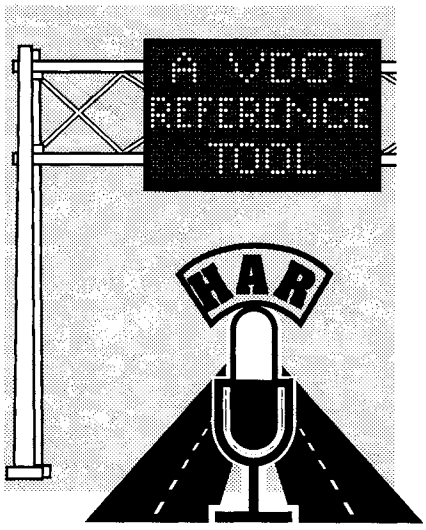
TECHNICAL
ASSISTANCE REPORT

GUIDELINES FOR THE EFFECTIVE OPERATION AND CONTROL OF VDOT PERMANENT VARIABLE MESSAGE SIGN AND HIGHWAY ADVISORY RADIO UNITS: STATE OF THE PRACTICE AND RECOMMENDATIONS



JOHN S. MILLER
Research Scientist

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Virginia Transportation Research Council
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Several persons contributed information and insights for this report. These persons are thanked for their assistance, but the author alone is responsible for the ideas expressed in this document.

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LIST OF ACRONYMS

EIS	Emergency Information Systems (software employed by the statewide Traffic Emergency Operations Center for maintaining incident-related information)
EMS	Emergency Medical Services
FHWA	Federal Highway Administration
HAR	Highway Advisory Radio
IEN	Information Exchange Network maintained by the I-95 Coalition
ITS	Intelligent Transportation Systems
NovaTMS	Traffic Management System for I-66 and I-395 in the Northern Virginia District
NTCIP	National Transportation Communications ITS Protocol
POC	Point of contact (a district representative who would coordinate VMS and HAR operations with the statewide Traffic Emergency Operations Center)
SIM	The Virginia Department of Transportation's Statewide Incident Management Committee
SSP	Safety Service Patrol
TEOC	Statewide Traffic Emergency Operations Center
TMC	Traffic Management Center
TMS	Traffic Management System for the Suffolk District
TOC	Traffic Operations Center for the Northern Virginia District
TTF	Tidewater Tunnel and Toll Facility (in the Suffolk District)
VDOT	Virginia Department of Transportation
VMS	Variable message sign (also called a changeable message sign)
VTRC	Virginia Transportation Research Council

ABSTRACT

On January 31, 1996, VDOT's Statewide Incident Management (SIM) Committee requested that guidelines for the control of permanent variable message sign (VMS) and permanent highway advisory radio (HAR) units be developed. The guidelines do not address specific operating procedures, such as what words should be used in a message or how long a message should be played; they concern who should control the operation of fixed-site VMS and HAR units proposed for installation over the next 6 years throughout the Commonwealth. The goal of any method of control should be to enhance the application of these devices for communicating real-time information to motorists.

For districts without a 24-hour traffic management facility, control of the permanent VMS and permanent HAR units should rest with the statewide Traffic Emergency Operations Center (TEOC). In this report, *control* means that although responsibility for the physical operation of the devices would reside with TEOC, the districts would significantly affect VMS and HAR applications. Since effective VMS and HAR use is costly in terms of personnel and resources, successful applications can be accomplished only by persons who can focus on the task as a job priority. For both planned and unplanned incidents, TEOC should assume physical control of the signs, but the district should provide significant input into how TEOC operates VMS and HAR devices through the district's point of contact (POC). This POC would work with TEOC to ensure the devices are being used effectively at all times.

For areas with a dedicated 24-hour operations facility, currently Northern Virginia and Suffolk, the facility should operate the VMS and HAR units, which is the current practice.

This report explains the rationale for these procedures, recommends related improvements, and proposes that VDOT consider creating a communications unit that would deliver real-time information to motorists. Such a unit appears necessary if statewide incident management is to become more successful.

TECHNICAL ASSISTANCE REPORT

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INTRODUCTION

A variable message sign (VMS), also known as a changeable message sign (CMS), is a programmable traffic control device that can usually display any combination of characters. These signs may be either portable, in which case they can be attached to a trailer and driven to a desired location, or permanent, in which case they are usually installed above the roadway. Highway advisory radio (HAR) units can be used to transmit traffic information to a vehicle's AM radio. HAR may include either a portable or permanent antenna.[1] VMS and HAR units may be controlled from the site, a traffic management center, or even multiple locations depending on the capability of the specific device.[2]

The VDOT SIM Committee's VMS/HAR Strategic Plan Location List shows that 104 permanently mounted VMS and 36 permanently mounted HAR units (fixed-site units) are proposed, planned, or already under construction for operation in the Commonwealth.[3] The capital costs alone for these devices are estimated to be close to $13 million. Additional VMS units will be placed in the vicinity of the 24-hour operations facilities in Northern Virginia and Suffolk.[4] The number of these units has increased significantly since 1994 when VDOT had an estimated 100 permanent VMS units operational in the Commonwealth.[5]

Critical to the utility of these devices is their successful operation. This operation entails continuously monitoring roadway conditions to disseminate accurate and timely traffic information. Unless an agency is willing to commit staff or resources to accomplish this aim, the public will quickly realize that the information is unreliable. Previous research, field experiences, and traffic management system literature in general have emphasized this point. For example, FHWA cites one of the five "functional objectives" of a traffic management center (TMC) to be to "maintain public confidence" where information that is either wrong or not updated will lead to motorists ignoring the TMC.[6] In sum, the high capital cost of these devices does not guarantee that the public will see a good return on its investment. Although initial costs for a permanent VMS or HAR unit might be $100,000 and $20,000, respectively, resources must also be dedicated to maintaining the devices and operating them effectively.

These devices are of special interest to persons involved with incident management, traffic operations, and intelligent transportation systems (ITS) since they are premier mediums for communicating traffic information to motorists. This communication is the backbone of improved traffic operations and is one of the chief methods of reducing congestion. Grenzeback et al. pointed out that one can mitigate the congestion caused by an incident by "diverting traffic before vehicles are caught in the incident queue."[7] The method through which one may reach such an audience once they are in their vehicles is with VMS and HAR.

PURPOSE AND SCOPE

VDOT has already made a large investment in VMS and HAR units and is planning to increase that investment substantially. As of yet, no operational procedures have been established to ensure effective control of these devices for maximum motorist utility.

The SIM Committee requested that operational guidelines be developed for control of the fixed-site VMS and HAR units to be installed over the next 6 years throughout the Commonwealth. These guidelines were not meant to address specific operating procedures, such as the wording or length of a message. Their purpose was to enhance the application of these devices for communicating essential, accurate, real-time information to motorists.

The study had five objectives:

1. Determine the current state of VDOT's VMS/HAR operations. In other words, determine what functional units deploy these devices, the conditions under which they are used, and how staff accomplish this work in addition to other duties.

2. Conduct a survey of selected states to determine their VMS/HAR operational methods.

3. Determine the key issues in communicating real-time information to motorists.

4. Outline the characteristics of the ideal VMS/HAR operational unit.

5. Develop recommendations for the effective use of VMS/HAR in Virginia.

METHODS

The following tasks were conducted during February and March 1996 to help achieve the study objectives:

1. *Discussions were conducted with representatives from several VDOT districts to learn how VMS and HAR units are currently operated.* The author spoke with representatives from two districts without 24-hour operations, Salem and Lynchburg, and representatives from two 24-hour traffic monitoring facilities, the Northern Virginia District Traffic Operations Center (TOC) and the Suffolk District Traffic Management System (TMS). The focus was on who currently operates or would operate VMS and HAR units. The Director of Virginia's statewide Traffic Emergency Operations Center (TEOC) and its emergency operations supervisor provided an overview of TEOC's current and anticipated capabilities. A representative from the Fredericksburg District provided the district's incident management plan and a description of events that occurred when an overturned tractor trailer carrying hazardous materials closed I-95 near Dale City for 14 hours. Representatives from the Bristol and Staunton districts summarized their respective incident management procedures as they relate to portable VMS and HAR applications, and a Richmond District representative described the district's incident management plan. To evaluate the training needed for operating VMS and HAR units effectively and the training currently offered by VDOT, relevant VTRC publications and a representative from VDOT's Maintenance Training Academy were consulted.[8]

2. *Personnel familiar with the operation of VMS and HAR units in selected states were surveyed by telephone to determine their operational methods, especially with regard to centralized or local operational control.* Representatives from California, Illinois, Maine, Maryland, New Jersey, New York, North Carolina, Pennsylvania, and Texas were contacted. All personnel were in the state department of transportation (DOT) or an associated agency. California was selected because it has produced an HAR operations guide. The other states were selected because they were either members of the I-95 Corridor Coalition or thought to be familiar with VMS applications.

