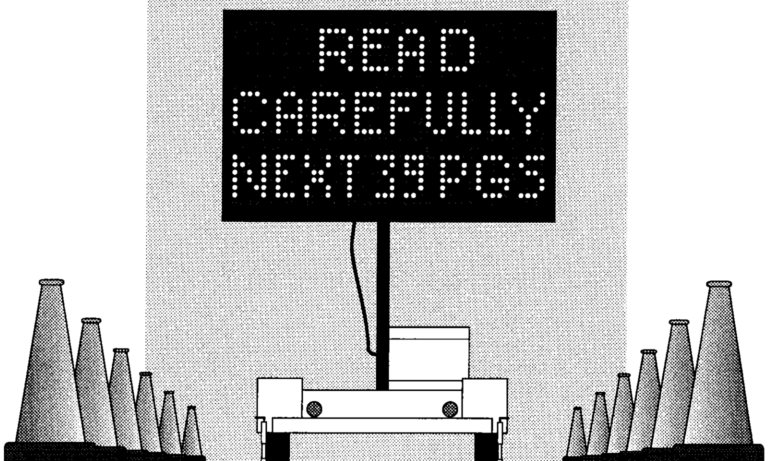
FINAL REPORT

DEVELOPMENT OF MANUALS FOR THE EFFECTIVE USE OF VARIABLE MESSAGE SIGNS



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Standard Title Page — Report on State Project

Report No.	Report Date	No. Pages	Type Report:	Project No.:
VTRC 95-R15	January 1995	39	Final Report Period Covered:	3065-030-940 Contract No.:

Title and Subtitle

Development of Manuals for the Effective Use of Variable Message Signs

Key Words

Changeable message signs
Variable message signs
Intelligent transportation systems
Motorist information systems
Incident management

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Supplementary Notes

Abstract

A comprehensive research effort to develop operator's manuals for variable message signs (VMSs) was undertaken to improve the operations of both portable and permanent (fixed-site) VMSs in Virginia. This report describes the development of two manuals, the *Permanent VMS Operator's Manual* and the *Portable VMS Operator's Manual,* which will be published separately.

These manuals were based on information obtained from the literature, VMS operators, and motorists. Issues addressed by the manuals include when a VMS should be used, where a portable VMS should be placed, and the design of the VMS message. The manuals are not simply a list of pre-defined messages. They are a series of concise modules guiding the operator through the thought process required to use a VMS effectively. The operator follows a logical decision tree from module to module, to achieve the best placement and best message for a VMS. Effective VMS use actually requires a complex thought process, despite the apparent simplicity of the messages.

The manuals include essential material about VMS operation. Based on theoretical calculations and motorists' experiences, it is strongly recommended that a VMS use no more than two message screens. A single message screen is preferred. VMSs should be used only to advise drivers of *changed* traffic conditions and convey specific traffic information concisely. Due to limited information capabilities, VMSs should be used in conjunction with other means of communication such as highway advisory radio and static signs. Most importantly, it is crucial that credibility be maintained. Incorrect information can have extreme consequences in terms of VMS effectiveness.

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(A Cooperative Organization Sponsored Jointly by the Virginia Department of Transportation and the University of Virginia)

Charlottesville, Virginia

VTRC 95-R15
January 1995

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INTRODUCTION AND PROBLEM STATEMENT

Congestion relief is a key issue in transportation. Recurrent congestion is common in areas where the transportation system has not kept pace with population growth. However, congestion is not simply a result of insufficient capacity. Lindley states that in U.S. cities, 60% of the congestion delay results from incidents.[1] Incidents may be planned, like a construction project, or unplanned, like an accident or a vehicle breakdown. Incident-induced congestion is made worse by the recurring congestion in high density areas. Either type presents the same dilemma: a traveler cannot determine what to do unless sufficient information is made available *before* the congestion is encountered.

Safety is another fundamental concern of transportation officials. In 1993, over 120,000 traffic accidents were reported in the Commonwealth of Virginia, with 77,852 injuries and 875 fatalities.[2] Some of these accidents were caused by abnormal traffic conditions, such as wet pavement, poor visibility, or erratic traffic flow resulting from congestion. Faced with such traffic hazards, motorists need real-time information about travel conditions in order to safely modify their driving behavior.

Driver response to congestion and other roadway hazards may range from such simple actions as avoiding a blocked lane to complex maneuvers like temporarily detouring from a freeway. All drivers in these events need real-time information. Intelligent Transportation Systems (ITS) solutions, designed to increase safety and efficiency, propose a variety of methods for providing real-time information to motorists. One method is the variable message sign (VMS), which, unlike much ITS hardware, has been in use for several years. (Variable message signs are also called changeable message signs, or CMSs, in some of the literature).

The VMS is a traffic control device that can display a variety of messages. VMSs vary in their display capabilities. Some display a small number of limited word messages from a pre-set library, some display any combination of characters of a fixed size, and some display symbols that occupy the entire screen. VMSs use a variety of display technologies such as flip-disks, light emitting diodes (LED), and fiberoptics.

The Virginia Department of Transportation (VDOT) and its contractors have increased their use of VMSs dramatically in recent years. VDOT owns over 300 portable VMSs, which are used mostly on Interstate highways for work zone traffic control and incident management, and over 100 permanent (fixed-site) VMSs, which are used extensively in the Northern Virginia Traffic Management System (TMS) and in the Hampton Roads Traffic Management System. A permanent VMS is one which has been permanently stationed in a fixed location, usually above the road. Their ability to display messages describing current traffic conditions has made the signs popular, but the added flexibility results in added operational responsibility.

Despite widespread VMS use, no practical guidelines for their operation exist. VDOT employees and private contractors must make judgments about when, where and how to use VMSs with little training or guidance. Confusing word choices, lengthy or ambiguous messages, or incorrect placement can render the VMS useless, or cause motorists to doubt the information.[3] Guidelines are needed to help operators use VMSs effectively.

PURPOSE AND SCOPE

To develop manuals for VMS operation ensuring that VDOT realizes the maximum benefits from its substantial investment in VMS equipment, the following objectives were established:

Define conditions specific to the Commonwealth that make VMS use practical. A literature review revealed a number of potential applications:[4,5]

- accidents/incidents
- congestion
- work zones
- weather related conditions
- special events
- general transportation messages
- advertising.

These potential VMS applications were then examined for practicality. For example, although advertising can be a source of revenue, using VMSs for advertising may lead drivers to ignore VMSs.

Determine operational parameters. Operational parameters are factors VMS operators can control that affect the signs' effectiveness. At the beginning of this study, the following were considered as possible operational parameters:

- message wording
- message content
- use of graphics or symbols
- blinking rate
- brightness level
- distance of the VMS from the incident, detour, or hazardous condition (applicable for portable VMSs)
- placement of the VMS with respect to diversion points, other VMSs, or the side of the roadway
- number of message screens
- message screen duration (applicable if the message is longer than one screen).

(The term "screen" refers to an individual display on a single VMS. A "two-screen" message is a single VMS alternating two different displays.)

Establish effective operational parameter settings for tradeoff conditions. The choice of operational parameters for different traffic conditions required sensitive tradeoffs. For example, suppose motorists need to be diverted to an alternate route because of an accident, and a VMS is appropriate to convey this message. A single-screen message will be read and retained more easily than a multiple screen message, but cannot impart as much information.

