Portable Changeable Message Sign (PCMS) Information

Cleveland/Lorain ITS Early Deployment Planning Study

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submitted to
Ohio Department of Transportation
District 12

by
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September 1996

TABLE OF CONTENTS

1. INTRODUCTION

A comprehensive Intelligent Transportation Systems (ITS) Early Deployment planning study was recently completed that identified where and how ITS technologies and methodologies could best be applied to improve the safety, efficiency, and capacity of the greater Cleveland/Lorain regional transportation network. As such, this study's final report, known as a *Strategic Deployment Plan* , recommended a series of phased actions for achieving these above goals. For example, the following items were identified for "Immediate Action":

- Continue "Road Crewzer" service patrols, and expand/adjust routes;
- Implement an education program for cellular telephone incident reporting;
- Appoint an Incident Management Task Force;
- Pursue legislative actions to eliminate legal barriers to the pushing and towing of disabled vehicles, and the efficient removal of spilled cargo;
- Plan diversion routes;
- Enhance the accuracy and timeliness of media reporting of traffic conditions;
- Purchase portable changeable message signs for use during major incidents;
- Conduct a site location study for highway advisory radio (HAR); and
- Install more closely-spaced reference markers to help callers report incidents and help response personnel locate incidents.

To more effectively achieve the anticipated results of these above deployment recommendations, ODOT commissioned a series of reports to guide the implementation of each such immediate action item. This document is one of those commissioned reports. More specifically, it is provided to answer relevant questions regarding the purchase and deployment of portable changeable message signs (PCMS) for use during major incidents.

2. PROBLEM STATEMENT

2.1 BACKGROUND

Message signs are widely used as part of many successful strategies for minimizing the impacts of incidents since they provide a means for quickly alerting motorists to problems ahead, including expected delays and/or possible alternate routes. Thus, message signs placed far enough ahead of an incident location can reduce driver frustration by empowering them with opportunities to re-route their trip around congested areas (if they so desire). With this in mind, the Cleveland/Lorain ITS Strategic Deployment Plan recommended that a series of twenty-nine permanent variable message signs (VMS) be deployed at specific locations throughout the entire Cleveland/Lorain metropolitan area.

2.2 ISSUE

In spite of these good intentions, however, the economic reality is that even though fixed-location VMS are one of the best tools for providing real-time information to motorists, they require relatively more significant capital expenditures as compared to "immediate action" items such as freeway service patrols, supplemental reference markers, and highway advisory radio. Thus, the above recommended VMS deployments were instead appropriately scheduled for implementation during a series of phases that would culminate in the mid-term time frame. Nevertheless, a need still exists for a strategy that can appropriately fill this information dissemination void until the postponed network of permanent variable message signs becomes operational.

3. SOLUTION

In response to these above needs for an interim method of disseminating real-time information to motorists, the Cleveland/Lorain ITS Early Deployment Planning Study recommends as an immediate action item the purchase of at least three portable changeable message signs (PCMS) for use throughout the areas encompassed by this study's proposed "Initial Deployment" corridors (see Table 1). More specifically, this study recommends that in the event of an incident of some magnitude, such a those lasting three to four hours or more, ODOT should have a procedure for deploying these PCMS at strategic locations around the region. Furthermore, PCMS investments can continue to provide value even after permanent VMSs have been deployed. For example, in the Cincinnati / Northern Kentucky area, PCMS will have future value as supplemental signage along arterial routes during major incidents and during significant special events that have the potential to cause long-term congestion. The following provides additional details regarding how the above can be accomplished.

Table 1. Recommended Initial Deployment Areas for a Cleveland/Lorain I.T.S.

ROUTE	FROM	TO	DISTANCE (miles)
I-71	US-42	Route end at I-90	13.6
I-77	I-480	Route end at I-90	5.8
I-90	Woodward Avenue	SR-175	19.3
I-480	0.3 mi. W of I-77	Warrensville Center Rd.	6.3
US-42	Drake Road	Route end at Public Square	17.9
		TOTAL:	62.9

3.1 Deployment Strategy

Operational / deployment strategies for various types of ITS subsystems (e.g., portable changeable message signs) are most effectively created when there first exists an underlying incident management paradigm that is independent of the particular equipment that may or may not yet be available to the various response agencies at the time that this overall philosophy is created and affirmed. This is because a philosophical basis allows implementors to see an evolutionary path for how each particular deployment will contribute to achieving the operational needs of a region's incident management plan. Furthermore, because driver acceptance of ITS is tightly linked to satisfying driver expectations of ITS (e.g., accurate information that is presented in a consistent format), operational / deployment strategies that are based upon a common paradigm will help to achieve consistently presented/implemented incident countermeasures. Thus, in order to best understand how portable changeable message signs may be utilized as an interim means for real-time information dissemination until permanent variable message signs are operational, it is appropriate to first obtain an understanding for how real-time information might be disseminated as part of a fully deployed Cleveland/Lorain ITS (e.g., one that includes permanent variable message signs and highway advisory radio, etc.).

