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16. Abstract In this report, researchers document the development of a field guide for portable changeable message sign use in work zones. Included in the report is a summary and critique of available national and state-level standards and guidance on portable changeable message sign (PCMS) use, description of the components included in the field guide, and implementation considerations for field guide deployment. The field guide was developed as a stand-alone product, but is included for illustrative purposes as an appendix to this report.					
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**DEVELOPMENT OF A FIELD GUIDE FOR
PORTABLE CHANGEABLE MESSAGE SIGN USE IN WORK ZONES**

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DISCLAIMER

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INTRODUCTION

STATEMENT OF THE PROBLEM

Portable changeable message signs (PCMSs) play a key role in traffic control at many Texas work zones. When used properly, these signs command more attention than regular static work zone signing. Furthermore, highway agencies and contractors can present a wide variety of information to motorists via a PCMS, making it a highly versatile tool to traffic control designers and to work crews. Although they can be highly effective tools when used properly, improper use of PCMSs can destroy their credibility with the motoring public. Also, improper PCMS usage can contribute to motorist confusion and incorrect driving behaviors, degrading the safety of motorists and workers as well as the operational efficiency of the traffic control plan.

To be effective, a PCMS must communicate a meaningful message that motorists can read and comprehend within a very short time period. Proper PCMS message design and use requires application of both human factors and traffic engineering principles. Guidelines on how to design and use PCMS have been developed through extensive research and field validation (1-19). Unfortunately, personnel who are expected to operate the PCMS come from a variety of educational backgrounds and types of experience. Those personnel who are given PCMS responsibilities (or inherit them by default) in the field often do not have adequate levels of training in PCMS message design and application (20). Those personnel also typically have many other responsibilities. These many responsibilities limit the time available to effectively evaluate site conditions, develop concise and useful messages, and monitor the relevancy of the messages on a continuous basis.

PCMSs can be used to notify drivers of future changes in traffic conditions in the work zone. Unfortunately, due to the many other responsibilities of those who operate the PCMS, field personnel often design very generic roadwork messages. These generic messages can cause PCMSs to lose effectiveness with the motorists. Previous studies of driver understanding of traffic control devices through several work zones on high-speed roadways in Texas suggest that other misapplications of PCMSs in work zones often contribute to driver confusion and anxiety about their appropriate travel paths (21). For example, PCMSs placed too close or too far from the features that they are providing information about, PCMS messages that are too long to read in high-traffic volumes when there were many large trucks present to obscure the sign, and

PCMS messages presented within freeway interchange areas that could not adequately convey to motorists which lane was closed ahead (i.e., the right lane of a two-lane left exit was closed) all created confusion for motorists.

Clearly, these issues and others regarding the proper application of PCMSs in work zones needed additional research and field-level guidance. This report contains the documentation of the results of research sponsored by the Texas Department of Transportation and conducted by TTI to address key research needs in this area.

PROJECT OBJECTIVES

The objectives of this research project were twofold:

- identify and prioritize key research gaps that still exist regarding the effective use of PCMSs in work zones and conduct human factors studies to address those research gaps, and
- develop appropriate field-level guidance regarding effective PCMS use in work zones.

In this report, the researchers describe the development of the field-level guidance. The results of an inventory of research gaps and the human factors studies conducted to address those gaps have been published in a previous research report from this project (19):

Ullman, G.L., B.R. Ullman, C.L. Dudek, A. Williams, and G. Pesti. *Advance Notification Messages and Use of Sequential Portable Changeable Message Signs in Work Zones*. Report No. FHWA/TX-05/0-4748-1. Texas Transportation Institute, College Station, TX, July 2005.

In the [chapter](#) that follows, researchers summarize and compare standards, specifications, and guidelines that currently exist with regard to PCMS use in work zones. These summarized documents, along with the human factors study results in the above report, served as a base for the development of a field guide for PCMS use. In the [next chapter](#), researchers briefly describe the development process of the guide. The guide was designed to fit on a single sheet (front and back) and to be applied by field personnel with minimal training in the human factors and traffic

engineering principles that govern PCMS message design and application. In the [final chapter](#) of this report, researchers discuss alternative implementation mechanisms available to effectively deploy the field guide and maximize its benefits in work zones throughout Texas.

REVIEW OF EXISTING PCMS GUIDANCE

NATIONAL-LEVEL GUIDANCE

Manual on Uniform Traffic Control Devices

The Manual on Uniform Traffic Control Devices (MUTCD) provides a number of basic guidelines about PCMSs that are to be followed in sections 2A.07, 2E.21, and 6F.55 (22). As noted in section 2A.07, changeable message signs (including PCMSs) should be used to convey regulatory, warning, and guidance information related to traffic control. Safety or transportation-related messages are also allowed but should be governed by agency policy:

“State and local highway agencies may develop and establish a policy regarding the display of safety and transportation-related messages on permanent and changeable message signs that specifies the allowable messages and applications, consistent with the provisions of this Manual.”