Prepare draft manuals for the operation of variable message signs. Drafts of the manuals were prepared. These manuals describe how to use a VMS under different traffic conditions for a variety of applications. The manuals attempt to balance the need for consistency with the benefits of allowing the operators to exercise their good judgement on the scene. VDOT operators experienced with variable message signs helped evaluate the draft manuals.

Validate the manuals with two focus groups of motorists. After the comments of VMS operators had been incorporated into a second draft, the opinions of motorists about various VMS applications and messages were sought. The focus groups were used to 1) test selected guidelines recommended by the manuals, 2) identify issues for future VMS research, and 3) obtain a user's perspective. The manuals were modified accordingly.

METHODS

This project used three information-seeking strategies: a literature search, surveys of VDOT personnel, and discussions with drivers in the Commonwealth. Much VMS research has been done and some of it is relevant to VDOT's needs. VDOT personnel, the primary clients for these manuals, contributed considerable practical insight, as did the motorists, the ultimate "customers" of traffic information.

Literature Review

The literature review included research reports published by the Federal Highway Administration (FHWA), Transportation Research Board (TRB) journal articles, product specifications for individual manufacturers' VMSs, national VMS and static sign standards, VMS specifications for VDOT, and other states' VMS guidelines. This literature fell into three categories:

VMS technological information. To help understand the physical limitations of VMSs, documents that addressed the principles of lighting and their relationship to various VMS technologies such as flip-disk, fiberoptics, and light emitting diode (LED) were examined. Field studies of legibility distance as a function of the external lighting conditions and the type of VMS were also investigated. VDOT VMS specifications were examined to assess the number and types of VMSs being used in the Commonwealth. Understanding the physical limitations of VMSs made the guidelines more practical; for example, knowing the VMS legibility distance helps operators develop messages short enough to be assimilated by motorists in traffic.

Operational aspects of VMSs. FHWA publications on VMS operations were examined. These publications were conceptual, rather than process-oriented. Special attention was paid to concepts which VMS operators could implement. Other states have guidelines and standards for VMS operation, and these sources were also perused.

VMS and static sign standards. National standards promulgated by the American Association of State Highway and Transportation Officials (AASHTO) and the American Traffic Safety Services Association (ATSSA) were examined to ensure consistency between VDOT's VMS use, national recommendations for VMS use, and static sign use.

Surveys of VDOT Personnel

Twenty surveys were sent to VDOT personnel, nine to the district traffic engineers and eleven to the safety officers in the nine VDOT districts, to determine how VMSs were used in the Commonwealth and what the VMS operators felt might be other applications for VMSs. The survey questions, shown in Appendix A, addressed five topics:

- applications of VMSs
- operational parameter settings
- effects of traffic, weather, and external lighting conditions on VMS operation
- effects of driver familiarity on VMS operation
- contractors that supply the VMSs.

After the survey, a meeting with the VDOT district safety officers verified the survey results and discussed potential components of the VMS manuals. Concerns that the manuals might become arbitrary and restrictive were addressed, since the manuals are meant to be guidelines, not rules. A separate meeting was held with VMS operators from the Northern Virginia Traffic Management System (TMS). At the meetings, VMS operators provided information about current VMS practices and recommendations based on past experience. After the meetings, VMS personnel received a preliminary draft of the manuals for comment. Toward the end of the project, VDOT Central Office personnel also reviewed the manuals and provided useful comments. The manuals were continually revised throughout the study for clarity, for more flexibility in areas where greater operator judgement was required, and for the training needs of inexperienced VMS operators.

Focus Groups of Motorists

Focus groups are an efficient way to obtain feedback from motorists. Individual suggestions can be immediately analyzed by other group members, and the dynamics of group interaction stimulate interest. Other methods such as mail-back questionnaires, telephone surveys, and face-to-face interviews were considered, but these methods had drawbacks not found in the focus group method. For example, mail-back questionnaires would make it difficult to explore questions raised by the interviewees. Telephone surveys might allow this type of probing, but the subjects would not be able to actually see the VMSs. No form of individual interview would allow the level of constructive interaction found in a focus group.

A weakness of the focus group is that the results may be less objective. Some subjects may suppress their disagreements to go along with the group. The focus group findings were not statistically significant, nor did the focus groups comprise a representative sample of the driving population. Finally, although this would have been the case with any opinion-collection methods, the focus groups could not examine all the recommendations in the manuals. However, since the types of information being sought from the focus groups were ideas and opinions rather than quantitative data, the benefits outweighed the disadvantages.

Two focus group sessions were conducted. The first session contained five staff members from the Virginia Transportation Research Council (VTRC), and the second contained twelve staff members from the American Automobile Association (AAA). Although both of these organizations address transportation issues, only staff members who did not have a traffic engineering background were selected.

The focus groups were asked to react to VMS messages involving four operational parameters addressed by the manuals: the content of the message, the wording of the message, the number of screens used to display the message, and what should be done with a permanent VMS when no message is necessary. The participants were shown various VMS messages and then asked to share their opinions about which features made the VMSs more legible, noticeable, and worthwhile. These messages had previously been videotaped using a three-line, eight-character-per-line flip-disk VMS. During the focus group sessions, subjects were shown portions of the videotape that corresponded to the questions. Approximately 15 questions were asked over a two hour period. These questions and the relevant messages are shown in Appendix B. The example shown below was used to investigate the best type of information to display in a work zone:

"Envision yourself on a two lane Interstate highway, such as I-66. Suppose that five miles ahead, construction has blocked the left lane, causing a bottleneck or backup at the point where the lane closure occurs. Please rank the usefulness of these messages on your sheet. Mark a '1' for most useful and a '5' for least useful."

message A	message B	message C	message D	message E
ROADWORK	ROADWORK	CAUTION	SLOW	ROADWORK
IN 5 MI	REDUCE		SLOW	AHEAD
MERGE RT	SPEED		SLOW	

The focus groups' reactions to the messages indicated why certain VMS applications were effective or ineffective.

RESULTS

Literature Review

Literature describing the physical characteristics and theoretical operation of VMSs was useful.[6,7,8,9] However, this information was not in a form that could readily be used by an operator. As the project progressed, the VMS guidelines of four states and another state's description of VMS use were examined. Some provided useful ideas, but none was acceptable for use by the Commonwealth.[10,11,12,13,14] One state's guidelines, for example, provided for up to four different screens per portable VMS message, which violates MUTCD standards.[15] Other state guidelines focused on what to do (e.g. a message should be no longer than two message screens) rather than how to do it (e.g. how to design a concise message using only two screens). A number of Federal Highway Administration (FHWA) publications were helpful for understanding

VMS technology, and some of the technical manuals had good information on determining VMS legibility.[16,17,18] The literature contained several useful findings:

1. *No more than two message screens should be displayed by a single flip-disk VMS.* Dudek begins with the premise that a laterally-mounted (portable) VMS will cease to be comfortably readable when the angle between the VMS and the road centerline is greater than 10 degrees, which occurs as the motorist gets closer to the VMS.[6,19] Reading the VMS becomes difficult because of the combination of psychological factors involved in driving and the disappearance of the VMS from the normal field of vision. An equation to account for the distance from the VMS to the point at which it is no longer comfortably readable ("unreadable distance") is given as:

$$\text{Unreadable Distance} = [S + (N-0.33)*L + 0.5*W]*5.67 \qquad (1)$$

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.

