING
Emergency	EMER	Road	RD
Entrance, Enter	ENT	Service	SERV
Expressway	EXPWY	Shoulder	SHLDR
Freeway	FRWY, FWY	Slippery	SLIP
Highway	HWY	Speed	SPD
Information	INFO	Traffic	TRAF
Left	LFT	Travelers	TRVLRS
Maintenance	MAINT (Use RDWK)	Warning	WARN

Other abbreviations are easily understood whenever they appear in conjunction with a particular word commonly associated with it. These words and abbreviations are as follows:

<u>Word</u>	<u>Abbreviation</u>	<u>Prompt Word</u>	<u>Word</u>	<u>Abbreviation</u>	<u>Prompt Word</u>
Ahead	AHD	● Fog	Mile	MI	● [Number]
Blocked	BLKD	● Lane	Minute(s)	MIN	● [Number]
Access	ACCS	Road	Oversized	OVRSZ	Load
Bridge	BRDG	● [Name]	Prepare	PREP	To Stop
Chemical	CHEM	Spill	Pavement	PVMT	● Wet
Construction	CONST	Ahead	Quality	QLTY	● Air
Exit	EX, EXT	● Next	Route	RT	● Best
Express	EXP	Lane	Turnpike	TRNPK	● [Name]
Hazardous	HAZ	Driving	Vehicle	VEH	● Stalled
Interstate	I	[Number]	Cardinal	N,E,S,W	[Number]
Major	MAJ	Accident	Directions		
Minor	MNR	Accident	Upper,Lower	UPR,LWR	Level

● = Prompt word given first

Caution should be used in employing these abbreviations with other prompt words since their high understanding has been established only with the words given in the table. For example, drivers very easily interpret BLKD as

BLOCKED when it appears with LANE in the form LANE BLKD. CHEM is interpreted by drivers as CHEMICAL when used in the message as CHEM SPILL.

The following abbreviations are understood with a prompt word by about 75% of the drivers. These abbreviations would require public education prior to usage.

<u>Word</u>	<u>Abbreviation</u>	<u>Prompt Word</u>	<u>Word</u>	<u>Abbreviation</u>	<u>Prompt Word</u>
Downtown	DWNTN	Traffic	Roadwork	RDWK	Ahead
Northbound	N-BND	Traffic			(Distance)
Congested	CONG	Traffic	Township	TWNSHP	Limits
Temporary	TEMP	Route	Frontage	FRNTG	Road
Condition	COND	● Traffic	Local	LOC	Traffic

● = Prompt word given first

Certain abbreviations are prone to inviting confusion because another word is abbreviated or could be abbreviated in the same way. AVOID USING THESE ABBREVIATIONS:

<u>Abbreviation</u>	<u>Intended Word</u>	<u>Word Erroneously Given</u>
WRNG	Warning	Wrong
ACC	Accident	Access (Road)
DLY	Delay	Daily
LT	Light (Traffic)	Left
STAD	Stadium	Standard
L	Left	Lane (Merge)
PARK	Parking	Park
RED	Reduce	Red
POLL	Pollution (Index)	Poll
FDR	Feeder	Federal
LOC	Local	Location
TEMP	Temporary	Temperature
CLRS	Clears	Colors

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