3.1.1 Full Deployment Model

As alluded to above, the question "When does ODOT deploy a PCMS?" will be answered in Section 3.1.3, below. The reason for this is that in order to clearly understand the rationale behind this upcoming answer, it is imperative that one be familiar with the entire incident information dissemination strategy for which PCMS deployments are recommended to evolve into once a Cleveland/Lorain ITS is fully deployed. The following sections provide this understanding.

Non-recurring congestion typically results from incidents or special events of varying severity and duration. In addition, the impacts of seemingly "identical" incidents are often significantly different based upon where and when they take place. For example, a stalled vehicle during rush hour will most likely cause more congestion than a stalled vehicle at midnight. Thus, the appropriate amount of traffic management actions necessary to effectively counter non-recurring congestion should depend upon the time-of-day, day-of-week, number of lanes impacted, and "expected time to clear" specifics for a particular incident. With this in mind, Table 2 provides a sample matrix of incident level / response definitions for guiding actions to be taken by traffic operations staff in response to non-recurring congestion along monitored roadways. In fact, this particular plan is similar to one being used as part of the ARTIMIS project (Advanced Regional Traffic Interactive Management Information System), which is currently being deployed throughout much of Metropolitan Cincinnati/ Northern Kentucky.

For example, if an incident occurs between the hours of 6:00 am and 10:00 am, blocks one lane of traffic, and is expected to be cleared in less than two hours, a "Level 1" situation is

declared. This would dictate turning on VMSs within one major interchange in the direction of the incident. However, if an incident impacts a single lane between the hours of midnight and 6:00 am, it would only be considered a "Level 0" situation (i.e., no special action required) because of the limited amount traffic that is typically on the roads during the overnight period. Additional examples are as follows:

- If an incident occurs between the hours of 10:00 am and 3:00 pm, blocks one lanes of traffic, and is expected to take greater than four hours to clear, then a "Level 2" situation exists. This would dictate turning on all VMSs within two interchanges of the incident.
- If an incident occurs between the hours of 3:00 pm and 7:00 pm, blocks more than two lanes of traffic, and is expected to take between 0.5 and two hours to clear, then a "Level 4" situation exists. This would dictate activating all VMSs in the direction of the incident.

Please note, however, that these are only guidelines. The shift supervisor is always authorized to dictate higher response levels in support of public safety agency requests, and/or if past experience deems it necessary.

Table 2. Sample Incident Level / Response Definitions (Full Deployment)

			Lanes Impacted/Action Level			
Time of Day	**Estimated Duration**	0 Lanes	1 Lane	2 Lanes	>2 Lanes	
0000 - 0600	< 2 hours	0	0	1*	3*	
	2 - 4 hours	0	0	2*	3*	
	> 4 hours	0	0	2*	3*	
0600 - 1000	< .5 hours	1	1	2	3	
	.5 - 2 hours	1	1	2	4	
	> 2 hours	1	2	3	4	
1000 - 1500	< 2 hours	1	1	2	3	
	2 - 4 hours	1	1	2	3	
	> 4 hours	1	2	3	3	
1500 - 1900	< .5 hours	1	1	2	3	
	.5 - 2 hours	1	1	2	4	
	> 2 hours	1	2	3	4	
1900 - 2400	< 2 hours	0	0	1*	3*	
	2 - 4 hours	0	0	2*	3*	
	> 4 hours	0	0	2*	3*	
Level 0	No special action required					
Level 1	Implement Response Plan to notify appropriate PSAs					
	Turn on Level 1 CMS and HAR					
Level 2	Implement Response Plan to notify appropriate PSAs					
	Turn on Level 2 CMS and HAR					
	Turn HAR flashing lights on at level 2					
Level 3	Implement Response Plan to notify appropriate PSAs					
	Turn on Level 3 CMS and HAR					
	Turn HAR flashing lights on at level 3					
	Provide Advisory Alternate Routing					
Level 4	Implement Response Plan to notify appropriate PSAs					
	Turn on Level 4 (and above) CMS and HAR					
	Turn HAR flashing lights on at level 4 Provide Mandatory Alternate Routing					
Level n CMS	n = number of decison points prior to the incident corridor					
Level n HAR	n = number of times the related advisory is repeated in a HAR cycle (e.g. within a 3 minute cycle)					
Level n*	* = notification of operations personnel may be required to implement outside normal duty hours					

3.1.2 Information Dissemination Locations

To apply this philosophy to the Cleveland/Lorain ITS, it is first necessary to define a series of driver decision points so that real-time information concerning incidents occurring along any included corridor can be appropriately disseminated as per the incident level / response definitions of Table 2. To facilitate this process, the recommended locations for permanent variable message signs as per the Cleveland/Lorain ITS Early Deployment Planning Study's Strategic Deployment Plan were coupled with information regarding major freeway junctions and potential access points to possible alternate routes. In the end, fifteen major driver decision point interchanges for trips into and out of the "Initial Deployment Area" of a Cleveland/Lorain ITS were defined (see Table 3). Figure 1 illustrates these driver decision points such that upstream corridors will become the information dissemination locations for incidents occurring downstream of these driver decision points.