When a safety or transportation-related message is to be displayed, the message should be simple, brief, and clear. Also, a safety or transportation-related message should not be displayed on a changeable message sign if doing so would adversely affect the respect for the sign. For example, overly vague or simple messages should not be displayed alone. Furthermore, the display mode used should be kept simple:

“The display format shall not be of a type that could be considered similar to advertising displays. The display format shall not include animation, rapid flashing, or other dynamic elements that are characteristics of sports scoreboards or advertising displays.”

Additional emphasis that changeable message signs should appear and be used as traffic control devices, and not give the appearance of advertising, is provided in section 2E.21:

“Changeable message signs shall display pertinent traffic operational and guidance information only, not advertising.”

In addition:

“Techniques of message display such as fading, exploding, dissolving, or moving messages shall not be used.”

Section 6F.55 of the MUTCD specifically addresses PCMSs and notes the primary purpose of PCMSs in temporary traffic control zones is to advise the road user of unexpected situations. Typical applications for PCMSs listed in the MUTCD include:

- where the speed of vehicular traffic is expected to drop substantially;
- where significant queuing and delays are expected;
- where adverse environmental conditions are present;
- where there are changes in alignment or surface conditions;
- where advance notice of ramp, lane, or roadway closures is needed;
- where crash or incident management is needed; and/or
- where changes in the road user pattern occurs.

With regard to the messages displayed on PCMSs, the MUTCD guidance is fairly general. Section 6F.55 presents five general recommendations:

- Each phase should convey a single thought.
- If the message can be displayed in one phase, the top line should present the problem, the center line should present the location or distance ahead, and the bottom line should present the recommended driver action.
- The message should be as brief as possible.
- When a message is longer than two phases, additional PCMSs should be used.
- When abbreviations are used, they should be easily understood (relying on recommendations in section 1A.14 of the MUTCD).

In reality, few messages can be configured as listed in the second bullet on a standard PCMS display, as the display characteristics are defined specifically in the MUTCD:

“Each message shall consist of either one or two phases. A phase shall consist of up to three lines of eight characters per line. Each character module shall use at least a five wide and seven high pixel matrix.”

The following list identifies a few other general guidelines in the MUTCD regarding the use of PCMSs:

- PCMSs should be visible to motorists at a distance of 0.5 mile under ideal daytime and nighttime conditions when placed near the roadway for operation.
- PCMSs should typically be positioned in advance of any other temporary traffic control signing.
- PCMSs should not replace any of the required warning or regulatory signs called for elsewhere in the MUTCD.
- The bottom of the PCMS message panel shall be a minimum of 7 feet above the roadway surface.
- The message being displayed should be legible from all lanes of traffic at a minimum of 650 feet from the sign.
- Successive PCMSs should be located on the same side of the roadway but separated by at least 1000 feet to allow adequate driver perception and reaction time to each display.
- The message panel should have adjustable display rates (minimum of three seconds per phase) so that the entire message can be read at least twice at the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.
- No more than two phases should be used within any message cycle.
- Messages shall not scroll horizontally or vertically across the face of the sign.

In summary, the level of guidance provided in the MUTCD is consistent with its intended audience of adequately trained transportation engineers. The manual does not describe specific messages to be used for specific types of situations, nor the specific locations where such signs should be placed within a typical temporary traffic control layout.

FHWA Portable Changeable Message Sign Handbook

The *Portable Changeable Message Sign Handbook PCMS* is a 2003 FHWA document prepared to supplement the MUTCD and provide additional guidance regarding PCMS use (23). The handbook is laminated, pocket sized, and spiral bound to allow it to be carried and used in the field. The scope of the handbook is broad, consisting of the following main topics:

- What is a PCMS?
- When Should a PCMS be Used?
- PCMS Screen Characteristics
- PCMS Message Design Process
- Placement of a PCMS
- When to Discontinue PCMS or Alter Message
- Other Operational Issues

Much of the information included in the handbook is extracted directly or paraphrased from the guidance in the MUTCD. The additional information includes PCMS screen characteristics (modular, continuous line matrix, full matrix) and placement of the PCMS. Not all of the information that is presented is universally accepted, however. For example, the discussion with regard to the different PCMS screen characteristics implies superior legibility distances for line and full matrix signs:

“These [continuous line matrix] signs offer the ability to use proportionally spaced fonts, as opposed to the monospaced text displayed by discrete character blocks. The benefits include a more natural-looking sign and, therefore, an easier-to-read message.”

In actuality, the use of proportionally spaced fonts are believed to not adversely affect legibility distance but have not been shown to significantly increase legibility distance either. The primary benefit of such a font is that it can allow, in some instances, an additional character or two to be displayed on a particular line of the sign without decreasing legibility, *as long as the character height is not reduced* (24). Interestingly, most PCMS manufacturers have constrained their signs to display no more than eight characters per line, thereby reducing the apparent advantage of proportional font usage. The handbook also suggests that phases with only 1 or 2 lines of text be displayed for 1.5 seconds, and phases with 3 lines of text be displayed for 3 seconds. This suggestion is in contrast to MUTCD guidance, which states that all phases should be displayed a minimum of 3 seconds each.