3. *The report of a hazardous materials incident in the Fredericksburg District was used to identify additional key issues in communicating real-time information.* Discussions with representatives from the district, the Northern Virginia TOC, and the Northern Virginia Traffic Management System (NovaTMS) clarified some of the details of the response to an incident that occurred on I-95 in October 1995.

4. *Incident management literature was reviewed to develop the characteristics of a model VMS/HAR operational unit.*[9,10,11]

5. *The SIM Committee was asked to review the report and provide feedback.*

CURRENT VDOT OPERATIONS

VDOT has several organizational arrangements that affect VMS and HAR operations. VDOT is a member of the I-95 Corridor Coalition, which affects how devices are coordinated with other states. VDOT also has one statewide 24-hour operations center, two regional 24-hour monitoring facilities serving their respective urbanized area, and nine districts that operate during regular business hours. VDOT's Maintenance Training Academy is also relevant as it could play a role in VMS and HAR training.

I-95 Corridor Coalition

The I-95 Corridor Coalition is a consortium of national (e.g., FHWA), state, local, and private agencies from Maine to Virginia that coordinate ITS applications, including the sharing of traveler information, along the I-95 Northeast Corridor. The Coalition has planned several projects that directly affect Virginia, such as the implementation of HAR and VMS units in the member states, expanded traveler information services that address multiple modes of transportation and commercial vehicle operations throughout the corridor, and incident detection applications. The Coalition also maintains an Information Exchange Network (IEN), which is a system that allows agencies from Maine to Virginia to share real-time information. This currently includes incident data and will be expanded to include additional facts, such as the location of VMS and HAR units and possibly the availability of other modes of travel.

Statewide Control

In part, the mission of TEOC, located in Richmond, is to coordinate state and regional responses to incidents where dissemination of information to the public is a priority. TEOC maintains a statewide perspective of traffic conditions. It operates 24 hours per day and is staffed by a director, a hazardous materials officer, an emergency operations supervisor, and six watch officers, with plans to expand to nine. At least one watch officer is present at all times, and usually two or more are present. TEOC is also linked to members of the I-95 Corridor Coalition through the IEN. TEOC does not have traffic monitoring devices to collect roadway data. It obtains information from VDOT districts and the IEN.

TEOC employs Emergency Information Systems (EIS) software to track incidents, countermeasures, and resulting effects such as roadway conditions. The software also has the capability to include an inventory of portable VMS and HAR units available throughout the Commonwealth, although the actual data are not yet available from the districts. The software allows TEOC to share data with the nine district offices and the traffic monitoring facilities in Northern Virginia and Suffolk. Finally, TEOC spends a substantial amount of time providing details about nonemergency conditions. For example, one representative explained that during

times when there is no emergency, 90 percent of the calls received via the Highway Helpline concern VDOT work zones.[12]

Districts With a 24-Hour Traffic Operations Center

VDOT has 24-hour monitoring facilities in the Northern Virginia and Suffolk districts.

Northern Virginia District

In Northern Virginia, a 24-hour TOC, in conjunction with an older traffic management system (NovaTMS) and the Safety Service Patrol (SSP), is responsible for 100 permanent VMS units, 60 of which can be used to provide motorist information, and 5 permanent HAR units. Currently, NovaTMS operates these devices, although they will soon be able to be controlled by either NovaTMS or TOC. TOC also plans to install 100 VMS and 14 HAR units, which TOC itself will be able to control. TOC and NovaTMS combined have 32 staff persons who can control the VMS units and will be training 6 persons to operate the HAR units. The application of these devices, whether for construction, maintenance, special events, or unplanned incidents, is supposed to be handled through TOC, and TOC assumes responsibility for notifying TEOC when necessary. TOC also has a working knowledge of the location of portable VMS and HAR units and how long it would take to activate them should they be needed. In addition, TOC can coordinate with the appropriate functional units (NovaTMS, SSP, or Fairfax County Police) to deploy these devices.

TOC is physically separate from NovaTMS but is hoping to have all the capabilities of NovaTMS in July 1996. This will mean TOC will have access to NovaTMS's traffic monitoring information from fixed camera sites and loop detectors as well as NovaTMS's ability to control more than 900 traffic signals in the Northern Virginia District. TOC also expects to be able to control all VMS units currently operated by NovaTMS, although this capability cannot be verified until it is tested, which is expected to occur in July 1996. TOC already has access to other sources of traffic information, such as video from a camera borne by a Fairfax County Police Department helicopter during peak travel times, weather information systems, and the EIS software that TEOC uses in conjunction with the VDOT-wide area network to transmit information from the I-95 Corridor Coalition and other sources. As of yet, TOC does not have a direct link to the Coalition but expects to obtain that information in the future from either the Coalition or TEOC.

Suffolk District

TMS operates all fixed-site VMS units in the district except those operated by the Tidewater Tunnel and Toll Facility (TTF). A total of 28 staff are employed by a private

contractor retained by VDOT: 16 work in maintenance and 12 work in operations. At any given time, 4 are in the TMS control room and 5 are serving as part of SSP. TMS is unique in that it is staffed not only by VDOT employees but also by a contractor.[13] TMS does not have an inventory of the portable VMS or HAR units owned by TTF or the VDOT residencies or area headquarters and does not receive information directly from the I-95 Corridor Coalition. As will be the case with TOC after July 1996, TMS can monitor traffic conditions using information from many sources such as loop detectors, ground cameras, and the EIS software available from TEOC.

TMS and TTF currently operate independently with respect to VMS and HAR: only TTF controls its VMS units, although a TTF representative noted that TMS and TTF will be integrated in the future. TTF generally lets TMS know when a major event will occur, such as a lane closure, but TTF is not responsible for traffic management throughout the region. TTF also controls HAR units in the vicinity of the tunnels but noted that the units have been in place for 13 years and are not generally used, partly because of their limited range. HAR unit upgrades are expected in the future, but their control has not been resolved. The TTF representative noted that with the new HAR units he expects there will be coordination between TMS and TTF.

Districts Without a 24-Hour Operations Center

A quick look at four of the remaining seven districts (Bristol, Lynchburg, Staunton, and Salem) suggested that each district has its own procedures in place for handling incidents and, if permanently mounted VMS and HAR units were available, would have its own method for controlling the devices. Except for the Fishersville Area Headquarters, which monitors I-64 on Afton Mountain for fog, none of the remaining districts currently has a 24-hour monitoring facility or permanent VMS and HAR units operated by VDOT. The City of Lynchburg operates four VMS units through its police department, and in the future all VDOT districts will have permanent VMS or HAR units.

In the Bristol District, one criterion for VDOT assistance is that if one lane of an interstate is expected to be closed for more than 1 hour, the district safety officer or the replacement on call is notified by telephone. The district safety officer then notifies one of four incident management teams, each of which is based at a residency, that assistance is needed. The team leaders and district safety officer have beepers in case an incident occurs after hours. Thus, all requests for assistance with managing an incident come through the district office.

On the other hand, in the Staunton District, incidents are handled directly by the residency. The State Police contact the appropriate residency for assistance when an incident occurs. Both districts have a working incident management plan.

A representative from the Salem District noted that the district's incident management plan is being created and that three employees (one traffic engineer and two technicians) could

assume the role of incident management coordinator if necessary. Generally, the district has more experience than most of the residencies with using portable VMS units, thereby placing the district in the role of advising residencies on how to operate the devices better. The district and residencies are also beginning to use VMS units more for different types of applications, such as construction, special events, and maintenance. Experience with VMS and HAR varies throughout the district: for example, one residency often uses HAR to direct football game traffic and has assumed permanent control of a portable HAR unit for that purpose. This is an exception, however.

Were permanent VMS and HAR units suddenly to be installed in the Lynchburg District, the district would rely on assistance from TEOC, residencies, or affected localities for operating them. A Lynchburg District representative highlighted the importance of coordinating application of the devices with the affected localities: for example, when Route 58 is blocked and diversion routes are being considered, the cities of South Boston and Danville need to be involved. The district has between five and eight persons involved with preparations for incident management, such as updating sketches for how to divert traffic if necessary.

Representatives from all four districts believe that both VDOT, through its district and/or residency units, and localities should affect how the devices are used. The Lynchburg District representative, for example, pointed out the importance of localities that either operate their own devices or whose roads would be affected by messages placed on the devices. The Salem District representative noted that the district office knows the capabilities of the various residencies and could emphasize to these residencies the importance of real-time information to make the message credible. The Bristol District representative explained that the district would want to be notified when messages on its VMS or HAR units were to be changed or deployed, as these would obviously affect traffic operations in the district. The Staunton District representative noted that local input into VMS and HAR messages would be useful, especially considering that current incident management procedures involve the cooperation of the State Police with a particular VDOT residency. A reason for involving the residency first, rather than the district, is that the former's staff are more aware of the details of the roadway in the specific area.