Table 3. Major Driver Decision Points

DECISION POINT	DESCRIPTION
A	I-71 and US-42 in Middleburg Heights
B	I-71 and I-480
C	I-71 and US-42 in Cleveland
D	I-71 and SR-176F (Jennings Freeway)
E	I-71 and I-90 / I-490
F	I-77 and I-480
G	I-77 and I-490
H	I-77 and I-90
I	I-90 and West 117th Street
J	I-90 and US-42 (Pearl Road)
K	I-90 and SR-2 (Cleveland Memorial Shoreway)
L	I-90 and East 72nd Street
M	I-480 and SR-176F (Jennings Freeway)
N	US-20 and West 117th Street
O	US-20 / SR-2 and US-42 (Pearl Road)

For example, if a "Level 1" incident occurs on northbound I-77 between I-490 and I-90, then the following permanent variable message signs should be activated (see Figure 2):

- Northbound I-77, upstream of the I-490 interchange
- Eastbound I-490, upstream of the I-77 interchange

Similarly, if a "Level 2" incident occurs on northbound I-77 between I-490 and I-90, then the following permanent variable message signs should be activated in addition to the above-mentioned "Level 1" VMS (see Figure 3):

- Northbound I-77, upstream of the I-480 interchange
- Eastbound I-480, upstream of the I-77 interchange
- Westbound I-480, upstream of the I-77 interchange

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REPLACE THIS PAGE WITH FIGURE 1
"MAJOR DRIVER DECISION POINTS"
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REPLACE THIS PAGE WITH FIGURE 2 / FIGURE 3
“ACTIVATED VMS...”
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3.1.3 Portable CMS Deployment Example

With the preceding sections providing a viable strategy for activating permanent variable message signs, it now becomes possible to adapt this philosophy for the deployment of portable changeable message signs (PCMS). In fact, as manifested in Table 4, there are only three major differences that are necessary for this adaptation:

1. A decrease in the number of response levels to either a "Level 1" (e.g., "Code Yellow") or a "Level 2" (e.g., "Code Red") because of the limited number of PCMS that will be available for deployment;
2. An increase in the corresponding action thresholds associated with each of these levels because of the reality that incidents must be of an extremely significant nature to warrant the dispatching of agency personnel to manually deploy each PCMS from a centralized storage area to their appropriate information dissemination locations; and
3. A changing of the "Number of Lanes Impacted" criteria to a "Percent of Lanes Impacted" criteria to better account for differing cross-sections on the included routes.

Table 4. Recommended Incident Level / Response Definitions (PCMS Deployment)

Time of Day	Estimated Incident Duration	Percent of Lanes Impacted (example) / Action Code			
		25% (1 of 4 lanes)	50% (1 of 2 lanes) (2 of 4 lanes) (3 of 6 lanes)	75% (3 of 4 lanes)	100% (2 of 2 lanes) (4 of 4 lanes) (6 of 6 lanes)
0000 - 0600	0 - 3 hrs.	--	--	--	--
	3 - 4 hrs.	--	--	--	--
	4 - 5 hrs.	--	--	--	--
	5 - 6 hrs.	--	--	--	*Yellow*
	> 6 hrs.	--	*Yellow*	*Yellow*	**RED**
0600 - 1000	0 - 3 hrs.	--	--	--	--
	3- 4 hrs.	--	--	--	*Yellow*
	4 - 5 hrs.	--	*Yellow*	*Yellow*	*Yellow*
	5 - 6 hrs.	--	*Yellow*	**RED**	**RED**
	> 6 hrs.	*Yellow*	**RED**	**RED**	**RED**
1000 - 1500	0 - 3 hrs.	--	--	--	--
	3 - 4 hrs.	--	--	--	--
	4 - 5 hrs.	--	--	--	*Yellow*
	5 - 6 hrs.	--	*Yellow*	*Yellow*	*Yellow*
	> 6 hrs.	--	**RED**	**RED**	**RED**
1500 -	0 - 3 hrs.	--	--	--	--

1900					
	3 - 4 hrs.	--	--	--	*Yellow*
	4 - 5 hrs.	--	*Yellow*	*Yellow*	*Yellow*
	5 - 6 hrs.	--	*Yellow*	**RED**	**RED**
	> 6 hrs.	*Yellow*	**RED**	**RED**	**RED**
1900 - 2400	0 - 3 hrs.	--		--	--
	3 - 4 hrs.	--		--	--
	4 - 5 hrs.	--		--	--
	5 - 6 hrs.	--		--	*Yellow*
	> 6 hrs.	--	*Yellow*	*Yellow*	**RED**

For example, if a 4:30 pm incident blocks all lanes of traffic along northbound I-77 between I-490 and I-90, a "Code Yellow" (i.e. "Level 1") response plan would be initiated if this incident was expected to last between three and five hours (see Figure 2), and a "Code RED" (i.e. "Level 2") response would be initiated if this incident was expected to last longer than five hours (see Figure 3). However, if this incident was expected to last for less than three hours, then no "codes" would be applicable and no response action would be taken (i.e. "Level 0").