With regard to the message design process, the handbook states that a PCMS message can use one, two, or, when absolutely necessary, three phases to relay its message. This guidance was consistent with older versions of the MUTCD, but is now incorrect with the two-phase maximum message specified in the MUTCD. PCMS use on construction and maintenance projects should be treated as an integral part of the traffic control plan (TCP). The handbook recommends that desired messages, locations, and general time periods of display be listed for all known or anticipated PCMS use during the project. Additional opportunities to use the PCMS may come up during the life of the project, and the TCP should allow for these unanticipated messages. However, the governing agency should retain control over selection and display of the unanticipated messages. The handbook also recommends that a default message be programmed into the PCMS in case the unit becomes disabled:

“Since the default message will act as a warning to field personnel that the PCMS has malfunctioned, a message should be chosen that will not alarm motorists and will not be used for any other purpose. Alternatively, to indicate that the PCMS is malfunctioning, a pattern such as solid bars may be used.”

One of the areas that the handbook does appear to provide good additional information is with respect to PCMS location. The guidance in the handbook is predicated on defining the action required – major or minor – by the motorist and then positioning the sign an appropriate distance upstream of the action point. Major actions are those that require complex decisions by

the motorist, such as having to use another exit ramp because the intended ramp is closed. Minor actions, on the other hand, are lane changes or minor adjustments in speed. This definition is consistent with concepts of positive guidance that have served the traffic engineering community for many years (25). The handbook indicates that PCMSs should be placed 500 to 1000 ft upstream of a minor action decision point, regardless of speed. Meanwhile, PCMSs should be positioned 1000 ft upstream of major action decision points on roadways with speeds of 40 mph or lower, but 1 mile upstream for roadways with speeds 45 mph or higher. The handbook also includes a recommendation to move the PCMS every few weeks so that it continues to command the attention of motorists.

In summary, the handbook does include information above and beyond the guidance provided in the MUTCD, particularly with respect to proper PCMS positioning and location relative to desired action points. The handbook includes a very brief checklist to serve as a reminder to field personnel of key items to consider when using PCMSs:

- ✓ Does the PCMS tell the motorist to do something?
- ✓ Are static signs not readily available?
- ✓ Does the PCMS tell drivers something new?
- ✓ Has approximately 1.5 to 3.0 seconds been provided for each phase of the PCMS so that each phase can be read twice?
- ✓ Have standard abbreviations been used?
- ✓ Can the PCMS be seen from the recommended visibility and legibility distances?
- ✓ Is the PCMS safely placed on or just off the shoulder?

However, the level of detail provided is still fairly minimal, especially with regard to how to specifically select and format information within the very tight space limitations of the PCMS display. As has been documented elsewhere, it is phase and message formatting principles that are most often violated in the field (19). PCMS formatting deficiencies are also key factors leading to motorist confusion in work zones (21).

FHWA Recommended PCMS Messages

In the mid-1990s, FHWA sponsored a study to develop a list of standard traffic control and warning messages for PCMSs (26). Researchers recommended standard messages for 30 different application scenarios. Work zone activities comprised slightly less than one-half of those scenarios, as shown in Table 1. In some instances, researchers presented alternative formats for a given scenario because a clear recommendation could not be made.

Table 1. FHWA Recommended PCMS Messages (26).

STEEL PLATES		FOLLOW PACE CAR	
MEN WORKING		KEEP LEFT	KEEP LEFT AHEAD
FLAGMAN AHEAD		DO NOT PASS	
LANE MARKING	PAINT CREW	SPEED LIMIT XX MPH	
BRIDGE CLOSED	BRIDGE CLOSED AHEAD	MINIMUM SPEED XX MPH	
ROAD CLOSED	ROAD CLOSED AHEAD	TRUCK CROSSING	WATCH FOR TRUCKS
LANES CHANGE	LANES CHANGE AHEAD	FOLLOW DETOURS	FOLLOW DETOURS AHEAD

STATE-LEVEL GUIDANCE

TxDOT Dynamic Message Sign Message Design and Display Manual

At nearly 500 pages in length, the TxDOT *Dynamic Message Sign Message Design and Display Manual* represents one of the most comprehensive guidance documents available on how to properly design and display traffic incident and roadwork messages on both large

permanent dynamic message signs (DMSs) and PCMSs (1). The manual is designed to assist a variety of users, from entry-level personnel to managers with extensive message design and display experience and expertise. Emphasis is placed on DMSs and PCMSs located on freeway facilities, but the fundamental concepts and message design processes are appropriate for other roadway types as well.

In addition to many of the broad guideline statements found in the MUTCD and the FHWA handbook, the Manual presents a very specific 48-step message design process developed around the concept of a base message set. The base message represents the total amount of information that drivers could use to make a fully informed driving decision such as whether or not to divert to an alternate route. The base message is comprised of the following message elements:

- roadwork descriptor,
- roadwork or closure location,
- lanes closed,
- effect on travel,
- action to take,
- audience for action, and
- good reason to follow the action.

In most instances, it will not be possible to provide all of this information to motorists within the time and space limitations of a DMS or PCMS. Therefore, methods of prioritizing and condensing the base message down to the most critical elements are presented in the design process. The priorities and methods differ somewhat depending on whether the DMS or PCMS is located close to the roadwork location, far upstream of the roadwork location, or on a different roadway than the location of the roadwork activity. In addition, the many possible variations in terms and formats of each message element are summarized in tabular form to aid the user in the selection process.

