STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

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GOVERNOR		ACTING SECRETARY

July 15, 1999

MEMORANDUM TO: Division Engineers

FROM: J. D. Goins, PE
Chief Engineer - Operations

SUBJECT: Amended North Carolina Department of Transportation
Policy for the Use of Changeable Message Signs

Attached, please find the amended Policy for the Use of Changeable Message Signs. This policy was established in July 1995 to provide guidelines for use of portable and stationary changeable message signs that resulted in the signs having a high level of credibility with the public. The Department desires to display pertinent and accurate messages concerning traffic and travel conditions on North Carolina Transportation Systems, which assists motorists in their driving decisions.

The Departments receives requests from various public groups for access or to display messages on Department owned stationary changeable message signs. The current list outlined in section IV. Display of Messages on Stationary Signs covers most requests. However, some requests made in the three major regions Charlotte - Gastonia, Winston-Salem – High Point - Greensboro, and the Raleigh – Durham metropolitan areas are not covered especially those pertaining to air quality red alerts. In areas where other modes of transportation are available to reduce congestion on our highways, the public must be provided with traffic and travel conditions that may alter their decision to drive and allow them to choose another mode of transportation such as carpooling or the use of transit. The policy was amended to include a priority five (5) under section IV. Display of Messages on Stationary Changeable Message Signs. The intent of this amendment is to provide other public information, which assists the Department in improving safety and reducing congestion.

The Traffic Engineering and Safety System Branch is currently revising the operational guidelines for the Use of Changeable Messages Signs that was developed as a companion to the policy. A library of standard messages to be included in all future specifications to be pre-programmed in stationary changeable message signs is also under development. You will be given an opportunity to assist in the compilation and review the revised guidelines and library of

standard messages before they are finalized. If additional information is needed, please contact Ann Lorscheider or Cheryl Evans of the Traffic Engineering and Safety System Branch at (919)-250-4151.

JDG/cle
cc-

Mr. L. A. Sanderson, PE, w/atta.
Mr. D. A. Allsbrook, Jr., PE (attn: Mr. Roberto Canales, PE, w/atta.)
Mr. J. M. Lynch, PE (attn: Ms. Terry Hopkins, PE, w/atta.)
Mr. Max Tate, PE, (attn: Mr. Brad Hibbs, PE, w/atta.
Ms. Janet D'Ignazio w/atta.
Mr. Sanford Cross, w/atta.
Mr. Patrick Simmons, w/atta.
Division Operation Engineers, w/atta.

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
POLICY FOR THE USE OF CHANGEABLE MESSAGE SIGNS

I.   POLICY STATEMENT

This policy provides specific guidelines for the use of stationary and portable changeable message signs (CMS) used on the North Carolina highway system. Messages displayed shall convey pertinent information to motorists, which assists in their driving decisions. Messages shall be conveyed in a standard, nonconfusing manner that allows drivers to both perceive and react to the information given in a timely fashion.

II. PURPOSE

CMS can be used to effectively reduce congestion caused by planned or unplanned incidents such as excessive daily traffic, accidents, detours, construction delays, special events, etc. Once a driver population has gained confidence that messages are reliable and relay pertinent information that assists in reducing delays, CMS can be used to convey information to alter traffic patterns or modes of transportation.

III. AUTHORIZATION

The Division Engineer will authorize the use of all CMS both state owned and Contractor furnished. Each CMS shall have a person designated by the Division Engineer to be responsible for the authorization of messages to be displayed and for the care, maintenance, and security of the CMS. This person may delegate certain responsibilities in regard to the CMS but should ensure that any personnel given access to the CMS understands and adheres to this policy. Access to the CMS shall only be given to responsible individuals. The Division Engineer will ensure that efforts are coordinated such that motorists are informed of the most critical information based on the priority of messages listed below.

IV. DISPLAY OF MESSAGES ON STATIONARY CMS

Messages shall be displayed on stationary CMS in accordance with the below listed priorities. When a stationary CMS is not being used to display one of the below listed message types, it shall remain blank.

Types of messages conveyed on stationary CMS have the following priority:

1. Emergencies such as evacuations or closures required by the NCDOT, the Department of Emergency Management, local law enforcement or the military.
2. Hazardous and/or uncommon road conditions which require motorists to alter their driving such as severe weather conditions, accidents, or work zone activities.
3. Traveler information and suggested alternate routes for delays and/or congestion caused by planned or unplanned incidents.
4. Advance notice for scheduled incidents such as lane closures, road closures, or special events.

5. Other public information which assists the Department in improving highway safety and reducing congestion may be displayed after careful consideration. However, the message must require motorists to alter their driving and direct approval by the Division Engineer must be received prior to displaying the message.

CMS shall not display messages that in any way advertise commercial events or entities. CMS shall only display messages, which pertain to highway safety or congestion reduction. CMS shall not be used to convey the same message for an extended period of time. CMS shall not repeat guide sign or warning sign messages.

V. DISPLAY OF MESSAGES ON PORTABLE CMS

Messages shall be displayed on portable CMS in accordance with the below listed priorities. When the portable CMS is not being used to display one of the below listed message types, it shall remain blank.

Types of messages conveyed on portable CMS have the following priority:

1. Emergencies such as evacuations or closures required by the NCDOT, the Department of Emergency Management, local law enforcement, or the military.
2. Hazardous and/or uncommon road conditions which require motorists to alter their driving such as severe weather conditions, accidents, or work zone activities.
3. Short term detours (mandatory) for a partial audience for which no other signing is in place.
4. Traveler information and suggested alternate routes for delays and/or congestion caused by planned or unplanned incidents.
5. Advance notice for scheduled incidents such as lane closures, road closures, or special events.
6. Other public information which assists the Department in improving highway safety and reducing congestion may be displayed after careful consideration. However, the message must require motorists to alter their driving and direct approval by the Division Engineer must be received prior to displaying the message.

CMS shall not display messages that in any way advertise commercial events or entities. CMS shall only display messages, which pertain to highway safety or congestion reduction. CMS should not be used to convey a message for an extended period of time that could be conveyed with a conventional warning sign.

Approved: _____ Date: ___7/15/99___
                    (Signature)

Chief Engineer - Operations

Revised 7/14/99

OPERATIONAL GUIDELINES FOR THE USE OF CHANGEABLE MESSAGE SIGNS

SECTION I

1. INTRODUCTION

In July, 1995, a formal policy was adopted by the North Carolina Department of Transportation, outlining the use of changeable message signs (CMS), both permanent and portable. Following is a brief clarification of the sections of this policy as they apply to portable signs. It should be reinforced that these operational procedures shall not supersede the policy.

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CMS <u>shall not</u> display messages that in any way advertise commercial events or entities. CMS shall only display messages which pertain to highway safety or congestion reduction. CMS shall not be used to convey the same message for an extended period of time. CMS shall not repeat guide sign or warning sign messages.

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6.   Other public information which assists the Department in improving highway safety and reducing congestion may be displayed after careful consideration. However, the message must require motorists to alter their driving and direct approval by the Division Engineer must be received prior to displaying the message.

CMS <u>shall not</u> display messages that in any way advertise commercial events or entities. CMS shall only display messages which pertain to highway safety or congestion reduction. CMS should not be used to convey a message for an extended period of time that could be conveyed with a conventional warning sign.

Approved:_____Larry R. Goode_____ Date:___7-11-95___
                          (Signature)

_____State Highway Administrator_____
                          (Title)
(This is a reproduction of the original signed policy)

1.1 POLICY

Sections I. (Statement) and II. (Purpose) both suggest that CMS must relay pertinent information to the motorists. Numerous human-factor studies conducted nationwide prove that motorists disregard CMS which have displayed unimportant or erroneous messages in the past. It is important to gain drivers' confidence in the accuracy of the messages displayed. This is obtained by consistently relaying real-time information.

Section III. (Authorization) states that the Division Engineer has the ultimate authority over all CMS. He will most likely delegate this authority to responsible persons. It should be noted that numerous persons may be delegated access to programming CMS. In addition to DOT personnel, other persons, such as contractors may be allowed access to program NCDOT's CMS. Everyone with this access should understand the priority of messages to be placed and should contact the responsible party if another message is overridden. As situations change, the person(s) designated to program signs may be changed by the Division Engineer.

Section V. discusses the display of messages on portable CMS. The types of messages to be relayed on these CMS are ranked in order of importance to the motorists. If more than one situation is occurring, of which the motorists need to be informed, the below listed priority list shall be used to determine which message to display. When a CMS is not being used to display one of the below listed message types, it shall remain blank.