Please note that these modifications still conform to the overall information dissemination philosophy that is recommended to be used once permanent variable message signs have been deployed. This can therefore enable drivers to maintain a consistency of expectations of where and when advisory messages might be disseminated for various types of incidents such that when the Cleveland/Lorain ITS' network of permanent VMSs becomes operational, the public's "learning curve" of how to best utilize this information can be shortened; resulting in potentially greater public acceptance of ITS and its associated transportation management strategies.

3.2 Operations

As a corollary to what was just mentioned in the above paragraph, utmost care must be taken to ensure that the information provided to motorists is accurate, reliable, and easily understood; otherwise, the signs will simply be ignored by the motorists. Furthermore, maintaining the credibility of the signs in the public's mind is of paramount importance if the signs are to be effective in reducing congestion, enhancing safety on the freeways, and providing further justification for full deployment of a network of permanent VMS throughout the entire Cleveland/Lorain metropolitan area. To this end, the following summarizes how ODOT should develop and disseminate credible PCMS messages.

3.2.1 Message Composition

Several human factors issues, including target value, legibility distance, and viewing comfort are important considerations in the use of portable changeable message signs.

Target value represents the distance from which a motorists notices a sign, whereas legibility is the distance from which they can read the sign. The discomfort caused by glare or harsh light describes the viewing comfort experienced by a driver. In addition, the number of words in a message is limited by the time available for reading a sign, which is further determined by vehicle speed and legibility distance. Finally, the legibility of a message on a sign is also determined by the transverse location of the sign; that is, the relationship between the particular lane in which a driver is located, and the location of a PCMS (i.e., in the median of a roadway, or on its right shoulder or left shoulder, etc.).

With this in mind, the following guidelines are offered:

- Generally, it is assumed that drivers require an average reading time of 1.0 seconds per word. Although, this time can be reduced when familiar terms are used to form easily recognizable phrases or when messages are for local drivers familiar with an area.
- Alternatively, messages longer than about six words could overload drivers and therefore may not be desirable. For example, an eight-word message (about four to eight characters per word) excluding prepositions such as "TO", "FOR", "AT", etc., approaches the processing limits of drivers traveling at high speeds.
- An exception to the above guideline might be when multi-frame messages are provided. However, these may only be appropriate during daytime peak hours or during other periods of heavy congestion because they are typically the only situations when drivers have extra time to read these messages due to the slower operating speeds of traffic moving under these circumstances.

For further details regarding relevant research results associated with changeable message signs and the selection and design of CMS messages, please refer to the following reports which are available from the National Technical Information Service:

- Dudek, C.L. "Guidelines on the Use and Operation of Changeable Message Signs." Report #FHWA/TX-92/1232-9. November 1992.
- Dudek, C.L. "Guidelines on the Selection and Design of Messages for Changeable Message Signs." Report #FHWA/TX-92/1232-10. November 1992.

Irrespective of the actual message chosen, though, the basic guideline is that higher speed traffic requires shorter messages for effective communication via portable changeable message signs. It should also be mentioned that since ODOT has frequently utilized PCMSs during long-term construction projects, existing ODOT message guidelines should be taken into consideration when developing appropriate PCMS messages for managing long-term incidents as defined within the context of this report.

3.2.2 Message Library

Cognizant of the above message composition requirements and associated needs to facilitate the timely dissemination of appropriately worded messages, it is appropriate that

a global message library containing all messages for all PCMSs be maintained on a central computer server at the agency responsible for the PCMSs. Individual message libraries, or sub-libraries, that are subsets of the global library should also be maintained for handling messages that may only be applicable to the unique needs of specific PCMS locations. As such, the central computer server should reference library entries via indexes into the library; should have the capability to add, modify, and delete library information on PCMSs, including modifying individual library entries or replacing entire libraries; and should have entries tagged with size, date, and checksum information so that a central computer server can verify library version information.

3.2.3 Message Dissemination

When a Traffic Manager confirms the existence of a long-term incident of sufficient magnitude to require PCMS deployment to appropriate locations as per Section 2.1, above, the PCMS software should be able to utilize operator inputs of this information and links with the above message libraries so that it can suggest PCMS messages to display. If confirmed by the Traffic Manager, then the messages can be immediately sent via cellular telephone to the appropriate PCMSs.