Another important component of the Manual is a 30-page quick-reference guide for DMS and PCMS messages. This guide indicates the exact terms and formatting to use for different freeway and lane closure scenarios (i.e., lane closures close to the DMS or PCMS, lane closures

far downstream of the signs, closures on intersecting roadways, different numbers of closed lanes, etc.). This guide allows those individuals without extensive background in DMS and PCMS message design and applications to quickly determine the most appropriate message to display and how that message should be displayed on the sign. Presently, the guide is limited to lane and freeway closures due to incidents and roadwork activities, but will eventually be expanded to deal with additional situations.

TxDOT Standard Plans

TxDOT has also recently added some guidance for PCMS operations into its set of construction standard plans (27). The guidance consists of 16 numbered statements and a table of acceptable and unacceptable abbreviations. The statements, which include directions on how to locate and delineate the PCMS at a work site as well as guidance on how to display messages, are presented below.

1. The Engineer/Inspector shall approve all messages used on portable changeable message signs (PCMS).
2. PCMSs placed on the shoulder or in the [right-of-way] R-O-W but not behind a concrete traffic barrier shall have a minimum of four plastic drums placed perpendicular to traffic on the upstream side of the PCMS.
3. Messages on PCMSs should contain no more than 8 words (four to eight characters per word), not including simple words such as “TO,” “FOR,” “AT,” etc.
4. Messages should consist of a single phase, or two phases that alternate. Three-phase messages are not allowed.
5. Each phase of the message should contain a single thought.
6. Use the word “EXIT” to refer to an exit ramp on a freeway, i.e., “EXIT CLOSED.” Do not use the term “RAMP.”
7. Always use the route or interstate designation (IH, US, SH, FM) along with the number when referring to a roadway.
8. Specify the actual days of the week; e.g., TUES THROUGH FRI or TUES-FRI in the coming week that work will occur.

9. The message term “WEEKEND” should be used only if the work is to begin Saturday morning and end by Sunday evening at midnight. Actual days and hours of work should be displayed on the PCMS if work is to begin on Friday evening and/or continue into Monday morning.
10. The Engineer/Inspector may select one of two options which are available for displaying a two-phase message on a PCMS. Each phase may be displayed for two seconds each or four seconds each.
11. Do not “flash” messages or words in a message. The message should be steady-burn or continuous while displayed.
12. Do not present redundant information on a two-phase message; i.e., keeping two lines of the message the same and changing the third line.
13. Do not use the words “Danger” or “Caution” in the message.
14. Do not display the message “LANES SHIFT LEFT” or “LANES SHIFT RIGHT.” Drivers do not understand the message.
15. Do not display messages that scroll vertically or horizontally across the face of the sign.
16. The following table ([Table 2](#)) lists abbreviations and two-word phrases that are acceptable for use on a PCMS. Both words in the phrase must be displayed together. Words or phrases not on this list should not be abbreviated.

The Standard Plans also note that PCMSs should be removed from the right-of-way or placed behind concrete traffic barriers when not in use.

TxDOT PCMS Special Specifications

TxDOT construction projects that include requirements for PCMSs typically include a special specification outlining the physical and operational characteristics of the sign. A “standard” specification for statewide use is available ([28](#)). However, many districts expand upon the requirements in that standard specification to tailor the sign to their particular needs or to include additional requirements such as minimum photometric performance values.

Table 2. Abbreviations Allowed on PCMS (27).

Word or Phrase	Abbreviation	Word or Phrase	Abbreviation
Access Road	ACCES RD	Miles	MI
Air Quality	AIR QLTY	Miles Per Hour	MPH
Avenue	AVE	<i>Time</i> Minutes	<i>Time</i> MIN
Best Route	BEST RTE	Monday	MON
Boulevard	BLVD	Normal	NORM
Bridge	BRDG	North	N
Cannot	CANT	Parking	PKNG
Center	CNTR	Parking Lot	PRK LOT
Construction Ahead	CONST AHEAD	Road	RD
Detour Route	DETOUR RTE	Right Lane	RGT LN
East	E	Saturday	SAT
Emergency	EMER	Service Road	SERV RD
Emergency Vehicle	EMER VEH	Shoulder	SHLDR
Entrance, Enter	ENT	Slippery	SLIP
Express Lanes	EXP LANE	South	S
Expressway	EXPWY	Speed	SPD
<i>Distance</i> Feet	<i>Distance</i> FT	Street	ST
Fog Ahead	FOG AHD	Sunday	SUN
Freeway	FRWY, FWY	Telephone	PHONE
Freeway Blocked	FWY BLKD	Thursday	THURS
Friday	FRI	To Downtown	TO DWNTN
Hazardous Driving	HAZ DRIVING	Traffic	TRAF
Highway	HWY	Travelers	TRVLRS
Hours	HR	Tuesday	TUES
Information	INFO	Turnpike	<i>Name</i> TRNPK
Left	LFT	Upper Level	UPPR LVL
Left Lane	LFT LN	Warning	WARN
Lane Closed	LN CLSD	Wednesday	WED
Lower Level	LOWR LVL	Weight Limit	WT LIMIT
Maintenance	MAINT	Wet Pavement	WET PVMT
Roadway Designation	IH-, US-, SH-, FM-	West	W