Training

VDOT has a Maintenance Training Academy that may begin to play a role in training for incident management for the various VDOT districts. An Academy representative noted that course materials on incident management have recently been made available to Virginia by the U.S. DOT and that the Academy, with TEOC assistance, will tailor the course to Virginia's needs and then teach it to various VDOT functional units. (Exactly how this will be done has not been established.) The Academy has not taught any courses on HAR but is looking at developing a course on portable VMS units with VDOT's Traffic Engineering Division. The 24-hour operations centers develop their own training regimens for their staff; a TEOC representative

explained that about 1 month's training is required before a new employee can begin to serve as a watch officer. The training entails a variety of functions, such as answering telephone queries, updating the incident management software's database, and working with other agencies.

OPERATIONS IN OTHER STATES

As detailed in the Appendix, some states use central control and some use local control to operate their VMS and HAR units. The New Jersey North Operations Center, the New Jersey South Operations Center, the Maryland State Highway Authority, and the Illinois Tollway Authority have a centralized philosophy for operating VMS units. The New Jersey Turnpike Authority operates HAR units from a centralized location. Other states, such as North Carolina, Texas, and Maine, have a more localized control procedure, depending on the availability of resources. The routine sharing of control of VMS units between functional units appears to have been successful in some locations, such as Austin, Texas, and Charlotte, North Carolina. In a couple of instances, agencies other than the state DOT can operate the devices under certain circumstances.

KEY ISSUES IN COMMUNICATING REAL-TIME INFORMATION TO THE PUBLIC

A representative from the Fredericksburg District provided a copy of the district's incident management plan as well as a critique of the multiagency response to a crash that involved an overturned hazardous materials commercial vehicle on I-95 in late October 1995. Information gleaned from the critique highlights key issues that will be faced by any VDOT functional unit when trying to disseminate information.

1. *Most important, information dissemination needs to be a priority for one party that will take a proactive approach to accomplishing the task.* During the incident, confusion resulted when the fire unit at the scene told the district public information officer that VDOT's services for information dissemination were not required and would be handled by the county's public information officer. The county's officer did not notify the county's emergency operations center, which caused further problems such as certain commercial radio stations not broadcasting updated details of the incident.

2. *Obtaining credible information is a continuous process.* At 10:30 A.M., approximately 5 hours after the crash occurred, it was estimated that two lanes would be opened by 1:30 P.M., but they were opened at 7:30 P.M. The lack of a public information officer at the scene prevented updated information from becoming readily available. A TOC representative pointed out that they received only a couple of

telephone calls from the area; this lack of feedback about how events are progressing prevents one from letting motorists know the severity of an incident.

3. *The severity of an incident is not always known at the outset.* The responders to the incident realized as they began to try to contain the hazardous materials spill that they needed additional equipment. This implies that a monitoring agency will need continually to reassess the message being communicated to motorists regardless of the communications device. This further implies that there will not always be a clear-cut division between what constitutes "emergency" or "normal" conditions because the severity of an incident is not always clear when it first occurs. If multiple messages are desired, it seems that prioritizing them could become a substantial part of VMS or HAR operation.

4. *Constant contact with other agencies is crucial to obtaining timely data.* Although VDOT may not control all aspects of an incident, it will be held responsible by the motoring public for getting updates from other agencies such as EMS. In this case, VDOT had difficulty in getting all the information it needed: the fire department on the scene was not receptive to VDOT's inquiries. There will be instances where VDOT may have to interview agencies aggressively. (This does not mean VDOT representatives should not listen to those who are in charge of incident response; it simply means that VDOT will likely need to have staff available to collect information from agencies whenever these agencies can provide it.)

5. *Strengths and weaknesses of alternate routes need to be known.* The chosen detour route was not able to accommodate tractor-trailers making a turn at a particular intersection, and matters might have been helped if traffic had been diverted at an earlier exit. This exacerbated traffic control problems on a route that was already over capacity.

6. *A single point of contact is desirable.* A TEOC representative noted that one advantage of Fredericksburg's style for responding to incidents is that a single emergency operations coordinator is responsible for communicating with TEOC. Other districts use several persons to fill that role. Confusion about the relationship between TOC and NovaTMS resulted in representatives from NovaTMS not being asked to participate in the incident critique, which underscores the need for a single point of contact for events concerning another jurisdiction.

7. *A knowledgeable, centralized information disseminator is needed for imperfect situations.* The Fredericksburg contact asked TOC to activate "variable message boards" but did not specify portable or permanent. When NovaTMS received the request from TOC, it responded by activating certain permanent VMS units but not the portable devices, as they were not specifically requested. The missing element in this instance was a checklist to ensure that everything possible was done or

considered to respond to the incident. There will continue to be instances when callers from the incident scene will not specify all the equipment necessary. At the receiving end of those calls, however, there is a need for a single entity that will consider all the appropriate courses of action (e.g., activate a portable VMS, use a static sign, call the fire department) even if the caller from the scene does not enumerate them. The entity therefore needs both the responsibility and the authority either to perform the necessary actions or to designate someone else to do them. For example, if that entity is TOC, then TOC would be responsible for making sure that all actions were taken, such as activating portable VMS units. TOC would also need the authority to perform these actions; for this particular task, that authority would entail having NovaTMS or SSP activate the portable VMS units. This does not mean the physical duties of NovaTMS and TOC must be altered; it means that one entity would be charged with seeing that the necessary tasks are requested and performed.

8. *An evaluation procedure is needed that is critical enough to indicate necessary changes yet palatable enough so that affected players continue to be involved.* One of the clear challenges to incident management is getting multiple agencies to agree to work together in spite of their varying foci. The incident management coordinator noted that the critique did make headway on some problems: for example, when the multiple players discussed the incident, they figured out why portable VMS units and certain permanent VMS units were not activated and what steps should be taken to use them in the future. On the other hand, some problems, such as the lack of a VDOT public information officer on the scene, were still not resolved. When asked, the coordinator responded that a uniform evaluation procedure could be useful because it would help ensure that future critiques covered the necessary topics, rather than dwelling on one component of incident management.

9. *Documentation of the key points of a critique is essential if lessons are to be learned for posterity.* Although the written critique hinted at several possible areas of improvement, a conversation with the district's emergency operations coordinator was required to discern the major issues. Further conversations with other personnel were required to clarify VMS issues, such as the need for TOC to be given continual information about the nature of an incident, the need for better communication between TOC and NovaTMS, and the need for TOC to be the first point of contact for events affecting TOC or NovaTMS. A NovaTMS representative further pointed out that problems were exacerbated by the fact that NovaTMS was not notified about the crash until 10 A.M., in spite of it having occurred almost 5 hours earlier. Such information was not clearly documented in the critique. The critique also did not specify which permanent VMS units had been deployed and what types of messages had been placed on them. Without this information, one cannot know why traffic continued to back up in Stafford: was it because too few VMS units were deployed, VMS units were activated but not soon enough, VMS units were activated but not worded strongly enough, the permanent VMS units are simply not in the right places

to divert traffic, motorists did not know where to divert, motorists did not believe the VMS units, or another reason? A single good critique will not answer all these questions, but VDOT may make progress by documenting well what happens during several incidents. Even if the VMS problems are resolved for this particular area, the lessons are worth passing on to other jurisdictions that will likely encounter the same issues in the future.

CHARACTERISTICS OF THE IDEAL VMS/HAR OPERATIONAL UNIT

The ideal VMS/HAR operational unit would recognize an incident as anything that reduced the capacity of the roadway, whether the incident was planned, as in the case of a work zone or special event, or unplanned, as might be the case with a disabled vehicle. Therefore, it is suggested that an ideal unit would have these 11 characteristics:

1. *The unit is highly trained to use the device.* Publications regarding the use of HAR and VMS units suggest that successful operation of the devices will require substantial, periodically updated training and that reliance on only canned messages will not be sufficient. Low staff turnover would directly facilitate this ideal.

2. *The unit is specifically responsible for using the device.* The unit has a vested interest in using the device effectively. This does not mean that operating the device must be the only job duty of the unit, but failure to have successful operation of the device as a priority means that in practice time-consuming details, such as monitoring the situation, will not be accomplished.

3. *The unit can ensure that there is always a person who can control the device.* Motorists quickly grow accustomed to the same message and will learn to ignore the device unless there is a person who can alter the information as necessary. To prepare motorists for changes in traffic conditions, updated messages reflecting changed conditions need to be provided within minutes, rather than hours, after the change occurs. Thus, the unit needs to be able to update messages quickly.

4. *The unit is able to receive immediate feedback about how the device is working.* The roadway is a dynamic environment with motorists, traffic conditions, and even work zone lane configurations in a state of flux. Specific situations will occur that were not addressed previously or in training, and the unit needs to be able to know whether the device's intended message is being received, understood, believed, and followed. This feedback may come in the form of motorist complaints or police reports via telephone, observations of traffic flow from a monitoring screen, or another medium; the important aspect is that the unit needs to receive and respond to this feedback.