However, in the event a suggested message is inappropriate, the Traffic Manager should be able to interact with the PCMS software to compose a limited-scope ad hoc message that is based upon combinations of existing pre-approved words and phrases in the above PCMS library. Nevertheless, all such messages created by Traffic Managers should require supervisor approval via password verification before they are sent any PCMSs. Finally, in the event that the PCMS message library does not contain the appropriate key words or phrases to create limited-scope ad hoc messages, it should be possible for a PCMS message to be composed free hand. However, this mode of message composition should only be available to the appropriate agency supervisor via special password verification. Any other attempts to access this capability by non-authorized personnel should be rejected.

3.3 Procurement

Section 631.15 and Section 731.03 of ODOT's Construction and Material Specifications manual provide current specifications for changeable message signs. To supplement this information, Appendix A (see attached) has been provided such that it includes a set of sample specifications for portable changeable message signs utilized as part of ITS projects.

4. DISCUSSION

The following subsections discuss relevant issues associated with current implementations of portable changeable message signs, and lessons learned/recommendation-type issues that may be of benefit to those planning future implementations of portable changeable message signs.

4.1 Communications

As indicated by their name, portable changeable message signs are mobile. Thus, any communications link that would limit their use to fixed locations, such as would be the case if communications were provided via traditional land-line telephone service, should be completely avoided. Similarly, since PCMSs as used in the context of this report are for mitigating long-term incident/emergency situations, which often require messages to be changed multiple times during any given incident/emergency situation, information dissemination cannot be dependent on manual methods that require on-site data loading into each PCMS (as is often the case when PCMSs are utilized on construction projects). To alleviate this dilemma, some type of wireless communications link becomes critically necessary in order to achieve both efficient and effective incident management-related PCMS deployments.

Traditional cellular technologies have been the most convenient way for agencies to communicate with remote portable changeable message signs. However, when a major incident happens, significantly increased demand for cellular voice circuits may make it difficult, if not impossible, to initiate communications with agency PCMSs. For example, during a recent major incident on the I-75 corridor in Kentucky, agency access to cellular-controlled PCMSs was denied when motorists, who were stuck along the interstate due to a bridge closing, saturated the area's cellular voice circuits while trying to obtain incident and alternate route information. Thus, to help avoid a similar situation in the future, it is recommended that the Cleveland/Lorain ITS communicate with their PCMSs via available Cellular Digital Packet Data (CDPD) service, which utilizes short/bursty-type cellular data transfers that are not in conflict with cellular voice circuits.

4.2 Number of PCMS

The Cleveland/Lorain ITS Strategic Deployment Plan recommends as an immediate action item the purchase of three PCMS (cost, approximately $45,000 each) for utilization as per the guidance of this document. However, as illustrated in Figure 3 and discussed in Section 2.1.3, above, three PCMSs may not be enough to provide adequate coverage for disseminating appropriate information to drivers regarding significant downstream incidents. For example, in the Figure 3 scenario (assuming two signs have already been deployed as per the Figure 2 scenario), it may be difficult to determine where to place the only remaining PCMS if an upstream decision point has more than one "input" roadway. As detailed in this example (see Figure 3), the following questions logically arise:

- Should northbound I-77 receive the remaining PCMS since it is the route number on which the incident occurred?
- Should eastbound or westbound I-480 receive the remaining PCMS since it may be carrying significant traffic that is about to turn north into the congestion; thus contributing to further incident-related congestion at the blockage point?

Therefore, to help avoid this dilemma, it is recommended that at least five PCMS be purchased as an immediate action item. Especially, since these PCMS will still have significant usable value even after a network of permanent variable message signs have been installed throughout the entire Cleveland/Lorain metropolitan area (see Section 2.1).

4.3 Lateral Placement

Appropriate judgment should be utilized when placing PCMSs such that they do not block a roadway shoulder that could end up being one of the only routes for emergency response vehicles to take into or out of an incident area if traffic backs-up to beyond the location of the PCMS. Thus, whenever possible, it is recommended that PCMSs be placed entirely within a freeway median or within the grassy portion alongside a freeway's outer shoulder.

4.4 Longitudinal Placement

Based upon research results on the design and use of changeable message signs, including published reports from the Federal Highway Administration and the Arizona Department of Transportation, the following criteria for site specific placements of changeable message signs have been generally adopted:

1. The minimum spacing between a PCMS and other guide signs not co-located with the PCMS should not be less than 1000' (one-thousand) feet.
2. A PCMS should be located no less than 4000' (four-thousand) feet from a potential diversion exit.
3. A PCMS located upstream of a freeway interchange should not be used for messages requiring diversion at an exit beyond the interchange.

Since these criteria are consistent with Section 7G-8.1 of the Ohio Manual of Uniform Traffic Control Devices, which states that portable changeable message signs "...should be located approximately 3/4 mile in advance of a...point of required action", it is thus recommended that these above principles be utilized to guide the longitudinal placement of all PCMS to be deployed within the context of this report.