The more recent specifications also include requirements that the PCMS be programmed with 31 standard messages, as shown below (29):

- | | |
|-------------------------------|---------------------------|
| 1. Ramp Closed Ahead | 17. Road Closed Ahead |
| 2. Shoulder Drop-Off | 18. Shoulder Use OK |
| 3. Detour Ahead | 19. Left 2 Lanes Closed |
| 4. Two-Way Traffic Ahead | 20. Right 2 Lanes Closed |
| 5. Form One Line Left | 21. All Traffic Exit |
| 6. Form One Line Right | 22. Caution Slow Traffic |
| 7. Form Two Lines Right | 23. Road Repairs Ahead |
| 8. Form Two Lines Left | 24. Detour Next 2 Exits |
| 9. Center Lane Closed Ahead | 25. Detour Next Exit |
| 10. Left Lane Closed Ahead | 26. End Shoulder Use |
| 11. Right Lane Closed Ahead | 27. Right Lanes Must Exit |
| 12. Caution-Vehicles Crossing | 28. Left Lanes Must Exit |
| 13. Max. Speed XX MPH | 29. Left 3 Lanes Closed |
| 14. Merge Right | 30. Right 3 Lanes Closed |
| 15. Merge Left | 31. Center Lane Closed |
| 16. Freeway Closed Ahead | |

These messages are identical to those called out in other state department of transportation (DOT) specifications (30). It should be noted that some of the required messages actually violate the guidelines shown in the TxDOT Standard Plans, such as using the term CAUTION in messages 12 and 22, or using the term RAMP in message 1. More importantly, there is no guidance as to how these messages are to be formatted when input into the PCMS for use. Several of the messages (e.g., 7 through 11, 27 and 28) cannot be displayed within the limitations of a standard three-line, eight-character-per-line PCMS. These messages would require the use of several abbreviations to allow them to be displayed in a single PCMS phase.

PCMS Guidelines from Other States

A number of state DOTs have established policy, procedures, and/or guidelines pertaining to the use of PCMSs. Some of the DOTs have included guidelines as part of their project planning, design, traffic, or construction manuals; others have created separate documents to govern PCMS and DMS use. Generally speaking, most of them cover the basic principles found in the MUTCD, FHWA handbook, or other older national guidelines (7). A few of them do include unique components that are worth mentioning in this review.

Florida

The Florida DOT has incorporated its set of PCMS guidelines for work zones into its Plans Preparation Manual, Section 10.10.3 (31). Much of the information presented is identical to that discussed previously. However, the manual does specify that the PCMS should be legible from 900 feet. Also, messages are to be designed and the PCMS operated so that they can be read twice by motorists approaching at 55 mph from 900 feet away. The manual also specifies that a PCMS is to be used anytime night work occurs within 4 feet of the travel way.

One of the interesting statements included in the Florida DOT manual is a restriction that no more than one abbreviation is to be used on each phase of the message. The standard list of abbreviations (similar to that shown above for TxDOT) is also presented. The reasons for the restrictions on abbreviations are not provided.

Another useful component of the Florida guidelines is a PCMS worksheet that can be used to plan appropriate messages and/or document the messages that are used in the field. Figure 1 replicates this worksheet. Researchers were unable to determine from Florida DOT contacts the extent to which the worksheet is used by their own or highway contractor personnel.

CHANGEABLE (VARIABLE) MESSAGE SIGNS WORKSHEET

Location of board: _____

Used: from ____ - ____ - ____ at ____ : ____ am/pm

to ____ - ____ - ____ at ____ : ____ am/pm

Message programmed by: _____

MESSAGE 1

□	□	□	□	□	□	□	□
□	□	□	□	□	□	□	□
□	□	□	□	□	□	□	□

MESSAGE 2

□	□	□	□	□	□	□	□
□	□	□	□	□	□	□	□
□	□	□	□	□	□	□	□

Timing:

Message 1 will run ____ seconds.

Message 2 will run ____ seconds.

Figure 1. PCMS Worksheet, Florida DOT (31).

Minnesota

Minnesota DOT (MnDOT) guidance on PCMS use is incorporated into the Department's work zone traffic control layout guidelines (32). Basic guidelines regarding PCMS use are summarized in a two-page appendix. Again, the content in the guidelines is similar to that available at the national level and in Texas. Unlike other states, however, MnDOT guidelines specifically indicate that a PCMS can be used as an arrowboard, as long as it meets all of the display size and other requirements of an arrowboard and is used exclusively as an arrowboard.

Additional MnDOT guidelines are included in *Guidelines for Changeable Message Sign (CMS) Use* that has been prepared by MnDOT's Office of Traffic Engineering to guide CMS use in the state's Traffic Management System (33). The guidelines address both permanent and portable signs more completely than in the work zone traffic control layout document. A series of statewide standard formats for a limited number of messages have been developed for use by MnDOT Traffic Management Center operators. However, many of these formats are for large permanent signs and do not translate easily to the limited PCMS format. The guidance does state that message information on PCMSs should be limited to the nature of the construction impact and the effect on drivers. Example impact messages such as LEFT LANE CLOSED, EXIT 167 CLOSED, etc. are illustrated. Likewise, basic driver effect message examples such as USE CAUTION, USE ALTERNATE ROUTE, and EXPECT DELAYS are also suggested.