1. EMERGENCY - These are unplanned events where extreme traffic diversions are required. Examples:
- the Department of Emergency Management conducting a hurricane, nuclear or haz/mat evacuation;
- the military requiring road closure for major troop/equipment transport;
- closure of facility due to accident involving damaged structure or toxic spill.

I-85 CLOSED	EXIT 21 TO US 74
ISLAND CLOSED	EVAC. ROUTE US 64

In the event of such an emergency, another agency would most likely be in command of the situation and may direct specific use of CMS but in all likelihood would rely on NCDOT for locating and programming signs and developing the exact wording of messages.

2. HAZARDOUS CONDITIONS - The majority of information relevant to the motorists would fall into this category, therefore it is extremely important for all parties to cooperate and ensure that motorists are receiving the most important information at any particular time. Examples:
   - extreme weather such as ice, snow, fog, flooding, rockslide, etc.;
   - unusual roadway conditions for the roadway type such as lane shifts, rough pavement or narrow lanes on a freeway due to construction or maintenance;
   - lane/shoulder closures or blockages;
   - accident and/or emergency vehicles in a lane or on the shoulder;
   - workers or construction equipment in close proximity to an open travelway;
   - severe congestion causing reduced speeds.

RIGHT LANE CLOSED	1/2 MILE
RIGHT LANE CLOSED	VEHICLE ON SHLD
LEFT LANE CLOSED	WORKERS NEXT 2 MILES
LEFT LANE CLOSED	TRUCKS ENTERING
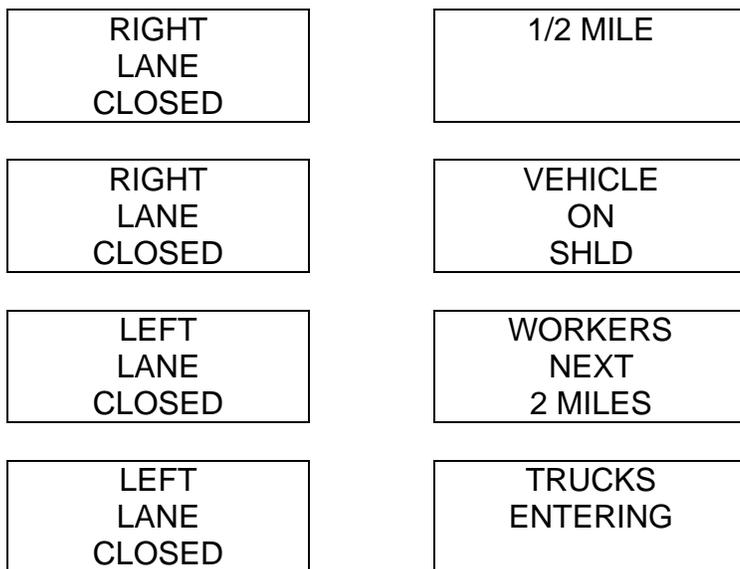
3. SHORT TERM DETOUR - If detours are planned to be in place for more than a week, plans should be made to use conventional detour signing. As with any message on a CMS, it will loose its effectiveness if it is not changed frequently, because motorists will cease reading the CMS even when a new, pertinent message is displayed. If the detour was not planned, the CMS should be used as an alternate to conventional signing; however, if the detour is expected to remain in place for more than a month, conventional signs should be ordered as soon as possible. Examples:

   - detour for specific audience such as over-width vehicles which cannot traverse a construction zone with barriers;
   - overnight ramp closure for which no detour is given since it is assumed that motorists know alternate routes;
   - temporary weight restriction due to maintenance of structure.

WIDE LOAD EXIT 44 TO NC 19/23	TYVOLA RAMP CLOSED

4. TRAVELER INFORMATION - By giving the motorists as much information as possible about real-time traffic conditions, it is assumed that the individual motorists will make intelligent decisions as to how to avoid congestion and delays. In order for motorists to react to this type of information they must trust that it is accurate or they will not change their route or time of travel. Examples:

- expected delay; allow motorists to determine their alternate route;
- suggested alternate route(s);
- combination of the above;
- suggested routes to a large traffic generator
- alternate modes of transportation available (van-pool, carpool, transit or the HOV lanes on Independence Blvd. in Charlotte).
- preventative actions

20 MIN DELAY ON I-40/85	ALT. US 70

CONGESTED THRU GRAHAM

AVOID RUSH HOUR 5 - 6 PM	CARPOOL

GAME TRAFFIC	LEFT LANES
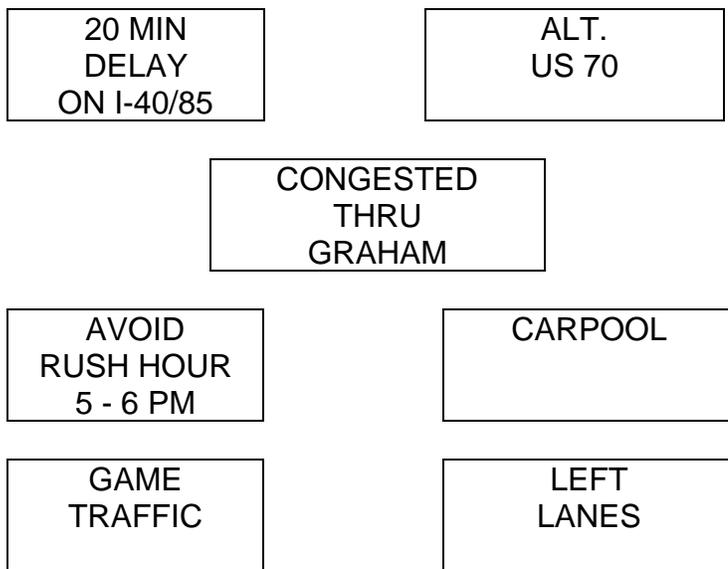
5. ADVANCE NOTICE - If a planned event/ incident is expected to occur, motorists should be warned ahead of time to avoid that area during the event. Examples:

- large, traffic-generating sports event;
- scheduled lane closure with a heavy traffic impact;

HEAVY TRAFFIC SUN 1 - 4	PLAN AHEAD

LANE CLOSURES 7PM - 6AM	or	MAJOR CONSTR THIS WKND
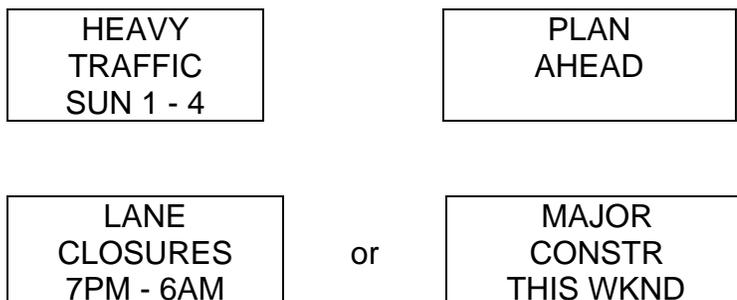
6. PUBLIC INFORMATION PERTINENT TO HIGHWAY SAFETY - This type of message requires an action by drivers and <u>shall only be displayed with the Division Engineer's approval</u>. Example:

- License, DUI, seat-belt or weight check by law enforcement officials.

LICENSE CHECK AHEAD	or	OPERATION SPEED WATCH

1.2 APPLICATIONS OF PORTABLE MESSAGE SIGNS

The primary purpose of CMS is to advise the driver of unexpected traffic and routing situations. Their most frequent use is on high density roadways, but they have applications on all types of streets and highways.

Examples of effective CMS uses include:
* accident and incident management;
* providing advance notice of ramp, lane or roadway closures;
* where significant traffic delays are expected;
* where speed of traffic is expected to drop substantially;
* new detours;
* changes to detours;
* where adverse environmental conditions are present;
* advance notice of construction activity;
* where there are changes in alignment or surface conditions.

1.3 MESSAGE PRIORITY

1.3.1 Multiple Messages

It may be necessary to relay multiple pieces of information to motorists. This can be accomplished with some creative message design. For instance, if a segment of I-95 is closed due to an overhead bridge which has partially collapsed, it will definitely qualify as a priority 1 message situation. If, at the same time, the truck that hit the bridge is on fire and billowing smoke onto the alternate route, US 301, it will qualify as a priority 2 message situation. In the following example, three panels are used to emphasize to the motorists that a critical decision needs to be made prior to Exit 89.