5. SUMMARY / CONCLUSIONS

As has been documented in the appropriate sections of this report, portable changeable message signs (PCMS) can help to fill the information dissemination void that will exist during long-term incidents until such time that a network of permanent variable message signs (VMS) can be deployed as part of a full-scale Cleveland/Lorain ITS. However, it is cautioned that any interim use of PCMSs be consistent with recommended long-term strategies for incident dissemination via permanent VMSs. This will enable drivers to maintain their experience-based expectations of where and when advisory messages might be disseminated for various types of incidents; thus, shortening the long-term "learning curve" of how to best utilize this information for improving the overall efficiency and enjoyment of their trip-making experience. Nevertheless, agencies that are considering to utilize portable changeable message signs in the manner described in this report should feel confident that their efforts/investments can achieve positive results.

6. APPENDIX A. Draft PCMS Specification

DRAFT SPECIFICATION

FOR

PORTABLE CHANGEABLE MESSAGE SIGNS (PCMS)

SECTION 1.0

PORTABLE CHANGEABLE MESSAGE SIGNS (PCMS)

1.1 DESCRIPTION OF EQUIPMENT

- This specification describes a trailer-mounted, portable sign upon which varying, electronically generated lamp messages will be displayed to highway traffic as advisories or for the purposes of warning and/or control.

- The signs shall be solar powered and shall have a trailer mounted changeable message board consisting of a light emitting diode (LED) lamp matrix panel powered by a bank of batteries in order to convey bright, distinctive messages to the traveling public. The batteries shall be recharged automatically by a group of solar panels located at the highest point on the unit. The solar powered variable message sign shall be designed with sufficient energy backup to operate for a period of 21 (twenty-one) days without any sunlight. The signs shall be remotely controlled through a cellular phone system utilizing Cellular Digital Packet Data (CDPD) type transmissions.

- The solar powered changeable message sign (PCMS) described herein shall be a standard model produced by a manufacturer with experience in the production of trailer-mounted traffic control products. All workmanship, materials and assembly procedures shall be of quality design. Each component of the complete unit shall be adequate for and compatible with all structural and performance requirements of the complete unit. The equipment shall remain operational under inclement weather conditions.

- The **CONTRACTOR** shall furnish and test each PCMS to the satisfaction of the Engineer as indicated in Section 1.7 of the Specifications.

- The **CONTRACTOR** shall deliver the accepted PCMS to the Cleveland/Lorain ITS Operations Control Center (OCC) in Metropolitan Cleveland, Ohio. The signs shall become the property of the Ohio Department of Transportation (ODOT).

1.2 CONSTRUCTION REQUIREMENTS

1.2.1 General

The trailer and all mounted equipment shall be structurally adequate for unlimited, normal operation in wind velocities normally encountered on high speed roadways. The equipment shall be designed to enable one

person to perform all transporting and operating functions easily and effectively without assistance. Except where otherwise specified herein, all exterior surfaces of the trailer and all mounted equipment shall be painted with an appropriate highway orange colored paint.

1.2.2 Trailer

The two-wheel trailer shall be structurally adequate to serve both as a carrier and as an operating platform for all components of the complete unit. The base structure shall be fabricated from structural rectangular steel tubing of sufficient dimension and thickness to provide and adequate foundation for the unit. The tongue shall safely handle a 6,000 (six-thousand) pound load. All tubing shall be joined by welding and all structural welds shall be continuous bead welds. All tubing ends shall be closed.

Axle and suspension systems shall be rated at 3,500 (three-thousand five-hundred) pounds minimum. Wheels and tires shall be a minimum of 15" (fifteen) inches, 4 (four) ply and shall be rated for towing at highway speeds of 65 (sixty-five) miles per hour. A steel fender of 11 (eleven) gauge (minimum) steel shall be installed over each wheel. The overall width of the trailer shall not exceed 96 inches.

Each trailer shall be equipped with a hydraulic brake actuator system and a two-inch, ball type coupler. The braking system and coupler shall be designed for a 6,000 (six-thousand) pound maximum load. Double safety chains shall be provided for use when the unit is being towed.

Four crank type, heavy duty, industrial leveling jacks, one at each corner of the trailer deck, shall be installed. A swing jack shall be provided to support the tongue when the unit is parked. The swing jack shall have a capacity of 2,000 (two-thousand) pounds and provide for a minimum of 15" (fifteen) inches travel.

A lighting system shall be provided for the trailer to include tail lights, stop lights, turn signals, license plate light and reflectors. A trailer electrical cable and connector compatible with towing vehicles shall be installed. To eliminate internal tubing installation chaffing, all wiring shall be routed and clamped underneath the structural tubing.

1.2.3 Message Sign

The sign panel shall be of aluminum construction and so assembled to prevent dissimilar metal action from occurring. The sign panel array frame shall be a welded assembly made of 0.250″ (minimum) aluminum alloy angle or channel.