From equation (1), the unreadable distance, or the distance at which a portable VMS becomes unreadable, is calculated. This distance may then be subtracted from the legibility distance, which is the distance at which the VMS becomes legible, to yield the distance for which the VMS is readable. This calculation is shown in equation (2).

$$\text{Readable Distance} = \text{Legibility Distance} - \text{Unreadable Distance} \qquad (2)$$

The difference may then be divided by the travel speed in order to compute the time for which the VMS is readable, as shown in equation (3).

$$\text{Readable Time} = \frac{\text{Readable Distance}}{\text{Travel Speed}} \qquad (3)$$

This readable time then limits the maximum number of different message screens which may be used. These concepts are illustrated in Figure 1.

For example, suppose a VMS is mounted such that, as calculated by equation (1), it has an unreadable distance of 200 feet. The literature states that in daytime conditions, a flip-disk VMS has a legibility distance of 650 feet. Therefore, from equation (2), one may compute the readable distance to be

650 feet - 200 feet = 450 feet.

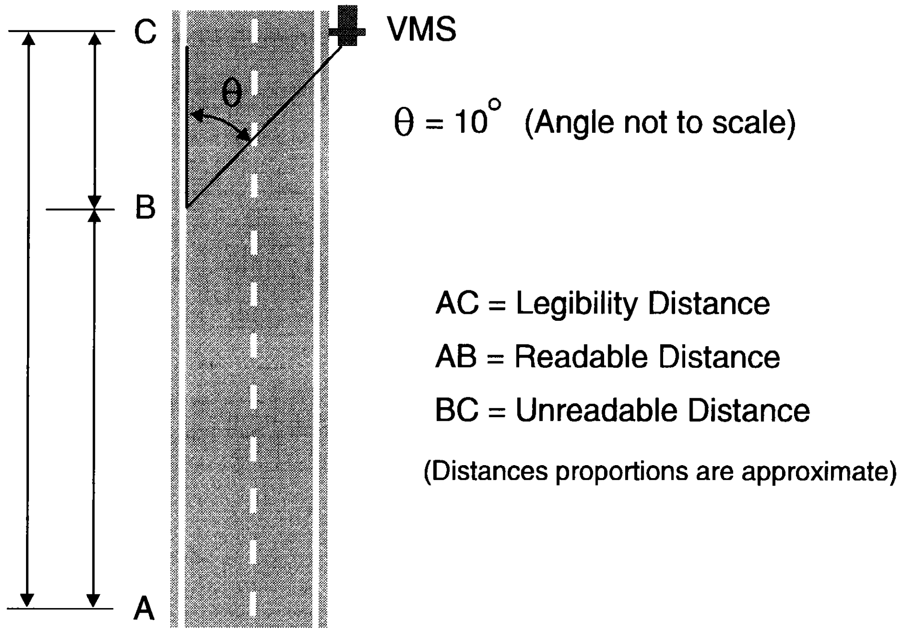

Figure 1.

A travel speed of 55 mph is equivalent to approximately 81 feet per second. If one uses equation (3) with these values, one finds that the readable time is approximately six seconds:

$$\frac{450 \text{ feet}}{81 \text{ feet/second}} = 5.6 \text{ sec}$$

Suppose one has a single VMS with three lines, eight characters per line, and the capability to display alternate message screens. If one allows a reading time of two and a half seconds per message screen, then it will take approximately two and a half seconds to read one screen, five seconds to read two screens, or 7.5 seconds to read three screens, the last of which is not possible at 55 mph.

This limitation is reinforced by the MUTCD standards, which specify the following:

- no more than two message screens should be used by portable VMSs.
- motorists should be able to read the entire VMS message twice while travelling at the posted speed.

For this case, the MUTCD standards suggest that even two screens might be too much for motorists to process, which leads to the conclusion that one should use additional message screens very judiciously.

A similar phenomena, where the view of an overhead VMS is obscured by the windshield as the motorist drives very close to the VMS, is described in the manual for permanent VMSs.[20,21]

2. *An effective VMS message may be constructed from pre-defined components.* The literature also addressed the issue of message content which provided a solid theoretical basis from which to construct the manuals. For example, one FHWA publication stated that advisory sign message elements should be (1) a problem statement, (2) an effect statement, (3) an attention statement, and (4) an action or instruction statement. Such message deconstruction was useful for understanding how to develop effective VMS messages, for it pointed to a standard procedure for building a message from essential components. However, given the limited information capabilities of flip-disk VMSs, in many situations it would be impossible to create a message long enough to contain all of those elements yet brief enough to be understood.

3. *Only single stroke fonts and capital letters should be used.* Studies aimed at determining the legibility distance for a flip-disk VMS revealed that double stroke lettering has a 25% smaller legibility distance than single stroke lettering.[22] Certain lower case letters are difficult to make with the current flip-disk VMSs, especially hanging letters such as "g", "y", or "p".[6]

   There is a legitimate reason to consider the use of mixed-case letters. Evidence exists that viewers may comprehend mixed-case words more quickly than upper-case words, assuming the viewer is close enough to read the text.[23] However, with VMSs there is a second consideration: the distance at which one can read the message. The height of the letter affects the legibility distance, which explains why one generally tries to use letters which are as tall as possible in a VMS message. Recent literature suggests that mixed case words are slightly more legible than upper-case words, but there are limitations to this finding. The loop height of the lower-case letters must be the same height as that of the upper case letters. To achieve this equality, the lower-case letters would have to be wider than the upper-case letters, which is not possible with most of VDOT's VMSs. Secondly, the differences found in the legibility distances were small: 50 feet for high-contrast materials and 16 feet for low-contrast materials, with the average legibility distance being around 600 feet.[24]

   The current flip-disk VMSs are estimated to have 650-foot legibility distances under good daytime conditions and 350-foot legibility distances under nighttime conditions. The current legibility distances of VDOT's VMSs are too small to be reduced further for a questionable gain in recognition speed from mixed-case letters; thus, the authors decided to recommend upper-case letters only. This decision is not a definitive rejection of the benefits of mixed-case messages, but one should consider them only in situations where legibility distance is not an issue.

4. *Credibility is essential.* Without credibility, even the best message will go unheeded. It is better to display nothing than to display a message which motorists will discover to be incorrect.[25]

Feedback from VMS Operators

Ten surveys, representing six VDOT districts, were returned. A subsequent meeting was held with district safety officers from all nine districts to obtain additional feedback. A separate meeting was held with operators at the Northern Virginia TMS. The results of these surveys and meetings are presented in two categories: background information describing current VDOT VMS practices, and comments about how to develop the VMS manuals. These people also provided some common-sense solutions not found in the literature or deduced by the authors.

VDOT's VMS Practices

1. *VMSs should be used to advise the motorist of* ***changed*** *traffic conditions.* Examples include lane closures, delays, or sudden stoppages. Greetings or general safety statements (e.g. "please drive safely") should be avoided.