I-95 CLOSED EXIT 89	EXPECT HEAVY SMOKE	DETOUR EXIT 89

Note that three panels were used to convey the message. Three panels should only be used if there is no reasonable way to convey the critical information in two panels. The third panel may be removed to increase readability.

If the fire was not part of the scenario a better sequence would be:

I-95 CLOSED EXIT 89		DETOUR EXIT 89 TO US 301

1.3.2 Special Highway Safety Messages

Portable CMS may be used to display messages "which assist the Department in improving highway safety and reducing congestion." Examples of this type of message include advance notification of checkpoints, since the slowed traffic is an abnormal traffic condition or workzone awareness campaign messages, such as:

STAY ALERT	THE LIFE YOU SAVE	MAY BE YOUR OWN

The policy states that "CMS shall not display messages that in any way advertise commercial events or entities", that "CMS shall only display messages which pertain to highway safety or congestion reduction". Special use of CMS may be requested by State Highway Administration or Public Affairs, but messages must still conform to policy and special messages must be approved by Division Engineer.

1.4 MESSAGE TYPES TO AVOID

The policy also states message types which shall not be displayed.

1. CMS shall not display messages that in any way advertise commercial events or entities.

An example of a **message not to display** is:

BUDWEISER CLASSIC		USE EXIT 147

A **better message** is:

GOLF TRAFFIC		USE EXIT 147

Although the same information is relayed, no names are used. This awareness will prevent businesses from being able to accuse the NCDOT of advertising their competitors.

Special attention should be given in avoiding the placement of advertisements in advance notification messages. The following is a message warning motorists of expected heavy traffic due to a planned athletic event. The NCDOT cannot be accused of advertising the event or any of its teams since this message does not include names.

| HEAVY
TRAFFIC
SUN. 1-4 | | USE ALT.
ROUTE
US 52 |

Multiple messages may have to be conveyed to motorists. Therefore, the sign programmer must decide what information must be omitted, due to limited space. For further information on message design see Chapter 5.

2. CMS should not be used to convey a message for an extended period of time that could be conveyed with a conventional warning or guide sign. A classic example of this is **ROAD/ WORK/ AHEAD**. Stock piles of standard signs are maintained by Division forces or can be fabricated and should be used in situations which necessitate the conveyance of a standard message for an extended period of time.

1.5 APPLICATION OF PERMANENT MESSAGE SIGNS

Typically, permanent message signs are used on high density roadways to advise the driver of unexpected traffic conditions and routing situations. Effective CMS uses include the same parameters as portable message signs as indicated above.

Upper-case lettering of a minimum height of 12 inches shall be used to display all messages. Lower-case lettering can be used for names of places, streets, and highways provided that the initial letter is upper-case; however, displaying the entire message in upper-case letters is preferable. The font shall be single stroke only because double stroke fonts have a shorter legibility distance.

1.6 MAINTENANCE

When maintenance procedures are required, it is not necessary to close any lanes to access the sign. Maintenance personnel shall park their vehicles, including a bucket truck, on the right shoulder of the roadway. Personnel can be lifted to the catwalk to gain access to the inside of the sign.

1.7 MESSAGE PRIORITY

1.7.1 Multiple Messages

It may be necessary to relay multiple pieces of information to motorists. This can be accomplished with some creative message design. For instance, if a segment of I-95 is closed due to an overturned truck carrying a hazardous material, it will definitely qualify as a priority 1 message situation. If, at the same time, the truck that overturned is on fire and billowing smoke onto the alternate route, US 301, it will qualify as a priority 2 message situation. In the following example, three panels are used to emphasize to the motorists that a critical decision needs to be made prior to Exit 89.

| I-95
CLOSED
EXIT 89 | | EXPECT
HEAVY
SMOKE | | DETOUR
EXIT 89 |

Note that three panels were used to convey the message. Three panels should only be used if there is no reasonable way to convey the critical information in two panels. The third panel may be removed to increase readability.

If the fire was not part of the scenario a better sequence would be:

I-95 CLOSED EXIT 89		DETOUR EXIT 89 TO US 301

1.7.2 Message Override Based on Priority

Numerous persons may have access to a CMS and authority to place messages on the CMS. These agencies and individuals include Division Incident Management personnel, Division Construction staff, Maintenance staff, contractors, city Traffic Engineering staff, and possibly law enforcement or Emergency Management staff. Any individual and/or agency with these privileges shall be aware of and adhere to the policy. Most Divisions have procedures (written or unwritten) for placement of messages on CMS by any person other than the one individual delegated the responsibility for the sign from the Division Engineer. If one individual or agency wants to replace an existing message being displayed on a CMS with another, it shall only be replaced with a message of higher priority, for example, the message I-85 CLOSED, which is most likely a priority 1 emergency message, would never be replaced with WORK ZONE STAY ALERT, which is a priority 6 Public Information message. The standard procedure in most areas of the state is that persons wanting to display a message should verbally inform the one person responsible for that CMS. That individual physically enters or changes the message, if appropriate, or verbally authorizes the requesting individual to reprogram the CMS.

Common sense and courtesy dictate that if an individual or agency replaces an existing message on a CMS:
- The message shall be the most pertinent information to the majority of motorist (highest priority - as mandated by the policy),
- the person responsible for the sign shall be informed as soon as possible (in many areas the Division, policy states that the one individual is to be informed prior to placement), and
- if an individual replaces another's message, they inform that person that the motorists are no longer receiving the original message and why it was changed.

SECTION II

2. HARDWARE

There are numerous CMS types and manufacturers. It is important to read the owner's manual specific to your particular sign. This chapter is merely a brief description of the components which make up a CMS.

NOTE: STATIONARY MODE

CONTROL CABINET

COMPUTER SCREEN

COMPUTER KEYBOARD

CONTROL CABINET

CELLULAR PHONE PORT

MODEM

SERIAL PORT

LAPTOP LOCATION

SWITCH   KEY
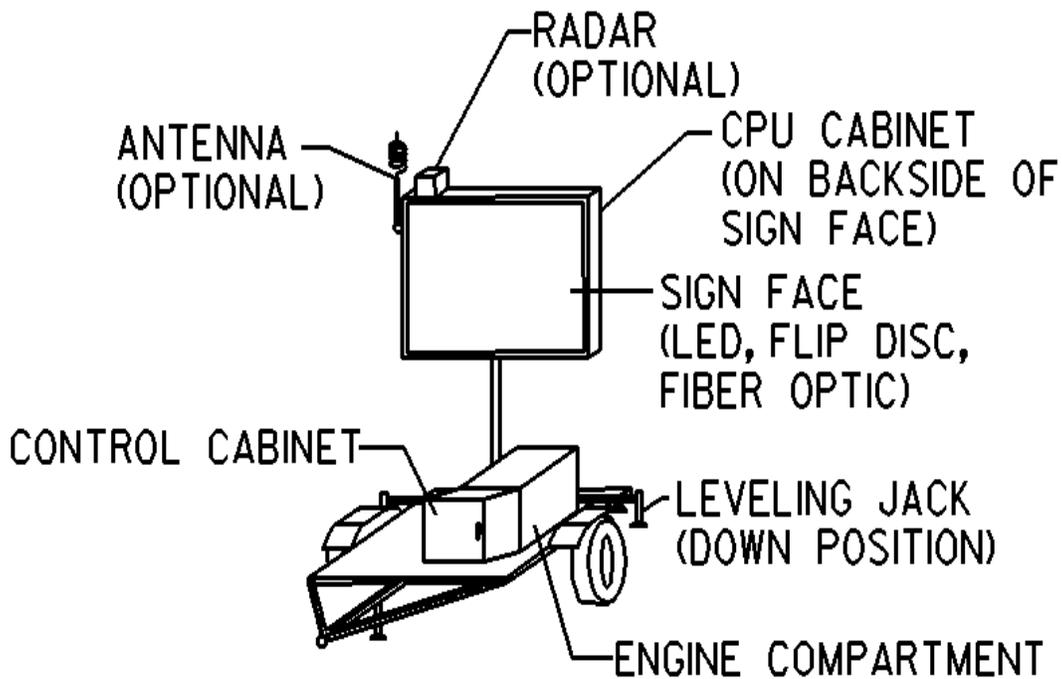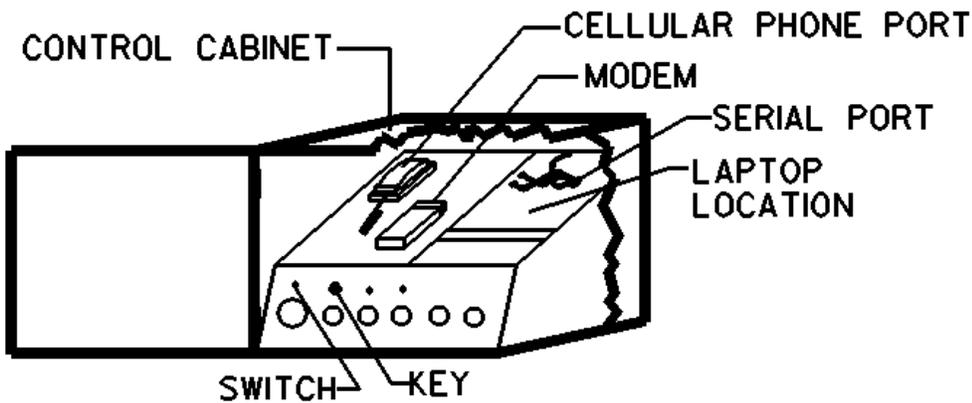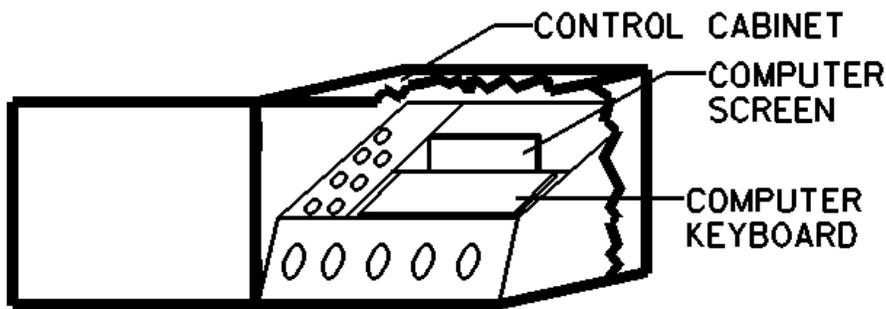
2.1 COMPONENTS