North Carolina

The North Carolina DOT has prepared a 44-page document that summarizes its guidelines regarding the use of PCMSs and CMSs statewide (34). The guidelines include a formal policy regarding CMS use by the department, covering such topics as the types of events that are authorized for PCMS or CMS use, restrictions on the display of advertising messages, etc. As would be expected, the guidelines include many of the same basic principles that exist in the previously described documents. However, a number of additional topics are addressed, including:

- priorities when multiple messages could be shown,
- message types and formats to avoid,
- description of the various hardware components of a sign,

- sign installation and placement recommendations,
- several typical messages,
- sign maintenance schedule recommendations, and
- sign troubleshooting tips.

The list of typical messages is perhaps the most extensive of any of the state guidelines reviewed. Unfortunately, they are spread throughout the document as examples rather than consolidated in a single location for reference purposes (discussed in terms of phases describing what, where, when, who, and why), which would appear to make it more difficult to find and utilize them effectively. The guidelines also include a message documentation form very similar in style to that shown previously in [Figure 1](#).

Oregon

The Oregon DOT has recently published a set of guidelines for PCMSs (35). Similar to the FHWA handbook, these guidelines are designed as a smaller (5.5 inch by 8.5 inch) pamphlet to facilitate easy travel and use in the field. The guidelines include a basic description of a PCMS, appropriate conditions for use, restrictions of use, message selection and verification, record-keeping requirements, and sample messages.

For the most part, the guidelines are again a replication of the MUTCD guidance or information that already exists in the TxDOT Manual. One unique feature of these guidelines is that they discourage the display of actual numerals for speed (i.e., 55 mph) and instead suggest that more generic statements such as SLOW and REDUCE SPEED be used. It is not clear whether this recommendation was included to avoid potential confusion with speed display trailers that have recently become popular additions to work zones, or for other reasons.

KEY POINTS EXTRACTED FROM THE REVIEW

The review of available national and state guidance regarding PCMS applications has illustrated a number of insights that are relevant to the development of field guidance for TxDOT. A summary of these key points is as follows:

- Much of the available guidance regarding PCMS messages and applications in work zones is fairly generic, useful to engineers and others who have an understanding of traffic engineering and/or human factors principles but likely of limited usefulness to field personnel who often have to quickly make message selections in the field.
- When specific guidance is provided in the guidelines, it is typically buried within the text of the guidance documents themselves, making it difficult for field personnel to extract and apply the recommendations quickly and easily.
- Even when efforts are made to provide guidance in the field by configuring the document in a more field-friendly format (i.e., smaller size, spiral bound, laminated pages, etc.), the size and organization of the document still hinders its usefulness.
- Some of the guidance provided is not necessarily consistent with current best practice guidance on PCMS applications. One of the areas that is most often neglected is the consideration of the character space constraints on a typical PCMS (three lines, eight characters per line). It appears that field personnel could benefit tremendously by having a list of phases that illustrate exactly how words are to be displayed on what lines, what abbreviations should be used, etc.

DEVELOPMENT OF THE FIELD GUIDE

FIELD GUIDE INTENT AND CONSTRAINTS

Early on in the project, researchers and the Project Monitoring Committee decided to develop an implementation product that was easier to use than even the handbooks and other guidelines previously developed for field use. As noted in the previous chapters, even those types of publications tend to be too cumbersome for field technicians and others needing simple day-to-day guidance on what to display for a particular situation and how that information should appear on the PCMS. Ideally, the critical information should be organized to fit onto a single sheet of paper that could be glanced at quickly to locate the most appropriate phase or phases to use.

Obviously, it would be impossible to incorporate all of the possible uses of a PCMS in work zones into such a limited space. Indeed, the key advantage of a PCMS is its flexibility in the information displayed and how such information can be formatted. Therefore, the key is to identify the highest priority items to include, and organize those items in a way that maximizes both the amount of useful information that is made available to the user, as well as the ease with which that user can locate and apply the information.

FIELD GUIDE COMPONENTS

The underlying philosophy adopted by the research team in the development of the field guide was that it should be consistent with the philosophies and concepts already documented in the TxDOT Dynamic Message Sign Message Design and Display Manual (1). As noted previously, this document represents the most comprehensive and up-to-date guidance available on this topic.

The manual is developed around the concept of the base message, which represents the total amount of information elements needed for a motorist to make a fully informed driving decision in response to a particular situation. The amount of information in this base message typically exceeds the amount of information that motorists can process while driving, or which can physically be presented within the limited amount of time a motorist has to view the sign while driving. Researchers also extracted a few ideas from some of the other handbooks and guidelines available for review. For example, the idea of reminding field practitioners about the

most critical items to consider via a checklist (as was included in the FHWA handbook (23)) was adopted. A few other terms were also adopted based on input received during interviews of TxDOT field personnel. Specifically, researchers included an advance notice message element in the guide to cover the different possible formats for presenting this type of information. In actuality, this information identifies the appropriate audience for action (i.e., those motorists planning to be on the roadway on the days, dates, and times shown) and is therefore consistent with the base message concept of the TxDOT manual. However, researchers believe that the advance notice information term is simpler and more consistent with how field personnel will select and apply that type of information. Likewise, a series of general warning descriptors have been included in the guide, although they actually represent action-to-take descriptor information in terms of a base message element. In this case, researchers believe that separation of these more generic phase formats from those formats that truly provide specific actions to take helps to emphasize the use of the specific action formats.