2. *VMSs should only be used when necessary.* VMS overuse could generate motorist contempt, rendering the VMS ineffective. Overuse tends to occur when a VMS is used to do something that should be done with a static sign. The operators stated that one should first consider static signs and only use a VMS after deciding that static signs alone cannot communicate the required information. Further, the operators noted that a VMS should be used in conjunction with static signs whenever possible.

3. *The VDOT districts use VMSs differently.* For example, some respondents indicated that they use up to four different message screens per VMS, while others indicated using only two message screens per VMS. Obviously the districts throughout the Commonwealth vary significantly in the proportion of out-of-town travelers passing through the area, levels of congestion, and signing needs. Rush hour traffic congestion in Northern Virginia is of a substantially different magnitude than that in Bristol. The differences in survey responses indicated the possibility that VMSs were not being used consistently. The question is whether or not such inconsistency results from different needs or from errors in VMS usage.

4. *VMS operators need to consider several operational parameters.* In addition to the operational parameters cited on page 3 of this Report, discussions with the operators revealed additional decisions under the VMS operator's control:

- coordination with other information media such as highway advisory radio or static signs
- how and when the message is updated
- what is displayed by a permanent VMS when there are no unusual traffic conditions to report.

Furthermore, the operators stated that blinking rates and brightness levels were not operational parameters. Message brightness and rate of blinking are not adjustable on most VDOT VMSs. One may only choose to blink or not to blink a message.

5. *Portable VMS batteries routinely need to be charged.* For portable VMSs, operators pointed out a need to charge the battery by turning on the VMS and letting it run for four hours every week when it is not used in the field. This does not apply to VMSs that run exclusively on solar power.

Development of VMS Manuals

1. *The operators need to control what is put on the VMS.* Outlining very specific situations is futile because traffic conditions and information vary too greatly to be covered by a list of standard messages. In addition, creation of a message is only part of VMS operation. Operators must also decide how, when, and where to use a VMS, and when to discontinue VMS use or alter the message. It is not possible to make these decisions for operators, but it is possible to provide them with guidance on how to make these decisions. The VMS operator's manuals needed to be guidelines rather than mandates; not overly restrictive, but more substantive than simply authorizing an operator to use "engineering judgement."

2. *The manuals need to be as simple as possible.* The operators commented that the equations for computing the readable distance for a portable VMS were too complicated for use in the field. The operators suggested a set of tables to compute the distance at which a VMS becomes unreadable. Based on operator feedback and FHWA field work, tables were established assuming 12 foot lane widths, 11 foot VMS widths, and three-line, eight character per line portable flip-disk VMSs with 650-foot legibility distances. Although an improvement over the equations, the tables were still too complicated for field use. Eventually the tables were simplified into a set of rules. By combining the operators' field knowledge with theoretical research, it was possible to develop a concise method for operators to determine effective parameter settings, such as the maximum number of screens which could be employed.

3. *The wording of the manuals is important to the operators.* For example, the first module of the portable manual originally stated that in order for a VMS to be used, the following statement must be true:

"Message accuracy can be ensured."

During the meeting with the operators, it became apparent that there was a need to define how message accuracy could be measured. The operators pointed out that trustworthy sources included a credible commercial traffic reporter, the State Police, or a visual inspection of the scene. TMS operators often receive phone calls from motorists about incidents, but often these calls contain misleading or incorrect information. Therefore the italicized statement above was changed to the one shown below:

> *"Message accuracy has been confirmed by a reliable source, such as State Police, a credible commercial traffic reporter, or visual inspection; a random caller is not a reliable source."*

Feedback from Motorists

The videotape of VMS messages and the questions posed to the focus groups generated much discussion. Despite the office environment, the focus group subjects could envision themselves in numerous highway situations where they might encounter a VMS. Their comments covered many aspects of VMS operations, including topics which had not been previously considered by the authors. The observations made by the focus group subjects are synthesized in two categories: VMS use and VMS operational characteristics. The former category refers to perceptions and expectations of VMS use, and the latter refers to factors that should be considered once the decision to use a VMS has been made.

VMS Use

1. *Signs are the primary channel of communication to the motorist.* Comments were made that signs, be they static or VMSs, are superior to other forms of communication such as flaggers and highway advisory radio, due to information limitations of the former and irrelevant information disseminated by the latter.

2. *VMS credibility is crucial.* The most significant problem mentioned by the focus groups was VMSs failing to display correct information. Motorists often do not believe the VMS because they recall previous instances where VMS information was wrong. Warnings of construction activity when none is occurring are a prime example. Credibility also depends on accuracy when displaying numerical information. If a VMS indicates that traffic clears in a certain distance, motorists' faith in VMSs would be damaged if the congestion had not dissipated after the posted distance.

3. *The VMS should communicate what action motorists need to take and when this action should occur.* This information may be either explicit or implicit in the message. For

example, message A is insufficient because it fails to tell motorists what they should do and when they should do it. Message B, however, tells motorists both which lane they need to avoid and how soon this lane closure will occur.

message A	message B
LANE	LFT LANE
CLOSED	CLOSED
AHEAD	1000 FT

4. *Unnecessary information should be avoided.* Messages that simply display "SLOW", "CAUTION", or "PLEASE BE CAREFUL" do not tell motorists specifically what they need to do.

5. *Permanent VMSs should be left blank if there are no unusual traffic conditions to report.* Most subjects felt a blank VMS meant that there were no unusual traffic conditions to report, while a VMS that displayed the date and time was both a waste of taxpayer resources and a distraction. A message such as "TRAFFIC NORMAL" could be interpreted differently by different drivers, so it is better not to display anything than to state that traffic is normal.

6. *Not all motorists want the same amount of information.* Focus group subjects did not agree on how much information they should be given. For example, when engulfed in congestion, some subjects want to know the distance to the point where the congestion dissipates while others feel such information is useless.

Operational Characteristics of VMSs

1. *The fewer message screens, the better.* The focus groups were divided as to whether two or three screens should be the maximum allowed, but all subjects agreed that multiple-screen messages were often difficult to read as a result of poor visibility, large vehicles blocking the view of the VMS, encountering the VMS in the middle of a message, or placement of the VMS on the opposite shoulder.

2. *Scroll time is important.* Subjects recalled instances where messages were displayed for longer than necessary. Motorists slowed down to see all screens of multiple-screen messages, thereby forming bottlenecks.

3. *Only well-known symbols and words should be used.* All three of these messages were confusing:

<table>
<tr><th>message A</th><th>message B</th><th>message C</th></tr>
<tr><td><<<<</td><td>LANES</td><td>LEFT</td></tr>
<tr><td>IN 3 MI</td><td>CLOSED</td><td>THIRD</td></tr>
<tr><td></td><td>| |X|</td><td>LANE</td></tr>
</table>

The problem with messages A and B was the use of symbols not understood by motorists: it was not clear that "<" meant motorists needed to merge left or that the "X" in message B designated which of the two lanes was closed. Message C used a term not understood by most drivers.

4. *Only symbols and words clearly displayed by the VMS should be used.* VDOT's current flip-disk VMSs have limited display capabilities. Words which are too long to fit on a single line or chevrons that are beyond the graphics capability of the particular VMS should be avoided.