2.1.1 Trailer

Once the sign is in the correct position for optimum viewing by oncoming traffic, the trailer should be disconnected from the towing vehicle, and then leveled with the use of the leveling jacks. The trailer shall be yellow or orange to increase its visibility. Proper equipment should be available for towing. The trailer has pins which must be inserted manually to lock the CMS into either transport or viewing position. The mechanism for raising and lowering the sign to its correct height also has pins which must be inserted manually to lock the sign face into position. The sign should never be transported in its raised position since its high center of gravity would cause it to be unstable.

2.1.2 Control Cabinet

Operations at the sign are performed from the control cabinet located at the front of the trailer. It contains a shelf which holds the computer, switches and gauges. (On some models, the shelf hinges up out of the way for access to the control cabinet wiring, relays, fuses and other electronics). Most CMS models cannot operate without the computer in place therefore they should be kept with the sign or in close proximity.

2.1.3 Central Processing Unit (CPU) Board

The CPU board, along with capacitors, terminal blocks and connectors to the board, is located in the compartment on the rear of the sign board. The CPU board and control cabinet contain all of the electronic circuitry necessary to operate the sign. This board communicates with the computer in the control cabinet and translates the signal into the actual display shown on the sign face.

2.1.4 Sign Face

The message sign panel can vary in size and may consist of one, two or three lines. It can be thought of as a very simple, very large monitor for the computer contained within. High-density urban freeways typically use three lines of eight or nine characters per line. The sign face must be able to automatically dim according to the change of light of its surrounding. Sign faces on the market today include the following:

- Flip-Disc - rectangular or circular leaves or flaps with one side reflective yellow and the other side black. These flaps independently expose or cover various fluorescent painted light-reflective surfaces in order to form the desired alpha-numeric character. The major benefit of a flip disc type of sign is its ability to default to a pre-programmed message as it suffers a power failure. Advantages are low power requirements, excellent tolerance to environment, and proven technology. Disadvantages are sun glare, fading of disks, and nighttime visibility.

- L.E.D.(Light Emitting Diode) - a cluster of solid state diodes are mounted in a socket which makes up a pixel. Advantages are low maintenance and long life due to no moving parts. Disadvantages are sensitivity to heat and humidity, required cooling in cabinet, small viewing angle. Many colors are available although visibility of certain colors such as green is low.

- Fiber Optic - a bundle of fiber optic cables are fastened to a lens at the face of the sign to create a dot (pixel). Typically, the light source is a single 50-watt tungsten bulb for every three characters and a second bulb for bright conditions, fog and also as a backup. Advantages are fiber optic's high visibility: however, the disadvantages are the small cone of vision (therefore not legible at close range) and the high maintenance cost due to short life span of bulb.

- Hybrid (Flip disc and L.E.D.) a standard flip disk with a small hole containing either a fiber optic bundle or a cluster of LEDs. Advantages are high visibility, ability to operate if light source fails and default to a given message if power fails. Disadvantages are sun fading, and maintenance of disks.

Only the first two types of sign panels are used by the NCDOT for portable cms. These two types are the only ones which meet NCDOT specifications. Other types may be allowed if they prove to perform equally. See the NCDOT Standard Specifications for further clarification.

2.1.5 Power Plant

The sign must have a source of power. Many signs on the market can have alternative sources of power added on.

2.1.5.1 Generator

Generator powered systems run on batteries that are continuously charged by the diesel fueled generator when it is running.

2.1.5.2 Solar Panel

Solar panels act as generators on solar powered systems. The energy received through the solar panels is stored in eight large batteries seated on the trailer of the CMS. This type of CMS is capable of operating independently of sun for 30 days with 2.5 hours of good sun required for each additional day operation.

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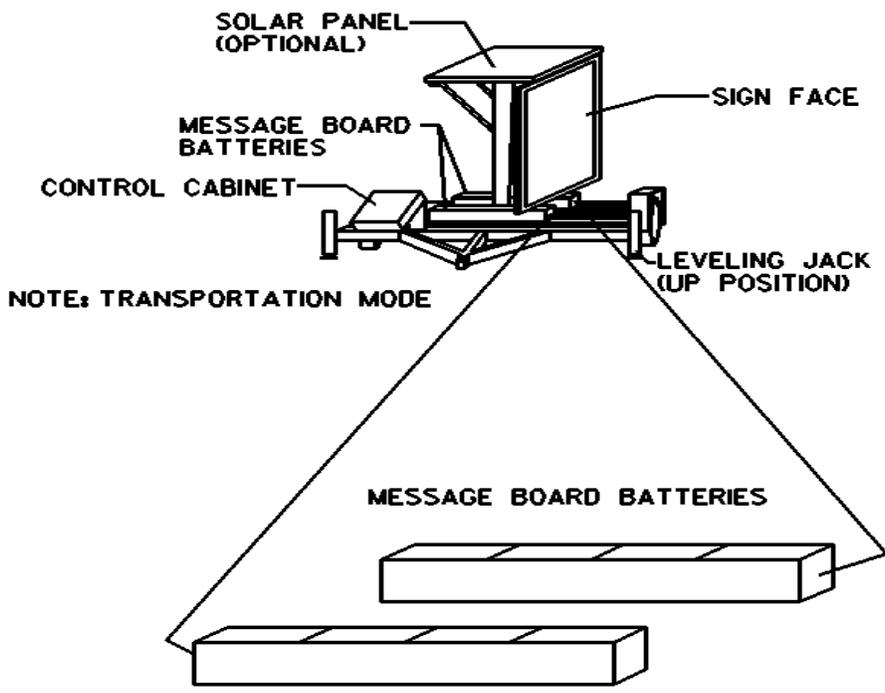
2.1.5.3 Line Power

The line power option allows the CMS to run on existing commercial electrical service. For extended operation in a single location, the sign may be powered from a line feed. Refer to the operation manual for specific requirements for line feed connection for a specific CMS. Line power will reduce the vibration from the generator and maintenance problems, such as unseated connections, caused by this vibration.

2.1.6 Warning

The warning option allows for the warning of engine start and low battery/engine failure. The engine start warning buzzer sounds before the engine start occurs. If a CMS does not include an alarm/buzzer, a warning label shall be placed on the compartment. The low battery/engine failure indicators flash when the sign battery reaches a low state and either the engine fails to start, or the sign cannot start the generator because the generator mode has been set to manual.