The length of the solar powered changeable message sign panel shall not exceed 128" (one-hundred twenty-eight) inches. The front face of the sign shall be covered with clear, ultraviolet inhibited lexan to prevent fading.

The sign panel message background shall be flat black in color. The sign panel shall be designed so that external light reflection is minimized. The solar powered changeable message sign shall contain three (3) separate lines. Each line shall consist of eight (8) characters, equally spaced a minimum of 3" (three) inches apart. Each character shall be a minimum of 18" (eighteen) inches in height and of sufficient width to be clearly visible for a minimum distance of 900' (nine-hundred) feet on a normal sunlit day. Each character shall be formed from LED lamp pixels in a minimum five-element horizontal by seven-element vertical arrangement. Line spacing shall be a minimum of 6" (six) inches. Message color shall be approximately 590 (five-hundred ninety) nanometers.

The sign shall have capability to display up to 6 (six) messages in sequence with variable timing in 500 (five-hundred) millisecond (maximum) increments under computer control. The entire sign shall completely change all lines of message copy in not more than 500 (five-hundred) milliseconds.

The sign shall be clearly visible and legible from a distance of 900' (nine-hundred) feet under both day and night conditions. Under variable light level conditions the sign shall automatically adjust its light source so as to meet the 900' (nine-hundred) feet visibility requirements without being too dim or intense.

The sign panel shall be supported on a telescoping upright member in a manner to permit raising the sign for operation and lowering the sign for transport. The upright shall include a device to enable 360 (three-hundred sixty) degree rotation of the sign panel and shall lock into the position to which it is manually rotated. Raise and lower travel shall nominally be 4' (four) feet and shall be accomplished by an electrically operated motor/pump/valve hydraulic power pack. The hydraulic power pack shall be equipped for manual operation in the event of failure of the electrically operated system. The bottom of the sign shall be at least 7' (seven) feet above the ground when in the raised position. In the transport position, the sign shall orient to the longitudinal axis of the trailer in a manner that effectively reduces aerodynamic drag during towing.

1.3 POWER AND MISCELLANEOUS REQUIRED EQUIPMENT

The solar powered changeable message sign (PCMS) shall be designed for reliable operation from 12 (twelve) volt DC power over an ambient temperature range of minus twenty-five (-25) degrees Celsius (-13 degrees F) to plus fifty (+50) degrees Celsius (+122 degrees F). The electrical and electronic components within the sign and the control system shall be designed for reliable operation in a 95% (ninety-five) percent relative humidity, noncondensing environment.

The solar powered changeable message sign (PCMS) shall be designed to operate from either of 2 (two) power supplies at the option of the operator.

The first power supply shall be a battery bank consisting of deep cycle, lead acid, batteries. The battery bank shall be housed in lockable heavy duty weatherproof battery boxes fabricated from 11 (eleven) gauge (minimum) steel. The batteries shall normally be recharged by a solar panel array producing a minimum of 424 (four-hundred twenty-four) watts of power. There shall be a separate, built-in battery charger with a minimum 30 ampere per hour rating for recharging the batteries from a 120 (one-hundred twenty) volt, AC power source.

The second power supply shall be 120 (one-hundred twenty) volt commercial electrical service.

The components and electrical circuitry required for using these two power sources shall be enclosed in an appropriate protective housing.

1.4 SYSTEM CONTROL REQUIREMENTS

The PCMS shall be controlled in all functions by an on-board dedicated computer which shall:

a) Be of solid state design and be removable.
b) Include a keyboard through which user originated messages may be entered for display or storage.
c) Include a liquid crystal display (LCD) screen upon which messages can be reviewed before display on the message sign.
d) Store a minimum of 200 (two-hundred) preprogrammed messages in static RAM for display when called upon by an operator through the keyboard or the CCS in the OCC.
e) Store a minimum of 50 (fifty) user originated messages in static RAM.
f) Store a minimum of 25 (twenty-five) message sequences in static RAM.
g) Maintain a stored message list in static RAM.
h) Provide a minimum 3 (three) year memory backup for the contents of the static RAM.
i) Provide password coding or key entry.
j) Provide control programming to present sequenced messages under operator control through keyboard entry.
k) Provide control for moving arrow displays.

The computer and power control unit shall be housed in a weather resistant, shock resistant lockable control box which shall include a light for night operation. The power control unit shall contain two current meters, one to show the amperage generated with the battery charger operating and the other current meter to reflect the amperage generated from the solar panels to be stored in the battery bank. The power control unit shall also incorporate a series regulator with thermal compensation for variances in ambient temperature to regulate the charge rate to the battery bank. A low voltage disconnect shall be provided to disconnect from the solar panel at 11.2 (eleven point two) volts DC (minimum).