5. *The order in which motorists view VMS information is vital.* "Order" refers to both the order of the lines and the order of the screens. For example, the line order of message A is confusing in comparison to message B, because motorists expect to see the word "ACCIDENT" first:

message A	message B
IN 5 MI	ACCIDENT
ACCIDENT	IN 5 MI
USE RT29	USE RT29

The order of the message screens is also important, as demonstrated below:

screen 1	screen 2	screen 3	screen 1
AVOID	FOLLOW	BRIDGE	AVOID
1 HR	DETOUR	CLOSED	1 HR
DELAY		IN 2 MI	DELAY

This three-screen message was intended to begin with "BRIDGE CLOSED IN 2 MI," but subjects were confused when shown the message in the above order, which is an example of what motorists might see when they encounter a VMS in mid-message.

6. *The word "DETOUR" implies that an alternate route has been thought out.* The focus groups underscored a key difference between the words "detour" and "alternate route." The former implies there will be signs guiding the unfamiliar motorist along the alternate route, while the latter means motorists must find the route themselves.

7. *Whether route diversion messages are suggestions or commands should be clear.* When motorists are notified about an upcoming route diversion, they also need to be told whether the route diversion is optional or mandatory. If diversion is mandatory, then the VMS should explicitly say so; for example, the phrase "ROAD CLOSED" may be used. If the route diversion is optional, then the word "CONSIDER" may be used.

DISCUSSION

Effective VMS use requires more thought than the brevity of the messages would suggest. The idea that users of an informational tool require guidance and training is not new. VDOT requires flaggers to pass a written test in order to operate a slow/stop paddle. Users of safety cones, orange barrels, and static signs are expected to complete a VDOT training course and comply with the 130-page Virginia Work Area Protection Manual. Decisions about permanent static signs are made by district traffic engineers who are familiar with the detailed MUTCD.

The VMS manuals are more detailed than one might expect, but this is a necessary step in the standardization of effective VMS use. The task of synthesizing the results into a usable operator's manual was guided by ideas below:

1. *The manuals must address where, when, and how a VMS is used, in addition to what messages should be displayed.* The creation of the message is only part of using a VMS effectively. The manuals should address the conditions under which a VMS should be used, its purpose, where it should be placed, how the message should be displayed, and under what conditions the VMS should be removed or the message changed. The manuals also need to address various aspects of the message, such as length, abbreviations, audience, and how to attain the proper balance between a message brief enough to be assimilated yet substantial enough to be informative. For example, if the VMS is to divert motorists to an alternative route, then the manuals should mention that static signs and highway advisory radio may complement the VMS, as well as address the content of the VMS message and when the VMS message should be updated.

2. *The manuals need to reflect the thought process which results in effective VMS use.* Unlike standards that simply state what constitutes acceptable VMS usage, the manuals need to describe how to do it. For example, if the *standard* is that a message should be no longer than two screens, the manuals have to describe the *path* an operator might follow to design a successful VMS use with a message no longer than two screens. To achieve this, the manuals were divided into modules representing distinct thought processes in overall VMS message development, ensuring that the correct decisions have been made at each stage. A sample module is shown in Figure 2.

10. HOW SHOULD DISTANCES AND LOCATIONS BE CONVEYED?

IF	a distance **or** a location is part of the message, then complete this module.
OTHERWISE	go to **11**.

When giving a location or distance, the question arises as to whether the operator should give a distance in miles ("ACCIDENT 3 MI"), an exit number ("ACCIDENT AFTER EX 100"), or the name of a prominent landmark ("ACCIDENT AT BROAD STREET"). In order to make this decision, complete this module.

T F The message applies **ONLY** to familiar drivers.

IF	True, then consider the use of cross-streets, landmarks, and exit numbers and select the term that is best known by the local population. Go to **11**.
IF	False, then continue with this module.

T F The route is an Interstate.

IF	True, then continue with this module.
IF	False, then give a distance in miles. Go to **11**.

T F The exits are numbered sequentially (i.e. they do **not** correspond to mile markers).

IF	True, then give a distance in miles. Go to **11**.
IF	False, then continue with this module.

T F At least one of the following are located within one mile after the VMS:

- an exit, **or**
- a static sign indicating a distance to an exit

IF	True, then give the location as an exit number. Go to **11**.
IF	False, then give a distance in miles. Go to **11**.

Figure 2. MODULE 10

The logical flow of decision points represented by the modules ensures correct VMS use. For example, when trying to convey location information to motorists, it may be better to tell motorists that there is an accident at a particular exit, near a well-known landmark, or a certain number of miles away, depending on the type of route, driver familiarity with the area, and amount of signing. If an operator is faced with this decision, module 10 quickly guides the operator to the correct use. In this example, if the operator is trying to inform motorists about an accident on an Interstate where the exits are numbered sequentially, then the location should be conveyed as a distance rather than as a particular exit.

Progressing through the decision points will also familiarize inexperienced operators with the choices involved in using a VMS, thus providing a training opportunity in parallel with VMS operational guidance.

3. *Modules can simplify the updating of the manuals.* The manuals must be updated regularly if they are to remain useful. The ability to alter particular modules without having to redo the whole manual will make this easier.

4. *The manuals have to be simple to be effective.* The manuals have to be as simple as possible, yet detailed enough to be useful. The method of calculating the maximum number of screens is an example of how this was done. The literature provides equations for determining the number of seconds for which a VMS is readable. This, coupled with a specification of the type of portable VMS the operators use in the field, resulted in a 14-page set of tables for computing the maximum number of screens. Detailed examination of the tables showed that for motorists to meet the MUTCD standard of being able to read the entire message twice, only one screen could be used at high speeds (i.e. above 45 mph). However, the focus groups of motorists indicated that two-screen messages were tolerable, and calculations demonstrate that there is usually enough time to read a two-screen message at least once under daytime conditions. Therefore the module was simplified to the following rule: one-screen VMS messages are ideal, two-screen messages are acceptable if necessary, and three-screen VMS messages should not be used

5. *Different operator's manuals are needed for portable VMSs and permanent (fixed-site) VMSs.* The manuals differ in:

    - *Placement and removal of the VMS.* Obviously, portable VMS operators must address both of these issues, while permanent VMS operators must wrestle with the question of what to display when traffic conditions are normal.

    - *Size of the VMS.* The manual for portable VMSs should be designed for displays of eight characters per line on three lines. Permanent VMSs, on the other hand, can be large enough to handle four lines with sixteen characters per line.

- *Number of screens.* For both permanent and portable VMSs, a maximum of two message screens is desired. However, the methods for deriving this maximum vary slightly due to differences in VMS size, legibility distance, and placement relative to the road.

CONCLUSIONS

The conclusions drawn from this study have been incorporated in the manuals, and would be redundant here. However, seven lessons are noteworthy:

1. *Effective VMS use requires a complex thought process, despite the apparent simplicity of the messages.* There is more to operating a VMS than is evident to the motorist who drives past one. In this respect, VMSs are not unlike other highway information media such as permanent static signs, slow/stop paddles, and work zone devices like safety cones or orange barrels.

2. *Other components of VMS operation are as important as the message itself.* While designing the message is the most obvious step in VMS use, other equally significant components include whether or not to use a VMS, determining the explicit purpose of the VMS, placement of the VMS, coordination with other information media, and collecting, verifying, and updating the information.

3. *Message credibility is essential.* The literature, the focus groups, and VMS operators concurred that displaying inaccurate information will result in motorists disregarding the VMSs, thereby rendering them useless.