2.2 OPTIONS

2.2.1 Radar

The Federal Communications Commission (FCC) requires that unattended radar devices be capable of transmitting and receiving a radar signal and that the return signal be able to count vehicles or trigger some type of speed display.   The FCC regulates radar emitting devices and requires that they conform to certain design and performance specifications. The radar option allows the sign to display a selected message whenever a vehicle exceeds a preset speed. Prior to setting the speed at which the preset message will be displayed, an average speed should be determined.   The **floating car method** can be used to determine the average speed of the facility. To perform this method, a driver simply drives at a speed which allows him to pass one vehicle for every vehicle that passes him.

The radar option cannot report the actual speed of a vehicle. CMS operators should be cautioned to monitor motorists' reaction to speed triggered messages. Motorists with radar detectors have been known to react hostilely to this option. The radar system can be easily disabled manually or by way of the computer.

2.2.2 Cellular or Phone Drop

The sign can be equipped with either a cellular phone or a permanent phone line, if it is to remain in a fixed position for a extensive period of time. The phone option allows all computer operations to be performed remotely. When used properly, a sign with a phone connection can have its maintenance and operations status checked periodically from a remote location. Some sign models can be programmed to call the office or a beeper when it requires certain maintenance operations. The modem required for the sign should not be confused with the modem in the remote location computer. For further explanation of that modem see Chapter 6.

3. SIGN PLACEMENT AND INSTALLATION

3.1 SIGHT DISTANCE

The signs should be visible from 1/2 mile under ideal day and night conditions. Each sign message should be legible from all lanes, at a distance of 1000' according to the NCDOT Standard Specifications, although research indicates that many drivers cannot read a sign at a distance greater than 650'. In the field, the cms should be sited and aligned to optimize visibility.

3.2 HORIZONTAL & VERTICAL ALIGNMENT

cms should not be placed in sags or just beyond crests. cms should be level and angled approximately three degrees away from perpendicular to the travelway to minimize glare. The signs, if facing either the East or West, should be checked at sunrise and sunset to ensure that their reflection of the sun does not blind motorists.

3.3 DELINEATION AND POSITIVE PROTECTION

Where possible, cms should be placed behind existing rigid or semi-rigid protection (barrier or guardrail).   This will help to avoid potential injury to errant motorists, while simultaneously aiding in the protection of this valuable equipment. When cms are required for long terms in locations where no protection exists, temporary guardrail or barrier should be considered.

Where positive protection is not feasible cms should be delineated with drums. If a CMS is placed on a 10' shoulder, a shoulder closure should be installed. If a CMS is placed adjacent to a 4' shoulder, it should be delineated with a minimum of three drums. If possible, cms should not be placed closer than 6' or farther than 20' from the edge of the travelway. A sign placed closer than 6' from the edge of the travelway becomes an obstruction which causes a reduction in traffic flow. A sign placed farther than 20' from the edge of the travelway becomes unreadable for many motorists.

3.4 PLACEMENT

Placement in advance of the temporary traffic control zone or incident should, as much as possible, take into account the following factors:

- cms will typically be placed in advance of any other temporary traffic signing and should not replace or duplicate any required warning or guide signing.

- Where used for route diversion, cms should be placed far enough in advance of the intersection or interchange to allow traffic ample opportunity to exit the affected highway. CMS should not be placed within an interchange since motorists' attention is on weaving traffic.

- Visual clutter should be avoided when placing cms.

- CMS should be placed in advance of predicted queues (backups).

- CMS should be placed in locations accessible by maintenance vehicles

- cms are normally placed on the right shoulder of the roadway.

- When two signs are needed to communicate multiple messages, they should be placed on the same side of the roadway, separated by at least 1000 feet.

- The sign should be turned three degrees away from perpendicular to the travelway to reduce glare.

- The sign shall be installed such that it has a 7' minimum vertical clearance to reduce glare, enhance sight distance and increase visibility.

- The sign should be leveled with the use of the leveling jacks which support most of the weight of the sign. When leveling a sign on wet or soggy ground, use 2"x2'x2' blocks to balance the sign.

4. SECURITY

4.1 PASSWORD AND PHONE SECURITY

Phone numbers of a CMS should only be given to persons authorized to program them. Any person, so authorized, should have a clear understanding of the priority of message types and their responsibility to cooperate with all other parties who may require the CMS to relay information to the motorists. When programming a CMS remotely from a car, with a laptop and cellular phone, the programmer should make all attempts to keep the phone and computer equipment out of the sight of passing motorists. Phone numbers can be easily "cell scanned" at the moment of transmission, so it is important to never let a potential "hacker" see you initiate a call. We do not want it public knowledge that signs can be accessed via a phone. It is good practice to disconnect cellular transmission after quickly verifying the messages being displayed by the CMS, since phone numbers can also be scanned if your cellular transmission switches cells.

Passwords should only be given to authorized individuals. Passwords should be changed regularly or upon a change to the personnel authorized to program the CMS. If a scheme is used to determine the monthly password, the scheme should be changed when authorized personnel is changed. This is especially important in the case of a disgruntled employee.

4.2 PHYSICAL SECURITY

Ensure all locks are sturdy and never leave any door open for even a moment. Chain and lock trailer to a fixed object if possible. If the CMS is to be left for a long term its trailer wheels should be removed. When the controller door is open, block it with your body so that passing motorists can not see the internal components of this compartment. Blocking this door also helps the operator decrease glare on the screen. Be sure to close the door when checking the message on the sign face; again, to ensure that passing motorists are not aware of cabinet's contents.

5. MESSAGE DEVELOPMENT

5.1 COMPONENTS OF A MESSAGE

When designing a message sequence, enough information needs to be given to the motorists to spur them to make a decision. If this is not done, the message may be ignored. The message can be broken down into the 5 W's (what, where, when, who and why). All of these components are not necessarily needed for each and every message. They may often be implied.

5.1.1 What? (and How?) - What action is required by the motorist?

This is the instruction you want motorists to follow. It could be to reduce speed, divert to a specific route, begin to merge, etc. The motorists will tend to ignore a simple WHAT statement unless they are also given a HOW. Motorists need to have as much information as possible so they can make an informed decision.

The WHAT component of a message may be implied. The following future event message is an example:

```
┌──────────────────┐
│      HEAVY       │
│     TRAFFIC      │
│     SUN 1-4      │
└──────────────────┘
```

This message gives the motorists a WHY and WHEN, but it implies that they need to plan to be elsewhere at that time. If the driver population is very familiar with an area, a WHY and WHERE may be given as:

```
┌──────────────────┐
│     TYVOLA       │
│      LOOP        │
│     CLOSED       │
└──────────────────┘
```

This implies that motorists must find an alternate route to Tyvola.

The WHAT component is the most important piece of information given which will affect drivers' decisions. They must be clear, comprehensible and recognizable.

```
┌──────────────────┐     ┌──────────────────┐
│     DETOUR       │     │      ROAD        │
│    EXIT 189      │     │     CLOSED       │
│    (WHAT)        │     │     (WHY)        │
└──────────────────┘     └──────────────────┘
```

WHATs include MERGE RIGHT, MERGE LEFT, KEEP RIGHT, KEEP LEFT, PREPARE TO STOP, REDUCE SPEED, DO NOT PASS, STAY IN LANE, SLOW TO xxMPH, STAY IN VEHICLE, TUNE RADIO 530 AM, EXIT 1 MILE, FOLLOW DETOUR, FOLLOW ALT ROUTE, etc..

5.1.2 Where? - Where is the decision point at which motorists must take an action?

a) When giving a location, only use major points of reference such as exit numbers. Do not use overpass or underpass names.

b) When the majority of motorists are interstate travelers who are not familiar with the names of local cross-street, locations should be described in distances to the nearest 1/2 mile.

c) If the majority of motorists are local, use the local street names. Most urban drivers are more familiar with street names than route numbers or SR numbers.

d) AHEAD is not a WHERE; it's a filler word. When giving notice of an incident, lane closure or heavy congestion, give an actual distance instead of using the word AHEAD. This will give the driver a point of reference and the opportunity to divert based on his knowledge of the area.

WHERE includes xxMILES AHEAD, AT MOREHEAD ST., NEAR (LANDMARK), EXITS xx TO xx, etc..

5.1.3 When? - When will an event occur for which a drivers should change their actions?

For future events, give specific data for its traffic disruption only if it is certain to occur. An example is a major, traffic-generating sports event. Do not make the message specific if real time information cannot be kept current. Type of message is usually required to be combined with a WHERE. The cms will lose their credibility if they advertise traffic conditions which never occur.

An example of a **message not to display** is:

The road may not open as planned. WHEN can be a date, time, holiday, WKND, etc..