5. *The unit has a procedure for evaluating the long-term effectiveness of the device.* Over time, particular problems may begin to become apparent that were not visible in the short run, such as certain types of messages being believed to be false or certain diversion routes being unacceptable. The unit would ideally have a formal evaluation procedure that serves as a tool for improving the quality of the information being disseminated.

6. *Lessons learned from short-term and long-term feedback are incorporated in future training.* This ties characteristics 4 and 5 into characteristic 1: what works and does not work for a particular location or situation needs to be assimilated into future operating procedures and training. Again, a low turnover rate would facilitate this.

7. *The unit can coordinate messages with other jurisdictions.* Localities, other VDOT districts, and other states may have information that is critical to travelers, and the unit needs to be able to convey this information to them. For example, if an incident happens on I-95 in Maryland, the unit needs to know what information, if any, should be conveyed to travelers on I-66 in Manassas. *Thus the unit would have a global perspective rather than think only of a particular jurisdiction.*

8. *The unit can prioritize messages well.* As the number of VMS and HAR units increases (along, unfortunately, with the number of incidents and work activities on the roadway), there will be a larger body of information that concerns travelers. The unit needs to be able to resolve how much information should be passed on to travelers and at what stage. In the event of a crash on I-95 in Maryland, for example, the unit needs to determine whether information concerning that crash should override information about, say, a crash elsewhere in Virginia, an upcoming special event that will affect local drivers, or a work zone nearby. The answer will obviously vary according to the location and severity of the planned and unplanned incidents.

9. *The unit has a means for continuously verifying the information to be communicated.* Not only does the message need to be checked before its dissemination, but the situation defining the message must be monitored. For example, a contractor may begin work later than anticipated or may finish early, meaning the associated message denoting a lane closure would need to be changed. Unplanned incidents can change traffic conditions rapidly, making the need to monitor the situation even more crucial. Even though VDOT might not control the behavior of other agencies, such as EMS, the unit needs to know what these agencies are doing in order to include the necessary information in the message. Unfortunately, acquiring this information may not be easy.

10. *The unit can ensure that the messages transmitted via VMS and HAR are consistent with other media.* A variety of tools are possible for alerting motorists to incidents,

such as commercial television and radio, static signs, the Internet, the Highway Helpline, travel clubs, public information brochures, and even local newspapers. VMS and HAR messages should be part of this systematic approach to disseminating information. This includes any devices that might be used by contractors.

11. *The unit knows the area.* Aspects such as the composition of the motorist population, the availability of alternate routes, changes to the roadway network (e.g., construction zones), and coordination with local jurisdictions and contractors need to be known by the unit. Comments made by VDOT employees and other state DOT personnel emphasized this notion. In VDOT's case, a person such as the district incident management commander will have this local knowledge.

The burden of these 11 characteristics will likely increase over the next 6 years. For example, the IEN available in TEOC will include traffic information concerning other states (e.g., a truck crash in Pennsylvania on I-78). Monitoring this information; determining which, if any, devices in Virginia should provide messages alerting motorists to the incident; and then resolving whether the updated message should override messages already on the devices will require personnel who can focus on that task.

Since VMS and HAR devices are being placed on major thoroughfares, units must be concerned with both local drivers and through travelers; the latter will not know VDOT district boundaries. VMS and HAR operation will not make life easier for those charged with carrying it out. These persons will provide a service demanded by VDOT's customers, and the units should be operated to meet this objective.

STRENGTHS AND WEAKNESSES OF VDOT'S CURRENT VMS/HAR OPERATIONS

It is straightforward that VMS and HAR units in districts with a 24-hour operations center should be controlled by the respective center. Currently, only two districts, Northern Virginia and Suffolk, fall into that category.

For the remaining seven districts, the question arises as to whether the district should control the devices as part of its regular duties during the 8-hour day or whether control should reside with TEOC. Certainly, staff at both locations can learn how to operate VMS and HAR units effectively, and staff at the district level will have knowledge of the local area that will help greatly in maximizing the utility of the devices. In theory, the 11 characteristics discussed previously could be achieved by any VDOT functional unit that was willing to commit the resources to make HAR/VMS operation a priority.

In practice, though, the long-term benefits of VMS and HAR operational units will be determined by their ability to convey real-time information on a continuous basis, where the key

is *reliability*. The unit should, therefore, be an entity whose primary focus is making sure that the correct information is disseminated. Within this context of reliability, key challenges facing Virginia as it looks ahead to operating VMS and HAR are maintaining their credibility, integrating them with other information dissemination methods, and maximizing their effectiveness. TEOC has as part of its mission a vested interest in all three areas: credibility is a priority because of TEOC's focus on information, integration is a priority because of the diverse ways in which information arrives at and is disseminated from TEOC, and effectiveness should increase because of TEOC's routine practice of training and updating staff in other areas. In fact, TEOC's mission statement explicitly defines the Center's role as being ". . . responsible for keeping the public informed during normal and extraordinary conditions, managing the flow of information across field units."[14] TEOC thus has a clearly defined role as a coordinator of information across district boundaries, whereas the districts themselves would have to perform that duty on top of their other responsibilities. The fact that individual districts can place different degrees of emphasis on incident response further suggests that a centralized approach complemented with local knowledge would enhance the reliability of the VMS and HAR messages. The impetus for this centralization is to give a single entity the specific responsibility for doing a particular task well.

Two of the problems encountered with the Fredericksburg incident illustrate the need for VMS/HAR operation to be a full-time effort: (1) certain VMS units were not activated in a district with 24-hour operations, and (2) no VDOT public information officer was on the scene in a district without 24-hour operations.

1. *District with 24-hour operations.* The problem appears to be progressing toward resolution: the Fredericksburg representative stated that TOC recognized that additional steps needed to be taken to ensure that all VMS units on I-495, I-395, and I-66 were used and that TOC and NovaTMS had made the appropriate arrangements. One may debate whether a solution has been found, as representatives from TOC, NovaTMS, and the Fredericksburg District expressed the continued need for better coordination and more consistent procedures with regard to VMS operation. It appears, though, that at least steps are being taken to be better prepared for the next incident. In this case, TOC—a 24-hour facility—has specific responsibility for VMS/HAR operation along with other incident management duties and has moved toward solving this problem.

2. *District without 24-hour operations.* The lack of a Fredericksburg District public information officer on the scene has not been resolved. Since the district does not have 24-hour operations, the officer has other duties during a regular 40-hour week. Thus, response to an incident during off hours comes on top of these duties. VMS/ HAR operation does not fit into a "business hours only" category. It needs to be the responsibility of an entity that operates 24 hours daily. Further, although a public information officer has the role of communicating with the media, such a person will not necessarily be trained to obtain the accurate traffic flow information that would be

essential to determining alternate routes or estimating the length of a delay. Yet successful VMS/HAR operation will require access to that type of data. In this case, the district does not appear to be moving toward resolution of an important issue.

A salient feature of what has been faced by other states is the element of cooperation. For example, North Carolina, New York, and New Jersey gave examples where districts, or the equivalent thereof, affected how VMS units were deployed. It is apparent that VDOT districts have knowledge of particular situations that should affect how HAR or VMS units are applied, such as coordination with residencies, area headquarters, or incorporated cities. Knowledge of the roadway was necessary, for example, to establish a diversion route for the incident on I-95 in Stafford County. Input from districts is not only encouraged but essential for VDOT, through TEOC, to respond to both planned and unplanned incidents. A dialog between TEOC and the districts is critical to accomplishing this mission. The attitude exemplified through the comment made about the South New Jersey Operations Center is relevant, where the Center is viewed as a resource that assists the various districts with traffic operations.

In brief, the employees in districts without 24-hour operations will have duties in addition to VMS/HAR operation. Now, for example, some of these districts do not have updated incident management plans. The fact that training for portable HAR units has not been offered by the Maintenance Training Academy—or requested of the Academy by the districts—suggests that operation of permanent HAR units will be just one of many duties faced by the districts. Many of the 11 characteristics previously discussed—such as prioritizing message applications in real-time, coordinating with other jurisdictions quickly, and continually verifying local and non-local traffic conditions—will require a dedicated staff for regular as well as emergency conditions. Characteristic 1, which points out the need for continuous training, suggests that better VMS/HAR operation would be achieved by fewer staff who spent more of their time operating these devices than a larger number of staff who had to fit that task in with their other duties. In terms of using the devices, a lower turnover rate would result if control resided in TEOC. Centralization of VMS/HAR duties in TEOC would help achieve characteristics 2 and 3, where it can be assured that a person responsible for the device is present at all times. Characteristic 10, which points out the need to coordinate VMS/HAR messages with those being disseminated by other communications devices, could also be handled by a central authority.