4. *VMSs can disseminate very limited information to the motorists.* Given the technological capability to display up to six message screens, operators can easily display a message containing too much information. However, motorists travelling above 55 mph can only read a two-screen message with difficulty.

5. *Due to their information limitations, VMSs can provide alternative route guidance for unfamiliar drivers only if used in conjunction with another information medium.* Given that portable VMSs should use a maximum of two screens (six eight-character words), they are inadequate to guide drivers unfamiliar with the area through a complex route diversion unless static signs or highway advisory radio are also used.

6. *Effective VMS use requires an investment in personnel, equipment and training.* For VMSs to display accurate, understandable messages, traffic conditions must be continually monitored to provide the information. Resources must also be devoted to training personnel in VMS operation.

7. *Effective VMS use requires decisions about how much and what types of information to display.* Motorists differ in the amount and types of information they desire. As the focus groups pointed out, some motorists do not necessarily want all available information about traffic conditions. VMS operators have an audience with diverse informational needs.

RECOMMENDATIONS

To maximize VMS effectiveness, VDOT is advised to implement the following recommendations. These items concern policy actions to be taken by VDOT and technical assistance efforts to be made by VDOT and VTRC.

1. *Develop pilot courses for effective VMS use.* VTRC should develop and teach two pilot courses for VDOT VMS operators, and eventually private sector personnel, on how to use a VMS effectively. One course would be for operators of permanent VMSs, and one course would be for operators of portable VMSs. These courses would introduce the manuals to VDOT field personnel and generate feedback on how to improve the manuals. Initially, course attendees should be VDOT personnel, including traffic engineers, district safety officers, and residency personnel who operate VMSs. Once the courses have been refined, the attendance list should be expanded to include private contractors operating VMSs, and the Virginia Transportation Technology Transfer Center should assume responsibility for periodically teaching the courses. VDOT should also publish the two user's manuals after they have been modified by the feedback from the two pilot courses. Ultimately VDOT should consider using the courses and user's manuals as part of a certification process for VMS operators.

2. *Computerize the portable VMS operator's manual.* Operators already use a computer interface to control VMSs. A computerized version of the manual should be developed by VTRC to work with the existing interface, thereby making the manuals available to operators in a form they can easily use in the field. Because permanent VMSs are used in a highly specialized setting within a TMS, a computerized application of the permanent VMS manual would need to be developed specifically for each VMS. Therefore the first step should be to computerize the portable VMS manual, as such a product could be applicable throughout the Commonwealth.

3. *Periodically update the manuals.* The manuals will probably need to be modified regularly, to reflect the needs of motorists and VMS operators, and changes in VMS technology.

    - *Motorists.* Research is underway to determine what the motoring public wants from VMSs, and the results of such research should periodically be monitored by

VTRC. For example, George Mason University is examining motorists' attitudes toward VMS information in Northern Virginia. That study will entail discussions with twelve focus groups and the distribution of surveys to motorists, where issues such as estimates of delays, alternate route recommendations, and the information needs of familiar and unfamiliar drivers will be addressed.[26]

- *VMS operators.* The field experiences of VMS operators will probably show that portions of the manuals need to be clarified, altered, or deleted. As the manuals have not yet been field tested, VDOT district safety officers and operators at the Northern Virginia TMS and Hampton Roads TMS should be contacted six months after receiving the manuals, and the manuals should be revised based on their input.

- *Changes in VMS technology.* The technical data shown in these manuals are based on flip-disk signs. VDOT has begun to purchase LED VMSs, however, which have different visibility characteristics. LED VMSs have greater legibility distances than flip-disk VMSs, but laterally mounted LED VMSs may become unreadable to the approaching motorist sooner than laterally mounted flip-disk VMSs. As these and other technological changes occur, the VMS manuals will need to be revised.

4. *The permanent VMS manual should be coordinated with the practices of other states participating in the I-95 Corridor Coalition.* It is important to provide consistency in VMS use for out-of-state motorists. For example, VDOT and other members of the I-95 Corridor Coalition should work towards a common standard for what to display on permanent VMSs when no message is needed. Other aspects that need to be coordinated include abbreviations and the types of information conveyed to motorists.

5. *Include VMSs in current motorist education efforts.* VMSs are an accepted traffic control device, and may be worth including in driver education courses. Organizations such as the Virginia Department of Motor Vehicles (DMV) and the American Automobile Association (AAA) should be consulted about discussing VMSs in their courses.

6. *Specify that VMS manufacturers build in a warning about creating messages with more than three screens.* Many VMSs can show a six-screen message, a display capability which may lead operators to believe that motorists can assimilate more information than is possible. Motorists can have difficulty reading even two message screens at higher speeds. A prompt, warning, or software limitation should be built in, to ensure that messages with more than three screens are created only under extraordinary circumstances.

FUTURE RESEARCH NEEDS

Seven operational aspects of VMSs warrant further investigation:

- *Investigate the amount of time required for motorists to read a message screen.* The literature suggests that motorists need approximately three seconds to read a three-line VMS with approximately eight characters per line. Some motorists and VDOT personnel have said that this is more time than is necessary to read a VMS. The advantages and disadvantages of shorter message screen display times (1.0 to 1.5 seconds per screen) should be examined.

- *Conduct field tests to verify the unreadable distances described in this report.* The methods for computing the distance at which a laterally-mounted VMS is no longer comfortably readable because the motorist is driving too close to it are based on previous studies conducted with static signs.[19] These studies presumed that a sign could no longer be safely read by the driver once the angle formed between the sign and the road was greater than 10 degrees. This angle was shown as θ in Figure 1. However, these studies presumed a static sign; also, the 10 degree angle was based on psychological considerations determined in 1940. If the cone of vision for a VMS is different from that for a static sign, or if the psychological considerations of 1940 no longer hold true, then the unreadable distances may need to be recalculated.

- *Investigate the effects of VMS age on legibility distances.* Conversations with consultants, FHWA personnel, and other state DOTs suggest that the reflective materials used in flip-disk and LED VMSs deteriorate with time, adversely affecting legibility distances. If this is true, either better technologies are needed or replacement costs must be scheduled.

- *Update the list of standard abbreviations.* An FHWA list of commonly understood abbreviations was published in 1981 and has not since been updated.[27] An updated list of abbreviations would be timely.

- *Investigate whether motorists prefer symbols to words.* The fact that not all drivers can read the English language warrants an investigation into the use of graphics, such as arrows, Xs denoting lane closures, and other symbols. Specifically, conforming the VMS operator's manuals to international standards should be considered, because some of the driving population holds the AAA international driver's license rather than a Virginia driver's license.

- *Consider using VMSs for travel information.* VMSs could provide travel information in addition to traffic information. For example, VMSs could inform motorists about the availability of parking at bus and subway stops or the availability of carpooling. The advantages of such uses should be investigated as well as their potential impacts on VMS effectiveness.

- *Study the use of mixed-case messages.* Mixed-case messages are said to be easier to read. The disadvantage of such messages is that the legibility distance is reduced unless one can make the lower case letters wider than the upper case letters. However, there may be conditions where the readability of a message is more important than its legibility distance; for instance, in an urban area with many commuters. A better understanding of when to use all capitals and when to use mixed case, and what font capabilities should be specified for future VMS purchases, would be beneficial. Improvements in VMS technology will result in increased legibility distances, and should result in better lettering styles than are currently possible.