5.1.4 Who? - If only a partial audience is required to take an action, who are they?

a) Over-width vehicles.

b) Motorists with a particular destination; such as in a secondary road or ramp closure detour situation.

c) Traffic in route to a specific event such as:

| GAME | LEFT |
| TRAFFIC | LANES |

Note that the word TRAFFIC can usually be deleted. WHO includes ALL TRAF, CARS, TRUCKS, BUSES, WIDELOADS, EMER VEH \ ONLY, (ROUTE NO) with a direction, LOCAL \ TRAFFIC, etc..

5.1.5 Why? - Additional information to assist and/or spur motorists' decision making.

This is the carrot to entice motorists to make a change to their driving and follow the message instruction. The following are examples:

AVOID
20 MIN
DELAY

USE
US 64
TO BEACH

REDUCE
SPEED

WATER
ON
ROAD

Without the why statements, the motorists will most likely ignore the instruction, but with the additional information, they will make an informed decision. WHY includes LEFT LANE CLOSED, RIGHT LANE CLOSED, RAMP CLOSED, xx MILE BACKUP, xx MIN DELAY, SLOW TRAFFIC, RT SHOULDER CLOSED, CHAINS REQ'D, EXPECT DELAYS, etc..

5.2 VERBIAGE AND DISPLAY OF A MESSAGE

5.2.1 Word usage

Avoid filler words such as AHEAD or CAUTION. Both of these words can be implied in most instances. Drivers will realize that if you are giving a warning you are also advising caution. They will also assume that they would only be advised of situations ahead of them. The word, TRAFFIC, when addressing a specific audience, can usually be deleted as well. Instead of two panels displaying GAME / TRAFFIC | USE / LEFT / LANES, a single panel displaying GAME / LEFT / LANES is sufficient.

When using more than one panel, repeat key words. Do not use both LEFT and RIGHT in same sequence, such as RIGHT LANE CLOSED / MERGE LEFT. Unalert drivers will scramble the message.

Use standard abbreviations familiar to the driver population. Express Lanes, for instance, are unfamiliar to North Carolina motorists, so the message THRU / TRAFFIC | USE / EXPRESS / LANE would only confuse the motorists.

5.2.2 Flash rate

Slowly flashing the problem statement (the WHY or WHAT) should attract attention. Do not flash a large portion of text. Do not flash at a fast interval rate. It will distract the motorist and decrease the message's legibility.

5.2.3 Flip rate and number of message panels

The 1993 Revision to Part VI of the MUTCD states:

> *"Messages should be designed taking into account the following factors:*
> - *No more than two displays should be used within a message cycle.*
> - *Each display should convey a single thought.*

- *Messages should be as brief as possible.*
- *When abbreviations are used they should be easily understood.*
- *The entire message cycle should be readable at least twice at the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.*
- *Messages shall not scroll horizontally or vertically across the face of the sign."*

If more than one panel is used, the message programmer should read the message, using each panel as the first, to ensure that motorists will not misinterpret them.

To clarify the importance of minimizing the number of message panels, the following charts and diagram are included for reference.

Φ=10° (ANGLE NOT TO SCALE)

AC = LEGIBILITY DISTANCE
AB = READABLE DISTANCE
BC = UNREADABLE DISTANCE
(DISTANCES PROPORTIONS ARE APPROXIMATE)

FORMULAS:
UNREADABLE DISTANCE = [S+(N-0.33)*L+0.5*W]*5.67
    WHERE S = DISTANCE FROM THE SIDE OF THE
              ROAD TO THE VMS IN FEET
          N = NUMBER OF LANES
          L = WIDTH OF THE LANES IN FEET
          W = WIDTH OF THE VMS IN FEET
READABLE DISTANCE = LEGIBILITY DISTANCE - UNREADABLE DISTANCE
READABLE TIME = READABLE DISTANCE
                TRAVEL SPEED

Reading time of a CMS, assuming it first becomes legible at **650 ft**.

Distance of CMS from edge of travelway	4 lanes at 65 MPH (95 ft/s)	3 lanes at 65 MPH (95 ft/s)	2 lanes at 65 MPH (95 ft/s)	4 lanes at 55 MPH (81 ft/s)	3 lanes at 55 MPH (81 ft/s)	2 lanes at 55 MPH (81 ft/s)	3 lanes at 45 MPH (66 ft/s)	2 lanes at 45 MPH (66 ft/s)
(ft.)	(sec.)	(sec.)	(sec)	(sec.)	(sec.)	(sec.)	(sec.)	(sec.)
2	3.8	4.6	5.3	4.5	5.4	6.3	6.6	7.7
6	3.6	4.3	5.1	4.3	5.1	6.0	6.3	7.3
10	3.4	4.1	4.8	4.0	4.8	5.7	5.9	7.0
20	2.8	3.5	4.2	3.3	4.1	5.0	5.0	6.1
30	2.1	2.9	3.6	2.5	3.4	4.3	4.2	5.2

One rule of thumb found in the literature states that a word requires a second to read, a simple phrase takes two seconds to read so a panel could take from 3 to 6 seconds to read. According to the chart above, usually there is not enough time to display three panels. Therefore, only two panels should be used to display messages.

Reading time of a CMS, assuming it first becomes legible at **1000 ft**.

Distance of CMS from edge of travelway	4 lanes at 65 MPH (95 ft/s)	3 lanes at 65 MPH (95 ft/s)	2 lanes at 65 MPH (95 ft/s)	4 lanes at 55 MPH (81 ft/s)	3 lanes at 55 MPH (81 ft/s)	2 lanes at 55 MPH (81 ft/s)	3 lanes at 45 MPH (66 ft/s)	2 lanes at 45 MPH (66 ft/s)
(ft.)	(sec.)	(sec.)	(sec.)	(sec.)	(sec.)	(sec.)	(sec.)	(sec.)
2	7.6	8.4	9.1	9.0	9.9	10.7	12.1	13.1
6	7.4	8.1	8.8	8.7	9.6	10.5	11.7	12.8
10	7.1	7.9	8.6	8.4	9.3	10.2	11.4	12.4
20	6.5	7.3	8.0	7.7	8.6	9.4	10.5	11.5
30	5.9	6.7	7.4	7.0	7.9	8.7	9.6	10.7

5.3 LEGIBILITY

Most matrix signs are limited in alphabet to upper-case letters. The arrangement of the matrix makes it difficult to form some of the parts of lower case letters. This is especially true for letters with loops, such as "g" or "q". In general, the practice of using upper case letters should be followed. If a word needs to be emphasized, it can be flashed or placed in bold print.

5.4 STANDARD ABBREVIATIONS

Standard abbreviations easily understood are:

Word	Abbr.	Word	Abbr.
Boulevard	BLVD	Normal	NORM
Lane	LN	Parking	PKING
Emergency	EMER	Road	RD
Entrance, Enter	ENT	Service	SERV
Hazardous	HAZ	Shoulder	SHLDR
Freeway	FRWY, FWY	Slippery	SLIP
Highway	HWY	Speed	SPD
Information	INFO	Traffic	TRAF
Left	LFT	Travelers	TRVLRS
Maintenance	MAINT	Warning	WARN
Right	RT	Route	RTE

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

Word	Abbr.	Prompt
Ahead	AHD	Fog*
Blocked	BLKD	Lane
Bridge	BRDG	[Name]
Chemical	CHEM	Spill
Construction	CONST	Ahead
Exit	EX, EXT	Next
Interstate	I	[Number]
Major	MAJ	Accident
Mile	MI	[Number]*
Minor	MNR	Accident
Minute(s)	MIN	[Number]*
Prepare	PREP	To Stop
Pavement	PVMT	Wet*
Route	RTE	Best*
Vehicle	VEH	Stalled*
Cardinal Directions	N, E, S, W	[Number]*

* = Prompt word given first.