A VDOT traffic engineer illustrated how TEOC's involvement would enhance rather than hinder VMS/HAR operation. For example, if an incident were located several miles from a VMS, developing a good message quickly with only a cellular phone and no visual display of the VMS could be harder for a person at the scene than for a TEOC operator who could see the character and line layout of the sign in a computer software display and obtain immediate information from the incident responder. Further, since most of the VMS and HAR units will be located on routes with a large volume of through traffic, the ability to consider the incident's impact on through travelers and prioritize that message with regard to information from other areas is also crucial. This comparison of minor and major incidents will need to be done by an entity such as TEOC that has a broad geographical perspective. In fact, there may be instances

when the needs of local travelers and through travelers are not the same, in which case the operator will have to assess the best approach to take for the situation (e.g., a small incident affecting only local drivers may be of less consequence than a major incident further down the road that affects a larger group of travelers). Finally, making a telephone call to TEOC can be accomplished more quickly than having a district representative drive to the VMS if he or she is not already at the incident scene.

RECOMMENDATIONS

Before VMS/HAR Installation

1. *The existence of "before" data on traffic performance that may be used as part of a subsequent "before and after" evaluation procedure should be verified.* These data might include traffic volumes, crash rates, and other performance measures for the situation being signed. (For example, if the Richmond District were to evaluate the utility of a VMS at the I-295/I-64 split, the delays associated with the "main" route and the "alternate" route during an incident could be obtained.) Consultation with VDOT's ITS Office in Richmond can help a district determine the types of data that would be useful.

2. *VDOT should prepare to conduct a public relations campaign where the public will be made aware of the purpose of the devices.* In the case of VMS units, for example, the district might use local media to let the public know that a blank VMS simply indicates that there is no essential traffic information to be conveyed, not that the VMS is malfunctioning. In the case of HAR units, the district would want to let the public know that HAR units will convey real-time traffic information rather than tourist information only, provided this is true. Assistance with letting the public know what VDOT is doing with these devices should be sought from VDOT's Public Affairs Division. The timing of this campaign should be early enough to ensure the public knows what the devices are doing once they are highly visible, but late enough so that VDOT is not in the difficult position of displaying devices before figuring out most of the "bugs" associated with them. VDOT may wish to consider a statewide public information campaign if deployment schedules are relatively similar in the districts.

3. *The accessibility of VMS and HAR sites should be assessed. Accessibility* denotes both communications access and physical access to the devices. In the former case, the district would want to know how likely it was than an employee could communicate with the district office or TEOC via cellular phone while at the site. In the latter case, the district would want to know how long it would take to reach the device, especially under adverse traffic conditions.

4. *For each district, a point of contact (POC) should be established for the district's VMS and HAR units.* This person would coordinate VMS and HAR usage with TEOC and would obtain input from VDOT district, residency, and area headquarters staff as well as local jurisdictions that are affected by VMS and HAR applications. The POC would coordinate details with TEOC and monitor cases where unforeseen circumstances made it impossible for TEOC to operate the devices, as detailed later. The POC could come from what are historically known as the maintenance or traffic engineering areas; most likely the POC would be the district's incident management commander, as outlined in the district's Emergency Operations Plan. The important aspect is that the POC would focus on operations and recognize that motorist information is one part of that effort.

5. *The technical capability to control permanently mounted VMS and HAR units from more than one location should be provided.* VDOT should have the capability to control VMS and HAR units from multiple facilities, such as TEOC, the other 24-hour centers, the device itself, and the districts, to prepare for disasters (e.g., a TMS disabled by a hurricane), unforeseen circumstances (e.g., an on-site incident responder whose cellular phone and CB are not working), and future organizational changes (e.g., VDOT may find it more efficient for TOC to control Culpeper's VMS and HAR units). It is critical that this capability include updating the control sites about the status of the devices (e.g., a change to a VMS message would immediately be known by the district and TEOC). Use of the National Transportation Communications ITS Protocol (NTCIP) should help this effort, and further investigation into VDOT specifications on this topic will be necessary.[15]

   The technical capability to operate the devices from several locations does not mean this should be the standard practice. Instead, this is meant to add an extra measure of reliability and flexibility as VDOT redefines its organizational structure and needs.

For Districts Without a 24-Hour Operations Center

1. *Permanently mounted HAR and VMS units should be physically operated by TEOC 24 hours per day for both planned and unplanned incidents, where an incident is anything that reduces the capacity of a facility.* In other words, TEOC personnel should assume responsibility for maintaining, changing, starting, or stopping a message unless circumstances render this undesirable, as noted in 6 below. The district should provide significant input into how these devices are operated, as explained in the items that follow.

2. *In preparation for their use for emergency conditions, the POC should be prepared to make TEOC aware of any local concerns regarding the VMS and HAR units.* For example, if consulting with a particular jurisdiction before using a VMS is necessary, this should be made clear to TEOC at the time of an incident. The responsibility for periodically verifying this list of local concerns should rest with the POC, however. For example, the POC could ensure that police and EMS agencies know about the Highway Helpline, as that is a single

telephone number any person can use to notify VDOT about incidents, regardless of the location in Virginia.

3. *Under nonemergency (e.g., preplanned) conditions, the district should take steps to ensure that the devices are being used effectively.* Therefore, when the district would like to activate a device, the following information should be provided to TEOC via the EIS software on a periodic basis (e.g., weekly).

   - *Description of the incident.* Whether a work zone, special event, or future construction activity is the topic, the POC would articulate why the device was needed and any unusual traffic conditions to be expected. For example, an HAR unit might alert motorists to slow-moving traffic where the right lane is blocked or describe how following a particular type of sign would enable them to get to a football game.

   - *Location of the appropriate devices.* The devices to be activated would be included; e.g., one work zone might well be served by using an HAR unit describing the impact of the activity in conjunction with a VMS telling motorists that more information was available via HAR.

   - *Recommended message.* The POC should communicate to TEOC the information to be conveyed to motorists. TEOC could then refine the message wording using resources such as the *VDOT HAR Operational Guidelines*, the proposed *VDOT VMS Operator's Manual*, or the relevant I-95 Corridor Coalition materials.

   - *Local preferences.* There may be aspects of the message that are crucial because of the location of the device. For example, a particular road might be known only by its name or number.

   - *Expected audience.* Whether the message pertains to only local or through traffic or any other identifiable population segment should be included. For example, a message might be applicable to travelers heading to a particular location, such as a naval base or rock concert.

   - *Person responsible for giving a time stamp.* The POC should designate a "time stampee" who would notify the POC the instant the message should be activated, deactivated, or evaluated. For example, if there will be a VMS indicating that two lanes are being closed because of construction, then the time stampee might be a project engineer on-site who could indicate the instant the lane closing process begins. This would preclude VMS messages that are incorrect as a result of anticipated work schedules not being met.

   - *Suggestions for monitoring the effectiveness of the message.* The POC should explain when the message is to be changed or altered. If possible, the POC should also note any methods by which one may discern the effectiveness of the message, such as whether

travelers slowed down in response to a work zone message or whether traffic flows changed as intended. Although this evaluation is optional, there will be instances where the POC and TEOC watch officer develop a method to evaluate the effectiveness of a particular message.

When changes to the anticipated VMS or HAR applications occur, the district should notify TEOC. Cancellation of special events or revised maintenance schedules, for example, would be relevant. It is therefore emphasized that although TEOC would be responsible for using the devices, the district POC would be responsible for coordinating with localities or other local units as necessary.

4. *TEOC should activate the message.* When the district POC has established that a message should be deployed, that person should contact TEOC to activate the appropriate VMS or HAR units. In the event of a relatively new type of application, the POC should evaluate how well traffic responds to the application.

5. *TEOC should notify the district of changes.* TEOC should notify the district POC once a device is being used for a purpose other than the one anticipated by the district (e.g., unplanned incident) or when the message itself is altered (e.g., wording changes). The former would allow the district POC to take the necessary steps, such as notifying localities that a particular route is being used for diversion, and the latter would enable TEOC and the district POC to come to an agreement gradually on how to develop effective messages.

6. *The POC should respond to technical difficulties in unexpected circumstances.* If a district field officer at the scene of an unplanned incident needed to activate a device but was not able to make contact with TEOC, the field officer could elect to operate the device. Such a decision would be warranted should failure to activate the device immediately adversely affect either the safety of motorists or the flow of traffic. Since, however, developing an effective message often requires trained personnel, and since it is envisioned that TEOC will be able to dedicate staff to such efforts whereas districts will not, instances where the district deploys a message without going through TEOC should arise only when it is not possible to contact TEOC.

For Districts With a 24-Hour Operations Center

1. *Districts with 24-hour control should physically operate their own VMS and HAR devices but should coordinate with TEOC as necessary.* Even though it is not on the I-95 corridor, the Suffolk TMS may find information obtained from the IEN beneficial to some long-distance travelers. Thus TEOC should make this information available to TMS through its EIS or VDOT should look into including Suffolk as a site to access the IEN from the I-95 Corridor Coalition.

2. *As appears to be current practice, 24-hour operations centers should ensure that they notify TEOC as necessary when incidents occur.* TEOC could then take action elsewhere throughout the Commonwealth (e.g., incidents in the realm of the Suffolk TMS may be mitigated by alerting drivers in Northern Virginia about them).