The field guide allows for either one phase or two phases to be used in the PCMS message, consistent with MUTCD standards. A phase must always be utilized from what is termed a “problem list.” The problem list illustrates several possible phase formats that represent various possible roadwork descriptors, roadwork location descriptors, lane or ramp closure descriptors, and lane or ramp closure location descriptors. The second phase, if used, can also be selected from this initial problem list, or from a second list of phase formats that describes action to take descriptors, effect on travel descriptors, location descriptors (if the format of the first phase does not or cannot include location information), advance notice descriptors, and the general warnings.

The list of acceptable phase formats is supplemented with an applications guideline section and a checklist section. The applications guidelines section is a list of 15 bullet items that explains the proper use of the field guide, identifies appropriate terms that can be interchanged within the various phase format templates, and tells the user to consult the TxDOT manual in situations where an appropriate phase format is not represented on the field guide. On the reverse side of the guide, the checklist consists of 11 items that the user should consider and acknowledge in the phase format selection process. The last item on the checklist specifies that the user document the messages, display characteristics, and the dates and times of display in the project diary for record-keeping.

The layout and actual phase formats for the field guide can be found in the [appendix](#) of this report.

PCMS FIELD GUIDE IMPLEMENTATION CONSIDERATIONS

Researchers believe that the format and content of the field guide developed through this project can significantly improve the consistency and quality of PCMS use in work zones statewide. Based on the previously documented inventory of PCMS work zone applications in several of the districts, a large majority of signing situations observed can be accommodated through the application of the information included in this guide (19). The potential value of the guide notwithstanding, the manner and extent to which it is ultimately integrated into TxDOT's current operations will define the level of success of implementation. A discussion of implementation options between the researchers and the Project Monitoring Committee yielded a number of possible alternatives. These alternatives are summarized briefly below. It should be noted that these options are not mutually exclusive alternatives. In fact, TxDOT may be well served in following all of the proposed options.

DISSEMINATION AS A STAND-ALONE DOCUMENT TO THE DISTRICTS

Certainly, one of the most logical implementation approaches is to disseminate the field guide as is (possibly as a laminated two-sided single sheet or form) as a stand-alone document directly to district and division personnel within TxDOT. The key to effective implementation is to make the distribution as wide as possible. For instance, it may be necessary to provide enough copies to each district to allow distribution to all area office, maintenance sections, and project offices. Another option would be to adopt and convert the field guide as an official TxDOT numbered form posted on the agency's intranet site to allow direct access. At least one of the Project Monitoring Committee members indicated that it would be worthwhile placing a field guide in the cabinet of every PCMS owned by the district. Furthermore, he advocated clearing the message library in computer memory on each sign and inputting the field guide phase formats to further ensure proper implementation.

INCORPORATION INTO CURRENT TXDOT STANDARD PLANS

The Project Monitoring Committee also noted that one of the key difficulties in gaining implementation acceptance of the field guide is in finding a mechanism by which the information

can be distributed to highway contractor field personnel. It has been noted that documents such as the MUTCD, the TxDOT Manual, and even FHWA handbooks are not likely to filter down to the field technicians or project inspectors or be kept close to them on a daily basis for reference purposes. One suggestion was made to incorporate the field guide contents into the existing TxDOT Standard Plans, essentially expanding the information about PCMS use already contained in those documents. Given that essentially all contract plan sets include the standard plans in them, this approach will ensure that field personnel have a greater likelihood of exposure and access to this information.

INCORPORATION INTO PCMS SPECIAL SPECIFICATIONS

A third implementation approach identified for the guide is to incorporate it into the current PCMS specification. This approach would ensure that vendors are aware of the planned usage requirements and could physically enter the approved phase formats into the PCMS prior to delivery, similar to the list of messages that are currently called out in the specification. If such an approach would create an overly complex purchase specification from the General Services Division, another option would be to simply refer to the guide by form number (assuming the guide is converted and adopted as an official TxDOT form) within the specification itself.

INCORPORATION INTO DMS AND WORK ZONE TRAINING COURSES

A final implementation option of the field guide is to incorporate it into training course materials. For example, a DMS training course designed around the TxDOT manual (1) is currently under development. In addition, the guide could be incorporated into several of the existing work zone traffic control training courses taught by the Texas Engineering Extension Service (TEEX).