5.5 TYPICAL MESSAGES

(See manual for pre-programmed messages on specific CMS)

ROAD-WORK-xxMILES	FLAGGER-xxMILES	KEEP-RIGHT
WORK-ZONE-xxMILES	RIGHT-LANE-CLOSED	PASS-LEFT
NIGHT-WORK-xxMILES	LEFT-LANE-CLOSED	PASS-RIGHT
DETOUR-xxMILES	CENTER-LANE-CLOSED	TRUCK-CROSSING
MEDIAN-WORK-xxMILES	RIGHT-2 LANES-CLOSED	ROAD-CLOSED-xxMILES
DETOUR xxMILES	LEFT-2 LANES-CLOSED	ALL-TRAFFIC-EXIT-RT
SIGNAL-xxMILES	MERGE-xxMILES	WRECK-AHEAD-SLOW
ACCIDENT-xxMILES	MERGE-LEFT	USE-LEFT-LANE
YIELD xxMILES	MERGE-RIGHT	USE-RIGHT-LANE
STOP-xxMILES	KEEP-LEFT	DO-NOT-PASS
WATER-ON-ROAD	FOG-xxMILES	RIGHT-LANE-NARROWS

5.6 EXAMPLES: The following are typical incident or work zone advisory messages:

RT. TWO LANES CLOSED **(WHY)**	PREPARE TO STOP **(WHAT)**
BEACH TRAFFIC SAVE 1 HR **(WHO)**	USE US 64 E EXIT 27 **(WHAT)**
ACCIDENT ON BRIDGE **(WHY)**	DETOUR AT EXIT 204 **(WHAT)**
BRIDGE CLOSED **(WHY)**	USE DETOUR EXIT 198 **(WHAT)**
BRDG CLOSED OCT. 1 - 31 **(WHY)**	USE EXIT 65 **(WHAT)**

COLISEUM EVENT **(WHO)**	USE RIGHT TWO LANES **(WHAT)**
GAME TRAFFIC **(WHO)**	USE ALL LANES **(WHAT)**
CONCERT TRAFFIC **(WHO)**	FOLLOW DETOUR SIGNS **(WHAT)**
EXIT 5 CLOSED **(WHY)**	DEC 4-7 **(WHEN)**
EXIT 5 RAMP CLOSED **(WHY)**	FOLLOW DETOUR EXIT 4 **(WHAT)**
ICY BRDG **(WHY)**	REDUCE SPEED **(WHAT)**
SLIPPERY ROAD **(WHY)**	REDUCE SPEED **(WHAT)**
DENSE FOG **(WHY)**	REDUCE SPEED **(WHAT)**
DENSE FOG **(WHY)**	LOW VISIBILITY **(WHAT)**

HIGH WINDS AT BRDG **(WHY)**	REDUCE SPEED **(WHAT)**
TRUCK CROSSING **(WHY)**	WATCH FOR TRUCKS **(WHAT)**
ROAD FLOODED **(WHY)**	REDUCE SPEED **(WHAT)**
ROAD FLOODED **(WHY)**	SLOW MOVING TRAFFIC **(WHAT)**
TRAVEL ON SHLDR **(WHAT)**	MON-FRI 6 AM -9 AM **(WHEN)**
BLOWING SNOW **(WHY)**	REDUCE SPEED **(WHAT)**
LOAD SPILL **(WHY)**	FOLLOW DETOURS EXIT 64 **(WHAT)**
LANE MARKING **(WHY)**	EXPECT DELAYS **(WHAT)**
LANE MARKING **(WHY)**	LT LANE CLOSED **(WHAT)**

LANE MARKING **(WHAT)**	10AM - 3 PM **(WHEN)**
SLOW MOVING TRAFFIC **(WHY)**	LANE MARKING **(WHAT)**
TRAFFIC ADVISORY **(WHY)**	TUNE TO 1610 AM **(WHAT)**
DANGER FALLING ROCKS **(WHAT)**	
I-85S CLOSED JUL 19-AUG 4 **(WHY)**	USE I-95S THRU NC **(WHAT)**
FLAGMAN AHEAD **(WHY)**	PREPARE TO STOP **(WHAT)**
SLOW MOVING TRAFFIC **(WHY)**	MEN WORKING **(WHAT)**
DEBRIS ON ROAD **(WHY)**	RT LANE BLOCKED **(WHAT)**
DEBRIS ON ROAD **(WHY)**	RT LANE CLOSED **(WHAT)**

EMERGENCY VEHICLES AHEAD **(WHY)**	MERGE RIGHT **(WHAT)**
NEW TRAFFIC PATTERN **(WHY)**	LANES SHIFT **(WHAT)**
DUST STORM **(WHY)**	LOW VISIBILITY **(WHAT)**
DUST STORM **(WHY)**	SLOW MOVING TRAFFIC **(WHAT)**
ACCIDENT AT EXIT 291 **(WHY)**	FOLLOW DETOURS EXIT 290 **(WHAT)**
ACCIDENT AT EXIT 5 **(WHY)**	PASS ON RT SHLDR **(WHAT)**
ACCIDENT AT EXIT 5 **(WHY)**	SLOW MOVING TRAFFIC **(WHAT)**

6. CMS PROGRAMMING

This chapter is for information only and is just a brief overview of the common elements of CMS software. See your manuals. CMS software is commonly in a series of pull down menus, where a user can pick a topic and a list of functions will appear.

6.1 TYPICAL SOFTWARE FUNCTIONS

a) Start/Stop Sign - ability to start or stop the sign thru the software.
b) Message Library from sign - these are the messages that the sign knows. It is important to develop a hard copy list of user programmed messages to avoid scrolling thru to find a specific message or reprograming a message. Typically message 1 thru 264 are preprogrammed in the factory and included in the manual. Messages 300 thru 564 can be programmed by the operator. REMEMBER: THE SIGN'S LIBRARY IS NOT THE SAME AS THE COMPUTER'S LIBRARY.
c) Message Library on computer- this library can be developed on computer and downloaded to the sign or to multiple signs.
d) Sign Status - Video display will show operator what is being displayed on the CMS, including flip rate, flash rate, light, and many signs can give self diagnostics such as fuel low or battery charge level.
e) Time Implemented commands (TICS) time defaults. Signs can be preprogrammed to start or stop at a certain time, to display a different message sequence at certain times, to call a phone number or beeper and indicate failures, or even to call a remote computer on a schedule to download its status.

6.2 PROGRAMMING FROM A REMOTE LOCATION

If CMS is to be programmed from a cellular phone (such as one in an inspector's truck) it should be noted that a special adapter is required for the phone. New modems and communications software will "shake hands", that is, they will adapt to the highest speed at which both can communicate. With older modems, which are in many of the signs presently used, the speed of the computer's modem must be preset to the known speed of the sign (9600 baud).

Again, the sign's library is not necessarily the same as the computer's library. After programming a message sequence it should be verified prior to displaying and immediately afterwards.

7. MAINTENANCE

7.1 TOOLS AND SPARE PARTS

This is a basic list. Other parts and tools should be acquired as needed.

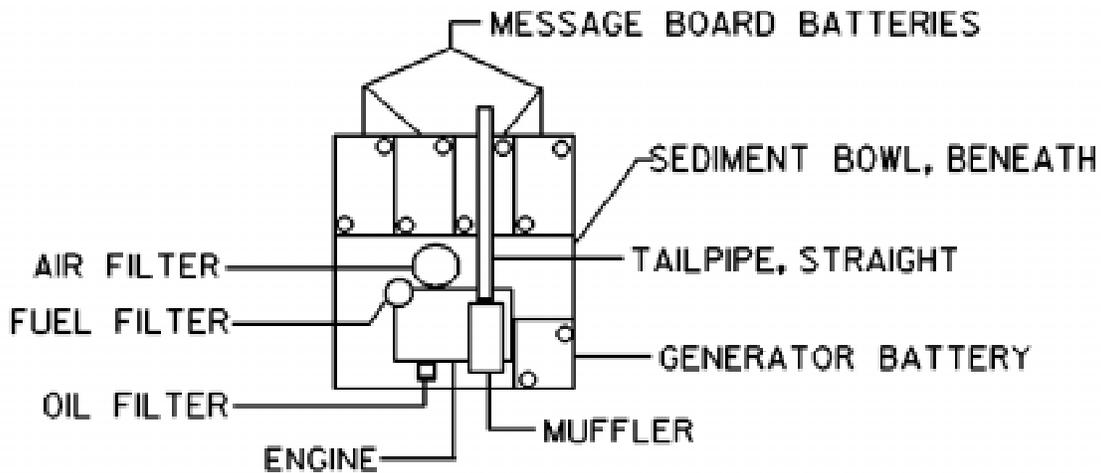| Maintenance Parts	Servicing Tools
Air Filter	Oil Filter Wrench
Fuel Filter	Voltmeter
Oil Filter	Screwdrivers
Transmission Fluid (for Hydraulic lift)	Adjustable wrench
Brake Fluid (for trailer brake)	Soldering Iron/Solder
Grease (to lubricate sign pole and leveling jacks)	Solder Sucker/Wick
Spare Fuses	Wire Strippers/Cutters
1/4 amp SB	Needle Nose Pliers
1/2 amp SB	Vice-Grip Pliers
2 amp SB	Screw starter
3 amp SB	Utility Knife
5 amp SB	
10 amp SB	
15 amp SB	

7.2 PREVENTATIVE MAINTENANCE

Refer to the maintenance manuals for in-depth maintenance instructions. The following is a brief summary of preventative maintenance requirements to keep the CMS generator, hydraulic lift, batteries and trailer in good working condition.