3. *The primary point of contact for each district with a 24-hour operations center should be established.* This means clarifying the relationship between a district's 24-hour operations center and any supporting units, such as NovaTMS or TTF. In the case of Northern Virginia, TOC should be the first point of contact. TOC can then make decisions about how to use resources such as NovaTMS and SSP and ensure that all appropriate steps are taken (e.g., deploy portable VMS units) even if these steps are not specifically requested by those at the scene of the incident. This should go hand in hand with letting all areas throughout the Commonwealth know that when an incident occurs, they need to alert TEOC.

   The term *supporting unit* and the concept that it reports to the 24-hour center are not meant to lessen the importance of this entity: NovaTMS plays key roles in monitoring the roadway and ensuring the safety of HOV lane transitions. This report outlines a certain hierarchy so that VDOT can ensure key tasks are not left undone because who should do them was not specified.

Long-Term Recommendations for All Districts and TEOC

Discussions with VDOT representatives in the districts and TEOC resulted in several suggestions for improvements in incident management in general. The following improvements are recommended:

1. *Inventory the portable VMS and HAR units in the district.* TEOC can store information about the location of portable units, and the district's 24-hour control center or TEOC could benefit from using these devices as part of an incident response. As pointed out by a Salem District representative, the district can often quickly explain which devices would be most readily available depending on the incident location. For example, the district could indicate whether a particular residency's HAR unit was already being used for another purpose or was free. Periodically, this inventory would need to be updated. This inventory could be provided to TEOC via the EIS software available in the district offices. As necessary, TEOC and the POC could jointly resolve where to station portable VMS units with cellular capability. They could be stationed at locations where incidents often occurred that were not covered by permanent VMS and HAR units. It makes sense for there to be coordination of permanent VMS and HAR units with cellular-controlled portable units, and TEOC should have the capability to control these in the future. The knowledge of where these devices are located might provide benefits

beyond the scope of this report, such as the ability to place them near high-crash sites to instruct motorists to take a specific action.

2. *Develop a preventive maintenance program for VMS and HAR units.* The Suffolk District representative pointed out that often when they are needed, many portable VMS units are in disrepair. Consequently, the district plans to work with the resident engineers to test the units regularly and ensure they are working. For example, portable VMS and HAR batteries must be charged periodically unless the device is 100 percent solar powered. Having solar capability does not automatically mean a unit's battery will not need to be checked. A preventive maintenance program for permanent VMS and HAR units is also needed: steps such as cleaning the Lexan sheeting may become necessary.

3. *Ensure training is available (and required where appropriate).* Persons who would serve as a district POC or would assist that person, along with the appropriate TEOC staff, should have encouraged access to VMS and HAR training. Several resources are available for learning how to use HAR and VMS units effectively: these include I-95 Corridor Coalition guidelines; a short course to be offered by the Maintenance Training Academy; and VTRC materials such as HAR guidelines, VMS manuals, a VMS training videotape, and short course notes along with instructor's materials. The Maintenance Training Academy may be able to play a pivotal role in training that is not historically a "maintenance" responsibility.

4. *Revise/update the process for developing district incident management plans.* The recommended procedures with TEOC and the district POC will affect incident response. With some districts' incident management plans slated for revision, this is a good opportunity to reexamine the incident response planning process in terms of content and design. Under content, for example, guidance on how to use the EIS software linking a district with TEOC should be included. Under design, a large area of effort has been the preparation of diversion routes. TEOC's geographic information system (GIS), which is being made more accurate with details to the county level being added, may be one way to illustrate proposed diversion routes. This should allow changes to the roadway to be incorporated in these diversion routes. It may also be feasible to have the incident management plan on-line by using the EIS software, allowing names, points of contacts, and procedures to be updated and made available to those in VDOT who need this information. A Fredericksburg District representative noted that the district's plan was out of date except for the maps of the alternative routes. Yet even these maps did not have all necessary information, such as which intersections could accommodate large trucks most easily. An on-line plan could help a district ensure that plans were updated as soon as changes became necessary rather than according to an arbitrarily selected schedule (e.g., yearly, monthly).

5. *Encourage districts to update information in TEOC EIS software.* Currently, TEOC enters data from construction reports into the EIS databases, such as the location of the work activity, duration, work zone layout, expected impact on traffic, etc. Since both TEOC and the districts have access to this network, districts can assist TEOC by providing this information themselves. In return, TEOC can more quickly respond to telephone inquiries on the Highway Helpline about these work activities. TEOC noted, for example, that telephone calls may concern why a particular sign was placed in a particular part of the work zone: if TEOC has full information, it can address the issue and save the district the effort of responding to the call.

6. *Develop a standard evaluation procedure for incident response.* A standard outline for critique of an incident response should be developed for use by districts and TEOC for planned and unplanned incidents. This procedure could be a synthesis of effective components of existing evaluations. Initially, the procedure might include broad steps such as identification of key players; establishment of the roles they played and what their roles should have been; the impact of the traffic layout; equipment that was available and needed; sufficiency of detour routes; adequacy of coordination with TEOC; and how well information was communicated to the public in terms of speed, accuracy, and availability. In the future, though, it is hoped that one could begin to quantify particular measures of effectiveness, such as delays that were avoided, time lapses between information updates, and even how much uncertainty was alleviated for motorists who were affected by the incident.[16] It is understood that many districts currently do evaluate incidents in terms of getting persons together to discuss what worked and did not work. Instituting this recommendation would give these groups a standard format to determine, over time, what areas of incident response needed improvement. VMS and HAR operation would be a component of this response as suggested in the section "Before VMS/HAR Installation."

7. *Provide a forum for district POCs and TEOC to meet periodically.* These personnel should be given the opportunity to meet at least once per year to exchange ideas about what works well and what needs improvement. Representatives from the 24-hour operating centers could also provide insights into the discussion.

Immediate Next Steps

Since these devices will likely be installed at different intervals over the next 6 years, the SIM Committee should evaluate how well the first wave of VMS and HAR units are operated. The results of this evaluation would be used to modify the outlined procedures. Evaluation items would include the following:

- *Staffing levels.* Both TOC and TMS have dedicated substantial staff to controlling VMS and HAR units, in addition to other duties. TEOC may also need more than one or two watch officers to operate fixed-site VMS and HAR units that are not under the control of the Northern Virginia and Suffolk districts. By evaluating how well the first phase of VMS and HAR units are operated, VDOT will have an opportunity to determine whether additional personnel and training are needed for either TEOC or the district POC.

- *Device reliability.* This verification phase will allow VDOT to determine whether TEOC VMS and HAR controllers can be used to verify that the correct message is activated by the VMS or HAR unit.[17]

- *Degree of remote control from TEOC.* This report recommends a model where both the district and TEOC would know the messages on each device. In this scenario, both the district and TEOC could change the message. The standard practice, though, would be for the district to ask TEOC to activate a device to convey particular information. (Should, however, the district not be able to reach TEOC, then the district could operate the device without TEOC's input.) Part of the rationale for this procedure is that TEOC personnel, with a heavy background in designing effective messages, would lend more consistency to the way in which messages were developed. Further, TEOC can prioritize messages, and considering that VMS and HAR units will be on major routes with through travelers, such prioritization will be essential. Members of the SIM Committee have expressed their concern about this arrangement, noting concerns such as delays associated with going through TEOC. Therefore, during an evaluation period, it would be of value to learn the advantages and disadvantages of this control strategy. It is likely that the details of how control should be coordinated between TEOC and the districts will evolve as lessons are learned about what is most effective. Thus, the author recognizes that details of this control method will be refined as the SIM Committee begins to evaluate the first phase of VMS and HAR units installed.

- *Ownership issues.* Clearly, the potential for "turf battles" exist given that two entities would cooperate to accomplish a given task. The ability of these entities to cooperate will need to be assessed.

Given that the capital costs of the proposed devices are expected to exceed $13 million, VDOT should not purchase these devices until a small portion of funds can be set aside to hire additional TEOC personnel, if necessary. Although hiring additional personnel can be difficult to justify in a time of downsizing, it appears that in this case failure to have adequate personnel will result in the devices not being used effectively.

A PROPOSAL FOR A NEW VDOT COMMUNICATIONS UNIT

The Assistant Commissioner for Operations, the State Traffic Engineer, the SIM Committee leadership, and other VDOT management as appropriate should study the advantages and disadvantages of creating a new functional unit dedicated to communicating real-time traffic information to motorists.

VDOT's Expanding Communications Role

VDOT's entry into the communications business necessitates functional units that can consistently provide accurate information. Communications units require some centralization to ensure consistency across district boundaries. For example, to provide an acceptable level of safety in work zones, VDOT's Maintenance and Construction divisions employ the *Virginia Work Area Protection Manual.* Communications units will need to place an even higher priority on consistency of service throughout the Commonwealth. These units will need to address any disparity in incident response performance throughout the districts but will still need local knowledge to target the various traffic streams accurately.