ACKNOWLEDGEMENTS

The authors are grateful to those without whose assistance this study could not have been performed. G.T. Bangley, R.M. Burgess, M.W. Campbell, L.W. Galyean, C.B. Harris, W.M. Henry, M.D. Irving, J.D. Kaylor, C.D. Light, R.M. Mosley, C.W. Phelps, B.C. Pierce, J. Sabato, L.S. Sheets, D.R. Smith, J.E. Sours, N.K. Spanks, W.L. Stover, R. Strickler, L.C. Taylor II, and M.K. Tweedy took time to provide input into VDOT VMS practices as well as suggestions for the portable VMS operator's manual. As the study progressed, J. Chu provided input into aspects of permanent VMS operation as well as suggestions for the permanent VMS operator's manual. D.C. Fogg, C.D. Hall, and D.B. Rush expended considerable effort reviewing these manuals. C. Blydenburgh, J. Kennedy, J. Lavely, J. Ponder, and S. Schott are thanked for taking the time to participate in the first focus group. Norman Grimm, of the American Automobile Association, is thanked for his help in coordinating a focus group of motorists. The twelve employees of AAA who participated in the second focus group are also recognized. C. Simmons and D. Warren of the Federal Highway Administration provided information about VMS technologies, legibility distances, and the effects of age on VMSs. E. Deasy and R. Howe alerted the authors to the existence of studies showing that mixed-case text is easier to read and recognize than upper-case text.

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APPENDIX A
VARIABLE MESSAGE SIGN SURVEY

Name: ____

District:____________________Position:______________________

Types of VMS used (manufacturer and model):_____________________________

____

I. Applications of VMSs

Do you use a VMS for any of the following applications? If so, please list the messages that you use for each category. If you use arrows or other graphics, please include these.

A. Construction zone:

B. Accident/Incident:

C. Congestion:

D. Diversion to an alternate route:

E. Weather conditions:

F. Special Events:

G. General transportation messages:

H. Other applications:

II. How the VMS messages are displayed

Please write the settings you use for each of the following parameters. If more than one setting is used, please give the range of settings used. If the particular parameter is not available, please write "N/A". Finally, if the VMS manufacturer gives specifications which you follow, please indicate these.

- **number of frames per cycle** (i.e. if a VMS displays "ACCIDENT AHEAD", and then erases those words and displays "USE ALT. ROUTE", and then reverts back to "ACCIDENT AHEAD") then there are two frames per cycle.

- **cycle length** (i.e. if the message changes, then the number of seconds required to display <u>all</u> the frames of the message)

- **flash rates** (i.e. if the message is flashing, then the number of times a message "flashes" per minute, and the number of seconds that message is visible) Note to readers: "Flash rates" refer to the "blinking rates" used in the report and in the manuals.

- **brightness of the message** (please give settings and the type of sign for day and nighttime operations as well as any variations of these settings)

- character size (height and width)

- distance sign is placed

  -- ahead of the incident/congestion/construction
  -- from the edge of the lane
  -- from other VMSs (if applicable)

- For portable signs only:

  -- number of days sign may be used until drivers begin to ignore it (if applicable)
  -- cones or other safety features used to protect the sign
  -- lateral placement of the sign (which side of the road, distance from the road, etc.)

III. Variations

How is the VMS operation affected by the following? If the VMS is not affected by a particular situation, please write "not affected."

- daytime versus nighttime operation

- variations due to weather

- variations due to the speed of traffic

- variations due to an urban or rural location

- variations among fixed VMSs versus portable VMSs

- familiarity of the driver population

IV. Contractors

Please list contractors in your area that use VMSs. *If you do not have this information, please indicate where it may be obtained (i.e. from a specific resident engineer in your district).*

V. Points for Discussion

If you have ideas relating to VMSs that you would like to discuss at the Traffic Engineering conference, please list them here. Topics might include helpful hints or rules of thumb that you use when operating VMSs, future applications of VMSs, or knowledge of what has worked and what has not worked in the field. **THANK YOU!**

APPENDIX B
FOCUS GROUP QUESTIONS
FRAMEWORK

There are three objectives of the focus group:

(1) to try out selected aspects of the VMS manuals.
(2) to use the focus group as a learning experience for conducting future focus groups on the same topic
(3) to identify needs for further research in the area of traveler information.

The plan below lists questions going from more general to more specific in nature. The goal of the majority of these questions is to achieve objective (1), e.g. to test certain aspects of the VMS manuals. In addition, the range of these questions will help to achieve objective (2), e.g. to learn from the responses to these questions how a focus group might be conducted better after this study. With this goal in mind, we plan to use three different medias: (a) oral communication with the focus group participants (for questions of a general nature), (b) written message samples, and (c) a videotape of a VMS with various messages. Finally, the goal of some of these more general questions is to satisfy objective (3)--to identify additional research needs in the area of traveler information.

With regards to what components of the manuals we will be testing, it appears that there are three broad categories that play a key role. These categories are

A. Purpose of the VMS
B. Amount of time needed to read the VMS
C. Information conveyed by the VMS:
    -- the message which is presented on the VMS screen
    -- how this message is interpreted by other people

CONTENT

Preliminary form

Have the participants fill out a form indicating (a) how much driving they do in a typical week, (b) how they get to work, and if by car, how long it takes them, (c) their driving environment--urban, suburban, rural, and (d) education level. Don't make them put their name. **Guarantee participants that their answers, both on the form and in the focus group, will be kept confidential. Tell them that the session will be taped in order to make sure no answers or comments are lost, but that the audiotape will be erased once the information has been transcribed.**

Refreshments

Juice, doughnuts, and coffee.

Introduction

The Virginia Transportation Research Council is conducting a study on the use of changeable message signs. These signs are sometimes called electronic message signs as they are electronic and can display a variety of messages which may be changed, such as "accident ahead" or "caution." You've probably seen these signs in a variety of areas: sometimes they are off to the side of the road in a work zone, and in a few places in Hampton Roads and here in Northern Virginia they are permanently installed above the highway. For example, permanent changeable message signs are on I-66, the Beltway (I-495), and the Shirley Highway (I-395).

We have developed some guidelines to help our workers use these changeable message signs so that they will be of more help to you. What we would like to do today is find out what you think about these changeable message signs and how we can use these signs most effectively. **We are extremely interested in finding out what the typical driver thinks when she or he encounters a changeable message sign.**

Thus, we would first like to first show you a changeable message sign and ask you a few questions about the use of changeable message signs based upon your previous driving experiences. We would then like to show you a videotape of a few of these changeable message signs in operation and get your reactions.

Finally, I'd like to add that the purpose of this meeting is to get your honest opinions on these signs, so if you feel we should be doing something differently, please let us know. **There are no right or wrong answers!**

Questions

A. Purpose of the VMS

1. What are some stressful or difficult driving situations which you have encountered while driving where you needed information?

2. What kinds of information would make driving safer, easier, or more predictable for you?

3. How would you prefer to get this information: flagmen, signs, radio, etc. Do you have any suggestions for transmitting highway information?

Now show a videotape of a portable VMS with the message "CONGESTION AHEAD" on it.