7.2.1 Generator

Task	Frequency
Check Oil	Weekly
Clean Air Filter	Weekly
Check Fuel Level	Weekly
Check Sediment Bowl (fuel transfer)	Weekly
Change Oil	100 hr.
Clean Sediment Bowl (fuel transfer)	100 hr.
Tighten Delivery Unions	300 hr.
Replace Fuel Filter	300 hr.
Replace Oil Filter	300 hr.
Inspect Battery Terminals & Fluid	300 hr.
Check Hydraulic Fluid	300 hr.
Check Brake Fluid & Lube Jacks and sign pole	300 hr.
Clean Cooling Fins	300 hr.
Set Rocker Arm Clearance	300 hr.
Set and Clean Injectors	300 hr.

PLAN VIEW OF UNCOVERED ENGINE

MESSAGE BOARD BATTERIES

SEDIMENT BOWL, BENEATH

AIR FILTER

FUEL FILTER

TAILPIPE, STRAIGHT

GENERATOR BATTERY

OIL FILTER

MUFFLER

ENGINE

7.2.2 Hydraulic Lift

With the sign lowered, periodically check the hydraulic fluid reservoir and add transmission fluid as necessary. The suction filter and valve protection filters should be cleaned periodically, and if not cleanable, they should be replaced. The panel raising mechanism should be greased periodically.

7.2.3 Batteries

Periodically inspect the battery terminals, clean and tighten as necessary. The battery fluid level should be checked monthly and filled with distilled water, if necessary.

7.2.4 Trailer

Check brake fluid, tires and lug nuts, and lubricate the jack. Tire pressure should be 55 to 60 PSI. Periodically inspect for loose connections and hardware and tighten as required.

7.2.5 CPU Cabinet

Ensure all connections are seated.

7.2.6 Controller Cabinet

It is convenient to keep spare fuses in the controller cabinet. Placing labels on switches and key positions is generally helpful. Placing warning labels such as KEY TO OFF POSITION TO AVOID BATTERY DRAIN can avoid some unnecessary maintenance.

Miscellaneous

For signs that are attached to line power, it is suggested that the sign generator be run at least twice a month to keep the engine lubricated and in good working condition. In addition, the sign should have the oil, oil filter, air filter and gas filter replaced if it has not been done prior to connecting the electrical power.

7.3 TROUBLE SHOOTING

Refer to the servicing manuals for in-depth servicing instructions. The following is a brief summary of some common problems and their possible causes.

Before attempting any troubleshooting, the following basic checks should be made.
1. The voltage of the sign battery bank is above 12VDC
2. The engine battery voltage is above 12VDC
3. LED1 on the CPU board flashes

Stated below are some of the most common problems found with portable cms and possible solutions to them, based on field observation and the manufacturer.

Problem: The generator turns over but does not start.
Possible Causes:
1) The engine battery is dead
2) The engine fuse is blown.
3) Broken wire to oil pump or connector

Problem: The amp meter does not show charging current with generator running.
Possible Causes:
1) If the Power LED on the CPU board is on steady, then the battery is probably fully
   charged and is taking no more current.
2) Alternator switch is in OFF position.
3) Alternator is not receiving +12VDC on its yellow terminal. (See manual.)
4) Engine may be running slow.
   Check the RPM. (See manual for making adjustments.)

Problem: The cursor does not work on the laptop.
Possible Cause:
1) The number lock is on; turn it off.

Problem: Sign face shows yellow/black horizontal stripes on all three lines.
Possible Causes:
1) If the top row is yellow, the CPU board is not receiving -30volts DC.
2) If the top row is black, the CPU board is not receiving +30volts DC.

Problem: An entire column, from top to bottom, of the sign does not flip correctly.
Possible Causes:
1) Column triac on the CPU board has shorted or opened. (Replace)
2) Column driver transistor on the CPU board is bad. (Replace)
3) A chip has gone bad. (Replace)

Problem: Sign does not show message.
Possible Causes:
1) If the Power LED on the CPU board is flashing:
   a) The battery needs recharging.
   b) Check the cable which provides the voltages necessary for the CPU board to monitor for proper connection.

2) If the 30 volt LED on the CPU board is on:
   a) If not, the +/-30 volts is not present.
   b) Make sure the power cord is firmly plugged into the invertor.
   c) Check F1 in the control cabinet.

Problem: Entire row across sign does not flip correctly.
Possible Cause:
1) A bad transistor pair. To determine the correct transistor pair to replace, note which row is bad. (If the first row remains yellow, the negative driver corresponding to that row is bad, or vice versa)

Problem: The engine will not start from remote laptop or time implemented command (TICs).
Possible Cause:
1) There is an open circuit line on the backside of the start relay.

<u>Problem</u>: The battery chargers are not registering, although the engine is running.
Possible Cause:
1) The wires running from the alternator to the alternator casing could be shorting out due to insulation breakdown, wear or a loose wire connection.

Note: If the sign is equipped with a battery backup compartment, disconnect the negative lead to the backup and turn off the main circuit breaker (CBI) anytime maintenance is performed in the backup battery electronics compartment.

<u>Problem</u>: One or more dots on the sign are not flipping.
Possible Causes:
1) The flip dot holder is not seated in its magnet slots.
2) The flip dot coil burnt out.
3) The diode on one of the dot modules is open (if all three rows on the same column are not flipping.)
4) The coil wires are not making good connection under the screws which mount the coil bracket.

<u>Problem</u>: Not sensing 120v, 30v or engine on/off.
Possible Causes:
1) The alternator wires are shorting to the case, causing the sense lines to the CPU to be inoperable.
2) One or more of the 1/4 amp slow-blow fuses in the AC sense circuitry is blown.

<u>Problem</u>: There is a comm time out error when trying to start sign remotely.
Possible Causes:
1) The phone line connection to the modem is loose, not making a good connection.
2) The modem speed is incorrect between the laptop and sign.
3) The modem in the PC central is too fast for the sign modem.

7.4 PROGRAMMING SHEET

```
            PROGRAMMING SHEET FOR
      PORTABLE CHANGEABLE MESSAGE SIGNS


    LOCATION  OF  BOARD:_____

    USED:FROM  _____-_____-_____ AT_____:_____AM/PM
            TO _____-_____-_____ AT_____:_____AM/PM

    MESSAGE  PROGRAMED  BY:_____
```

MESSAGE 1

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MESSAGE 2

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MESSAGE 3

□ □ □ □ □ □ □ □
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```
TIMING:
MESSAGE  1  WILL  RUN____.____SECONDS.
MESSAGE  2  WILL  RUN____.____SECONDS.
MESSAGE  3  WILL  RUN____.____SECONDS.
```

Note: A sheet similar to this, which is site specific to each area and type of sign, shall be developed because different sign types require different message ratings.

7.5 PREVENTATIVE MAINTENANCE CHECKLIST

CMS MAINTENANCE REQUIREMENTS

Task	Frequency
Check Oil	weekly
Clean Air Filter	weekly
Check Fuel Level	weekly
Check Sediment Bowl (fuel transfer)	weekly
Change Oil	100 hours
Clean Sediment Bowl (fuel transfer)	100 hours
Tighten Delivery Unions	300 hours
Replace Fuel Filter	300 hours
Replace Oil Filter	300 hours
Inspect Battery Terminals & Fluid	300 hours
Check Hydraulic Fluid	300 hours
Check Brake Fluid & Lube Jacks	300 hours
Clean Cooling Fins	300 hours
Set Rocker Arms Clearance	300 hours
Set and Clean Injectors	300 hours

SIGN #	TECHNICIAN:			
TASK	CHECK	CHANGE/SERV	FREQ/HRS	DATE
Oil				
Air Filter				
Fuel Level				
Sediment Bowl (fuel transfer)				
Delivery Unions (tighten)				
Fuel Filter				
Oil Filter				
Battery Terminal & Fluid				
Hydraulic Fluid				
Brake Fluid & Lube Jacks				
Clean Cooling Fins				
Set Rocker Arms Clearance				
Set and Clean Injectors				

REMARKS _____

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