In light of this obligation, the author recommends that VDOT establish a functional unit that would focus on communication of real-time information to motorists at the local and statewide levels. The unit might be given the title of "operations," "systems integration," "communications," or something else; the key feature is that it would emphasize disseminating information to motorists immediately. The Northern Virginia and Suffolk districts have moved in that direction as they have dedicated staff for that purpose. At the statewide level, TEOC has been set up to disseminate information to those who need it. Yet the remaining seven districts do not appear to have sufficient staff whose primary focus is providing such information to motorists. This might be expected, as these districts have had different needs in the past, given the historic contrast of rural and urban areas throughout the Commonwealth. Today, though, increased urbanization is changing the traveler composition throughout Virginia.

The function of information dissemination is carried out by various VDOT divisions, such as Public Affairs and Maintenance, who perform this function in addition to their other duties. This means that as an organization VDOT is not yet prepared to make this form of customer service a priority. This will continue to be the case so long as communications remains an afterthought compared to other VDOT foci such as construction and maintenance. Yet the motoring public is beginning to place as much emphasis on communication of information as on construction and maintenance. For this reason, a communications unit should be established.

The new unit would initially include TEOC, the district POCs, and the 24-hour operations centers and thus would have *connected* statewide and local components. Initially, the unit could focus on learning lessons about what works well: for example, the Suffolk District uses a contractor to operate some of its devices whereas the Northern Virginia District does not; the

advantages and disadvantages of these approaches could be learned. The unit would move toward integrating existing systems, such as coordinating the operation of portable VMS and HAR units with that of the permanent units during both emergency and nonemergency situations. It seems logical that VDOT would want its various communications devices to complement each other, and a communications unit could accomplish this aim. The staffing level of the unit would, of course, vary by district, but it seems likely that customer demands for accurate information are going to increase, with VDOT's responsibility to meet that demand rising accordingly.

Examples of VDOT's expanding communications roles abound. A VDOT employee recalled a remark made in jest that emphasizes this point: 20 years ago, a single individual had the job of "communications" whereas now the individual has been replaced by an entire group of managers. Although the comment flatters the public information stalwart of the past, it also illustrates the importance of communications in VDOT. Evidence includes the Highway Helpline, portable VMS and HAR devices, extensive media coverage of current and planned roadwork, well-advertised public hearings, an ITS staff that is focusing on communications with the motorist, safety service patrols, emergency operations centers, and traffic management centers. Each of these reflects a conscious decision to dedicate resources to accomplishing a new fundamental aim of the agency: communications.

The Need for a Communications Unit

One might argue that an additional unit to concentrate on disseminating real-time information is simply not necessary. The truism "we must do more with less" may tempt management to say that VDOT should simply redouble its efforts to achieve this additional chore. Indeed, many have argued that there are many ways in which VDOT can improve its performance in this arena. For example, VDOT could simply state that all its employees should consider traffic information a priority and, in this vein, that the inspectors at a construction site should work with contractors to ensure that the districts know when work activities are going to occur. Others suggest applying technology: rather than rely on a person to activate a VMS, for example, traffic sensors could automatically trigger a message based on traffic volumes. Finally, one could state: "Management is already aware of the problem and is taking steps to provide a solution. The creation of the SIM Committee and the role of the district incident management commanders are evidence of attention to this need." Thus, one might argue that VDOT would not benefit from yet another organizational unit but simply needs to work harder within its existing structure.

Yet the creation of a communications unit would not preclude any of these possibilities; it would be a catalyst for bringing them about. A communications unit could use these arguments to improve VDOT's performance. Although inspectors and contractors can contribute to such tasks, their salaries are based not on how well real-time information is disseminated but on how well and timely the construction work is done. Consequently, it seems unlikely that an accurate

VMS or HAR message would be a priority on a day filled with time-sensitive construction tasks. Articles in the local media describing blank or malfunctioning VMS units (one was seen by a commuter over a period of several months and another may have contributed to the death of a VDOT snowplow operator) support this argument.[18] Coordination difficulties between VDOT units and contractors are also impediments to letting motorists know what is happening on the roadway.[19] On the other hand, a dedicated communications unit could focus on making sure that VMS and HAR units reflect accurate information about work zones. The unit could also be proactive in learning about new technology that would automate some of the more time-consuming chores behind information dissemination. Finally, the unit could actively focus on coordination with all appropriate divisions, such as Maintenance, Construction, and Public Affairs.

In a reference to architecture, Sullivan noted that "form ever follows function."[20] This applies to VDOT's structure as well. VDOT employees are mandated to "put safety in everything we do" and "maintain the public trust." No manager would ever argue that these goals should not be given the highest priority, regardless of the task at hand. Yet this desired emphasis by management has not obviated the need for a senior transportation engineer who focuses on improving work zone safety or a Fiscal Division. The creation of these functions resulted from a conscious decision that their associated tasks are so important that staff must be dedicated to accomplishing the necessary objectives. If the Fiscal Division did not exist today and VDOT noticed irregularities in its accounting practices, would the appropriate response be simply to require state employees to remember to maintain the public trust?

Yet VDOT, as any organization, is resistant to change. Change is unsettling as it involves shifts in power and control. Any public or private entity can be particularly slow to change if the consequences of inaction are not immediately visible. Failure to respond to market forces, however, will eventually ruin any company. In VDOT's case, these market forces entail a change in what customers want, as well as a change in the number of suppliers. The product, real-time traffic information, can be offered not only by VDOT but by a host of other organizations.

The Paradigm Shift

Barker argued that although it is now a loosely used term, a *paradigm shift* is a change in the fundamental rules of an industry. This paradigm shift can change the fortunes of an organization, especially if the organization fails to see the import of the shift.[21] Barker used the example of Swiss watches to illustrate his point; the Swiss did not see the value of quartz technology and thus forfeited their market share of watches to competitors. VDOT also faces a paradigm shift. Some employees steadfastly believe that the agency should focus on designing, constructing, and maintaining roads, whereas others maintain that VDOT's role is to maximize the efficiency of Virginia's transportation system to keep persons and freight moving. There is a big difference between these two viewpoints.

In the past, VDOT set the rules about how customer service, namely construction and maintenance, was to be performed. Now, and more so in the future, customer service will include the provision of real-time information. VDOT is not yet equipped to be a leader in this new endeavor: unlike with construction and maintenance, other organizations have the power to set the rules about how this service is provided. It is not clear whether VDOT will make a contribution to this new type of customer service, although the failure to do so would not only affect the well-being of motorists but would also be detrimental to other organizations that do try to provide motorist information. For example, even if a commercial traffic information provider collected its own traffic data, VDOT could make a contribution by making VDOT-collected data available in a timely manner.

Neither VDOT nor the author can predict the future. VMS technology, for example, may be rendered obsolete in 15 years by in-vehicle signing efforts. On the other hand, VMS units may be around for longer than suspected. VDOT, however, can at least recognize the importance of changes in technology as they occur and look for applications that will help motorists. Yet it would be a mistake to interpret the advent of various communications tools—VMS, the Internet, etc.—as simply reflecting changes in technology.[22] They also represent a fundamental shift in what motorists want. One way to respond to this demand is to establish a VDOT functional unit that is customer driven, i.e., a communications, systems integration, or operations unit that focuses on the conveyance of essential, accurate, timely traffic information to drivers.

Where Do We Go From Here?

This proposal makes a point of not defining the structure of the new unit. Whether the new unit is called a "division" or is organized in some other manner is not relevant at this stage. Instead, it is necessary to focus on defining a need and then realizing that organizational modification is necessary to respond to that need.

The next step should be for VDOT's management to make a conscious decision about the importance of communicating real-time information to motorists. Briefly put, is information dissemination on a par with other VDOT tasks, such as constructing new roads and maintaining existing roads? *If the answer is no*, then VDOT should consider redefining its mission to be constructing and maintaining roadway facilities. *If the answer is yes*, then VDOT leaders need to begin a dialog with personnel in Richmond and throughout the districts to study seriously the possibility of creating a new unit. Formal consideration of alternatives would be done at this stage. Issues such as the unit's composition, its place within VDOT's organizational structure, interfaces with other VDOT units, and a timetable for its creation would also need to be examined.

NOTES

1. Smith, B. L., McGhee, C. C., Newman, B. R., Jones, S. L., and O'Leary, A. A. 1995. *An Investigation of Operational Procedures for Highway Advisory Radio Systems.* Charlottesville: Virginia Transportation Research Council.

2. California Department of Transportation. 1994. *Highway Advisory Radio Design and Operations Guide,* p. 3-1. Sacramento.

3. This includes a VMS that would be posted on Route 29 in North Carolina near the Virginia border, but the VMS would be the responsibility of Virginia.

4. In Northern Virginia, these locations are on I-95; in Suffolk, these locations are on I-64, I-264, I-564, I-664, and Route 44.