4. Have you seen changeable message signs while driving? Can you remember what they warned you of? How useful were they?

   possible prompt topics

   -- difficulty reading the VMS (because of the sign itself, weather, darkness, etc.)
   -- message usefulness
   -- message accuracy and credibility
   -- proximity of the VMS to the situation

For all messages, a videotape will be shown of an 8 character per line 3 line VMS. Each message, regardless of the number of screens, will be shown for a maximum of 7 seconds. This presumes a daytime legibility distance of 650 feet and a travel speed of approximately 63 miles per hour. This 650 feet is based upon an FHWA unpublished report and the 63 mph stems from the fact that VDOT tends to use these VMSs mostly on interstates). In the field, however, we will be filming each message for 30 seconds and then Ed will edit the messages.

5. (For this particular problem, show a videotape of I-64 east of Shadwell where one lane has been blocked due to maintenance.)

   Envision yourself on a two lane interstate highway, such as I-66. Suppose that five miles ahead, construction has blocked the left lane, causing a bottleneck or backup at the point where the lane closure occurs. Please rank the usefulness of these messages on your sheet. Mark a "1" for most useful and a "5" for least useful.

message A	message B	message C	message D	message E
ROADWORK	ROADWORK	CAUTION	SLOW	ROADWORK
IN 5 MI	REDUCE		SLOW	AHEAD
MERGE RT	SPEED		SLOW	

After showing the messages, give group members a copy of the messages in order to prompt their comments.

6. Now suppose on that same two lane interstate highway, I-66, there is an accident 5 miles ahead. Assume that you are familiar with the area, that you are traveling east to Washington, D.C., and that you know that Route 29 may be used as an alternate route. Please rank the usefulness of these messages.

Again, it is assumed only 7 seconds are available to view the entire message. Therefore multiple screen messages must be fit within that 7 second window--e.g. 3.5 seconds for the first screen and 3.5 seconds for the second screen. Realistically, this brings up the issue of when is a motorist likely to encounter the message? Therefore, for <u>all</u> two screen messages, we will begin the videotape halfway into the second screen--e.g. show the second screen for 1.75 seconds, then show the first screen for 3.5 seconds, and then show the second screen for 1.75 seconds. This will physically be accomplished by videotaping each screen for 30 seconds and then editing the videotape to show the screens for the correct amount of time.

message A		message B	message C
<u>screen 1</u>	<u>screen 2</u>	ACCIDENT	ACCIDENT
ACCIDENT	ACCIDENT	AHEAD	IN 5 MI
IN 5 MI	USE ALT		
	ROUTE		

message D	message E
ACCIDENT	IN 5 MI
USE ALT	ACCIDENT
ROUTE	USE RT29

After showing the messages, give group members a copy of the messages in order to prompt their comments.

7. When you see the message "ACCIDENT | USE ALT ROUTE" do you think you have a choice or is it required that you use an alternate route? What words make you think you have to act? *(second focus group only)*

8. Suppose you saw the following message on an interstate highway in an unfamiliar area (such as Grand Forks, North Dakota).

ACCIDENT
IN 8 MI
USE RT50

What does this message mean? Is the accident in 8 miles or is Rt 50 in 8 miles? Could this message be changed to make it clearer?

9. Suppose, while sitting in congestion on a major highway (e.g. I-66 or I-395), would the following message be useful?

TRAFFIC
CLEARS
IN 3 MI

10. *(show a video of a blank portable VMS)*
What do you think this means?

11. *(show a video of a permanent VMS displaying the date and time)*

THURSDAY
MAY 12
8:50 AM

What do you think this means?

12. What do you think should be displayed on a permanently installed changeable message sign when traffic conditions are normal?

B. Amount of Time for reading the VMS

Again, I would like to emphasize that this is not a test and that there are no right or wrong answers. Instead the purpose of this is to find out reactions of drivers to these signs, and since we can't ask every person on the road, we are asking you instead.

1. *(show a video of the following messages on an 8 character per line 3 line VMS. Again 7 seconds total time is allowed for each message. The * indicates where viewing will start. For the 3 screen messages, that screen will be shown for 2 seconds, then the next two screens will be shown for two seconds each, and then that screen with the * will be shown for one more second. For the four screen messages, the screen with the * will be shown for one second and then the remaining three screens will be shown for two seconds each.*

BRIDGE CLOSED IN 2 MI	*AVOID 1 HR DELAY	FOLLOW DETOUR	
BAD WEATHER AHEAD	PLEASE BE CAREFUL	*SLOW USE CAUTION	
*TRUCK FIRE AHEAD	LEFT THIRD LANE	MERGE RIGHT NOW	
ROCK CONCERT TRAFFIC	*AVOID 40 MIN DELAY	FOLLOW DETOUR SIGNS	
ACCIDENT 5 MI AHEAD	BEFORE EXIT 100	*EXPECT HEAVY DELAYS	USE ANOTHER ROUTE
I-495 NORTH CLOSED	*USE ALT ROUTE		

After showing each message, ask the following questions

Who could read the message?	*(count hands)*
Who remembers the message?	*(count hands)*
What was the most effective screen of the message?	*(discussion)*

C. Information Conveyed by the VMS

We would now like to show you a series of messages which are displayed by changeable message signs. After each set of messages, please tell us how you would react.

1. *(Show the following message and tell viewers to envision themselves again on an inter-state highway with two lanes in each direction.)*

   RIGHT
   LANE
   CLOSED

   How would you react to this message?

   (Then show the following two screen message)

RIGHT	MERGE
LANE	LEFT
CLOSED	

   Would you react differently to this message than the previous one?
   How many people prefer the first message?
   How many people prefer the second message?
   How many people did not understand the first message but did understand the second message?
   Does the meaning of the message change with the addition of the screen "MERGE LEFT?" If so, what is that change?

2. Suppose you are on an interstate highway such as I-66, with two lanes in each direction. Suppose further that the right lane will be blocked due to construction 3 miles from the sign. Please rank these six messages, again with a 1 for being the most useful. *(After the viewing of the messages, focus group members will each be given a copy of the messages.)*

message A

RIGHT <<<<<<<
LANE
CLOSED

message B

RIGHT MERGE
LANE LEFT
CLOSED

message C

<<<<<<
IN 3 MI

message D

LANES
CLOSED
| |X|

message E

entire screen filled by a left pointing arrow

message F

arrow scrolling across the screen:

<< 1 sec
<< 1 sec
<< 1 sec
<< 1 sec

Possible prompt topics:

- -- Arrows and diagrams versus words
- -- possible confusion with "right" and "left" in the same message

3. Suppose you saw this message and you were familiar with the area (i.e. if you are familiar with I-66, then suppose you are on I-66 and you know that Route 29 may be used as an alternate route).

screen 1	screen 2
ACCIDENT	USE ALT
IN 4 MI	ROUTE

Would you take the alternate route?
What information would you need to take the alternative route?

If you were **unfamiliar** with the area, would you take the alternative route?
What information would you need to take the alternative route?

4. Suppose you saw the following message:

ACCIDENT
AFTER
EXIT 100

What does the word "after" imply? For example, how soon after exit 100 is the accident?

If you have any other comments about VMSs or about how we could better conduct this focus group, please let us know.