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APPENDIX: WORK ZONE PCMS FIELD GUIDE

ACCEPTABLE PHASES AND FORMATS FOR PCMS MESSAGES DURING ROADWORK ACTIVITIES				
Application Guidelines	Phase 1: Problem Lists			
	Road/Lane/Ramp Closure List		Other Problem List	
	<ul style="list-style-type: none"> Only 1 or 2 phases are to be used on a PCMS The 1st phase (or both) should be selected from the <i>Road/Lane/Ramp Closure List</i> and the <i>Other Problem List</i> (front of this sheet) A 2nd phase can be selected from the <i>Action to Take/Effect on Travel, Location, General Warning, or Advance Notice Phase Lists</i> (back of this sheet) A Location Phase is necessary only if a distance or location is not included in the first phase selected If two PCMS are used in sequence, they must be separated by a minimum of 1000 ft. Each PCMS shall be limited to two phases, and should be understandable by themselves If a phase that is needed is not shown, consult the TxDOT <i>DMS Message Design and Display Manual</i> for guidance on appropriate message content and design <p><u>Wording Alternatives:</u></p> <ul style="list-style-type: none"> The words RIGHT, LEFT, and ALL can be interchanged as appropriate Roadway designations IH, US, SH, FM, RM, and LP can be interchanged as appropriate EAST, WEST, NORTH, and SOUTH (or abbreviations E, W, N, and S) interchanged as appropriate Highway names and numbers replaced as appropriate ROAD, HIGHWAY, and FREEWAY interchanged as needed AHEAD may be used instead of distances if necessary FT and MI, and MILE interchanged as appropriate AT, BEFORE, and PAST interchanged as needed Distances or AHEAD can be eliminated from the message if a location phase is used 	FREEWAY CLOSED X MILE	FRONTAGE ROAD CLOSED	ROADWORK XX FT
ROAD CLOSED AT SH XX		SHOULDER CLOSED XX FT	FLAGGER XX FT	LANE NARROWS XX FT
ROAD CLSD AT FM XXXX		RIGHT LN CLOSED XX FT	RIGHT LN NARROWS XX FT	TWO-WAY TRAFFIC XX MILE
RIGHT X LANES CLOSED		RIGHT X LANES OPEN	MERGING TRAFFIC XX FT	CONST TRAFFIC XX FT
CENTER LANE CLOSED		DAYTIME LANE CLOSURES	LOOSE GRAVEL XX FT	UNEVEN LANES XX FT
NIGHT LANE CLOSURES		I-XX SOUTH EXIT CLOSED	DETOUR X MILE	ROUGH ROAD XX FT
VARIOUS LANES CLOSED		EXIT XXX CLOSED X MILE	ROADWORK PAST SH XX	ROADWORK NEXT FRI-SUN
EXIT RAMP CLOSED		RIGHT LN TO BE CLOSED	BUMP XX FT	US XX EXIT X MILES
MALL DRIVEWAY CLOSED		X LANES CLOSED TUE - FRI	TRAFFIC SIGNAL XX FT	LANES SHIFT
XXXXXXXX BLVD CLOSED			✓ LANES SHIFT problem phase must be used in conjunction with STAY IN LANE action to take phase on next page	

ACCEPTABLE PHASES AND FORMATS FOR PCMS MESSAGES DURING ROADWORK ACTIVITIES

Checklist	Phase 2: Possible Component Lists				
	Action to Take/Effect on Travel List		Location List	Warning List	Advance Notice List
<ul style="list-style-type: none"> ✓ Only 1 or 2 phases are used on each PCMS ✓ Each phase is displayed for at least 2 seconds ✓ Phase does not scroll across sign nor flash ✓ At least one phase is selected from the Problem Lists ✓ Correct lanes, highways, exit numbers, days, dates, and/or times are displayed ✓ Once work is within seven days, calendar dates are replaced with days of the week ✓ PCMS is visible from at least 1000 ft away ✓ If 2 PCMS are used, they are separated by at least 1000 ft and are on same side of road ✓ The PCMS should be turned off when the condition no longer applies. ✓ PCMS message, display characteristics, and dates and times of display are documented in the project diary 	MERGE RIGHT	FORM X LINES RIGHT	AT FM XXXX	SPEED LIMIT XX MPH	TUE-FRI XX AM – X PM
	DETOUR NEXT 2 EXITS	USE XXXXXXXX RD EXIT	BEFORE RAILROAD CROSSING	MAXIMUM SPEED XX MPH	APR XX-XX XPM-XAM
	USE EXIT XX	USE EXIT I-XX NORTH	NEXT X MILES	MINIMUM SPEED XX MPH	BEGINS MONDAY
	STAY ON US XX SOUTH	USE I-XX E TO I-XX N	PAST US XX EXIT	ADVISORY SPEED XX MPH	BEGINS MAY XX
	TRUCKS USE US XX N	TRUCKS USE RIGHT LN	XXXXXXX TO XXXXXXX	RIGHT LANE EXIT	MAY X-X XX PM – XX AM
	WATCH FOR TRUCKS	EXPECT DELAYS	US XX TO FM XXXX	USE CAUTION	NEXT FRI-SUN
	EXPECT MAJOR DELAYS	PREPARE TO STOP		DRIVE SAFELY	XX AM TO XX PM
	REDUCE SPEED 500 FT	END SHOULDER USE		DRIVE WITH CAUTION	NEXT TUE AUG XX
	USE OTHER ROUTES	WATCH FOR WORKERS			TONIGHT XX PM – XX AM
	STAY IN LANE				