The PCMS shall incorporate an automatic intensity control feature to keep the LED lamp matrix intensity constant with a reduction in voltage. This allows the message to remain visible at a distance of 900' (nine-hundred) feet any time the unit is operational. The solar powered variable message sign shall also have a photocell to reduce the lamp intensity at night thereby reducing glare.

1.5 SOFTWARE

- In addition to the software normally supplied with the PCMS, the software shall have the capacity and be compatible with control from the Central Computer System (CCS) located in the Operations Control Center (OCC) for the Cleveland/Lorain ITS project.

- The communications between the PCMS and the CCS shall be by cellular phone using modems for interfacing as necessary.

- Using the CCS software, the CCS shall be capable of monitoring the status of each PCMS.

- In case of any malfunctions of the PCMS, the OCC software shall record such incident in the log file and a computer printout will be generated.

- If the PCMS indicates that a change has occurred, the CCS will request additional information form the PCMS (e.g., return current message, return current library).

- The PCMS software shall provide the capability to transfer portions of, or the entire library file to the CCS upon request.

- The PCMS software shall support automatic DST (Daylight Savings Time) implementation from the CCS.

- The PCMS shall provide the CCS an internal status record to include (but not limited to) the following:

    1) Current Mode (LOCAL, REMOTE)
    2) Current Time
    3) Current Message Type (static, sequence)
    4) Current Message (library index)

- The PCMS shall accept requests from the CCS to display messages from the library given the message index. Accept and display a message directly from the CCS.

- The CCS software shall prompt the PCMS to display static, alternating and flashing messages.

- The PCMS software shall support CCS requests to modify the internal library by replacing/deleting existing messages or adding additional messages.

2.6 CELLULAR TELEPHONE AND EXTERNAL COMMUNICATIONS

- This communication option shall allow the operator to have remote control of the on-board computer with the use of a cellular telephone/interface communications unit.

- Remote control shall be accomplished by using computer base station operation. This shall allow the operator to do any and all programming remotely which can be done when present at the unit. A cellular telephone unit and all software necessary for proper operation shall be provided with each sign.

- Interfaces with the PCMS and CCS shall utilize RS-232 and RJ-11 connectors.

- The Cellular Modem and antenna shall be as specified as follows and shall be included with the PCMS.

  - Locations that are not on the backbone fiber optic network and are not near any telephone service shall make use of spread spectrum modems to provide connectivity to a location with phone service or fiber optic interface. Spread spectrum modems shall not require FCC licensing for use on this project.

  - Spread Spectrum Modems shall have the following characteristics:

a)	Operating Frequency	902 - 928 MHz
b)	Modulation	Spread Spectrum: BPSK
c)	Spreading Code	Direct Sequence
d)	System Gain	125 dB
e)	RF Connector	"N" - type (female)
f)	Data Connector	RS-232: DB 25 (female)
g)	Transmitter Max Power Output	28 dBm
h)	Frequency Stability	10 ppm
i)	Frequency Source	Synthesized
j)	Bandwidth	5.0 MHz
k)	Unfaded BER	<109**(-10)
l)	Sensitivity	-97 dBm @ 10**(-6) BER
m)	Power	110 or 220 VAC
n)	Certifications	FCC Part 15

1.7 TESTING

Each PCMS shall be tested to show as a minimum:

1) Manual control by an operator.
2) Remote control by the CCS.
3) Selectability of messages.
4) Software capability as outlined in Section 1.5.
5) Solar power operation.
6) Operation with 120 (one-hundred twenty) VAC service.
7) Maneuverability of sign on the trailer.

8) Seven (7) day endurance test with several messages including a sequencing arrow message.
9) Visibility of messages as outlined in Section 1.2.3.
10) A daytime demonstration shall be required. A nighttime demonstration may be required if deemed necessary by the Engineer. A determination of acceptability will be made within 30 (thirty) days after all required information is received. The Engineer's decision concerning acceptability of all units will be final.

1.8 DOCUMENTATION

The **CONTRACTOR** shall furnish the following items at the time the signs are delivered to the Engineer. All items listed shall be furnished with each sign.

a) Three (3) operations manuals.
b) Three (3) parts books listing standard electronic parts numbers as well as manufacturer's stock number, if used .
c) Three (3) service manuals including schematic wiring.

1.9 WARRANTY

The PCMS shall be warranted for a period of 2 (two) years or until _____, whichever is greater. The warranty period shall begin on the date of acceptance by the Engineer.

Batteries shall be heavy duty and warranted for at least a 5 (five) year life.

1.10 METHOD OF MEASUREMENT

Portable changeable message signs (PCMS) shall be measured as a complete unit including solar equipment, cellular modem, antenna, and all equipment specified, furnished to the location specified, tested and accepted.

1.11 BASIS OF PAYMENT

Payment will be made at the contract unit price bid for each PCMS and shall be full compensation for all labor, materials, tools, equipment and incidentals necessary to furnish the item tested and accepted.