5. Miller, J. S., Smith, B. L., Newman, B. R., and Demetsky, M. J. 1995. *Development of Manuals for the Effective Use of Variable Message Signs.* Charlottesville: Virginia Transportation Research Council.

6. Federal Highway Administration, Georgia Tech Research Institute, and Star Mountain, Inc. *Human Factors Handbook for Advanced Traffic Management Center Design.* McLean, Va.: Turner Fairbank Highway Research Center.

7. Grenzeback, L. R. et al. 1990. *Incident Management.* Cambridge Systematics in conjunction with JHK & Associates, Transmode Consultants, Inc., and Sydec, Inc. Published by the Trucking Research Institute.

8. Virginia Department of Transportation. 1995. *HAR Operational Guidelines* (developed by Smith, B., McGhee, C., Newman, B., Jones, S., and O'Leary, A. and maintained by DuFresne, J. and Mondul, S. of VDOT's SIM Committee). Richmond.

9. Reiss, R. A., and Dunn, W. M., Jr. 1991. *Freeway Incident Management Handbook.* Report No. FHWA-SA-91-056. Washington, D.C.: FHWA.

10. U.S. Department of Transportation. 1991. *Massachusetts Incident Management Conference Proceedings.* Washington, D.C.

11. Mannering, F., Hallenback, M., and Koehne, J. 1991. *Executive Summary: Framework for Developing Incident Management Systems.* Olympia: Washington State Transportation Center.

12. The Highway Helpline is an 800 number that citizens and agencies may use to provide or obtain traffic information throughout the Commonwealth. TEOC monitors the effectiveness

of its telephone response through the use of quarterly telephone surveys of citizens who used the Helpline.

13. VDOT sets the rules for how this contractor operates. For example, current practice is that when an incident occurs and only the contractor is present at TMS, the contractor selects a message from a list previously approved by VDOT. A new message would be created only under VDOT's direction.

14. Virginia Traffic Emergency Operations Center. *Mission Statement.* Richmond.

15. B. Abernathy and J. Gunn of Kimley-Horn and Associates argue that a "peer-to-peer" approach is preferable to a "command and control" type of ITS architecture in "A Different Perspective on National Architecture," *Traffic Technology International*, Feb/March 1996, pp. 34-40. From a physical design perspective, this argument is certainly relevant, and the author agrees that such a design approach should be considered by VDOT as it builds operations centers or adds components such as VMS and HAR units. This is why the preceding paragraph in the text argues for the operational capability to control VMS and HAR units from a variety of locations. Yet in terms of agency operational responsibility, VDOT needs a functional unit dedicated to the task of information dissemination. Although the optimal solution is a 24-hour center, this option is currently not available to seven VDOT districts. Thus the model of TEOC controlling VMS and HAR units with district input does not seek to emulate the command and control approach; rather, it seeks to ensure that a task is done by making one entity directly responsible for accomplishing that task at all times. The peer-to-peer model is designed expressly for coordination across multiple jurisdictions where boundaries cannot be eliminated but must be addressed as a fact of life. Internally, however, VDOT may choose to establish or eliminate its boundaries as necessary. In this case, the author recommends removing a boundary between district and statewide functions and allowing a unit with a statewide perspective—TEOC—to perform a task that has statewide implications.

16. Techniques for evaluating incident response generally include measuring how much delay was eliminated. An important part of incident response, however, is motorist information that not only keeps motorists away from an incident but alleviates as much as possible uncertainty for those motorists already facing delays.

17. Two possible sources of error with operating a device are (1) whether the device receives the correct signal to activate a certain message and (2) whether the mechanical parts of the device then respond to the signal. For current units, algorithms exist that can determine whether the first error has occurred. The NTCIP standard may entail development of a pixel-based algorithm that addresses one or both of these sources of error, but that will likely not be known until June 1996. A Maryland representative indicated that scanned-image cameras can be acquired for approximately $8,000 to $10,000 for the purposes of verifying whether a device is displaying an intended message. Thus, consideration of the NTCIP standard, a review of practices of other states, and discussions with manufacturers should be

considered when VDOT begins to make decisions about VMS and HAR purchases. This is a separate question from that of determining if motorists are responding to the message in the manner intended.

18. An article in the *Daily Press* (March 3, 1996) entitled "No Sign of Progress" described a commute from Smithfield to Hampton where a portable VMS had either been blank or shown only irrelevant information. *The Washington Post* (January 15, 1996) described an incident where a VDOT snowplow operator died as a result of a crash where his lane had suddenly come to an end. There was a snowbank in that lane. Lucy Caldwell, a spokeswoman for the Virginia State Police, indicated that "The lane just came to an abrupt halt. . . . There's little likelihood that a motorist would see it." The article stated that a VMS had been placed about 300 yards ahead of where the lane ended in order to warn motorists about the snowbank, but that the VMS had been turned to its side and left blank. The article also stated that "Investigators believe that the sign was hit by another driver earlier that night."

19. A letter in the *Rappahannock News,* Washington, Virginia (January 31, 1996), entitled "VDOT Confusion" described a citizen's attempt to obtain information from a VDOT area headquarters. In that case, VDOT noted that snow removal contractors do not ever report back to VDOT.

20. Quotation from Louis Henri Sullivan. The quotation is supposedly from "The Tall Office Building Artistically Considered," *Lippincott's Magazine,* March 1896.

21. Barker, J. A. 1992. *Future Edge: Discovering the New Paradigms of Success.* New York: William Morrow and Company, Inc.

22. It is certainly true that VDOT has already entered into the communications business in the sense that it, along with other state DOTs, is using media such as VMS and HAR units to let motorists know about traffic conditions, such as construction zones. Such applications show that state DOTs are able to use technology to provide traffic information. The emphasis in this report is that the quality of that information may suffer unless a functional unit has an incentive to provide accurate, essential information in a timely manner.

APPENDIX

OPERATIONS IN OTHER STATES

Centralized Operations

The New Jersey Turnpike Authority runs permanent HAR units out of one central location for the Turnpike and uses a time stamp to give the public an estimate of the message's accuracy. One HAR operator gave the example of a work zone where a lane closure was supposed to be eliminated at 5 P.M. but where a 5:15 P.M. call alerted her to update the HAR message that indeed the closure was continuing. The New Jersey North DOT Operations Center plans to run a system of 34 permanent VMS units on I-80 out of one central location, with districts being able to contact the main office to request a message. In the past, the Center relied on duty officers to change VMS messages in an emergency when the Center was closed. The New Jersey South DOT Operations Center now runs two permanent VMS units; a representative noted that about 4 years ago there had been some discussion as to whether it was appropriate for the Center to run VMS units during working hours rather than turn them over to the regions (analogous to VDOT districts). The key to resolving this issue was to emphasize the purpose of the devices as a tool for incident management, which is a primary responsibility of the Center. A standard protocol has been established for the regions to let the Center know when to activate a lane closure message. The Center and the regions have also had a dialog regarding the purpose of centralized control: the Center's role is to assist but not "watch over" the regions. In this case, the Center is responsible for activating devices but receives input from the regions.

Maryland operates permanently mounted VMS units and travelers' advisory radio systems through two traffic management systems in Baltimore and Washington (from 5 A.M. to 9 P.M.) and its statewide operations center in Hanover (at all other times). Districts that would like to see a VMS message contact the statewide operations center directly. The representative mentioned two items of direct interest to Virginia: first, the central location has a standard prioritization scheme for messages (e.g., an unplanned incident is more important than a routine construction activity), and second, the state operations center requires that the construction representative contact the Center directly from the site regarding lane closures or openings. The latter requirement prevents the VMS from displaying an erroneous message when an activity does not begin or end on schedule.

Finally, the Illinois Tollway Authority operates 7 permanent VMS units from a central location and plans to expand to 15 in 1996. The units are spaced along the 277-mile Tollway. Local maintenance yards are encouraged to contact the Authority when they perceive the need for a VMS application.

Local Operations

A representative from the California Department of Transportation's Division of Traffic Operations noted that a local central source of control, such as a 24-hour operations center, has been useful for coordinating messages with localities that operate their own devices, such as the City of Anaheim. California relies on various traffic management teams (TMTs) associated with each district to provide some assistance with responding to incidents, including the use of portable HAR units. The representative noted that most permanent VMS units are under the 24-hour control of a "local" traffic management system (a system that serves a specific city or geographical area). The Illinois DOT has only permanently mounted VMS units in the Chicago area and permanently mounted HAR units in the St. Louis and Chicago areas. These devices are operated by their respective traffic management system. The Pennsylvania DOT maintains VMS units on I-95 in the Philadelphia region; these are not under the control of a 24-hour facility, but during off hours employees can be contacted to drive to the control center and activate the devices.

The North Carolina DOT (NCDOT) has installed permanent VMS units in the City of Charlotte, some of which may be operated by both the City and NCDOT. The agreement is that the city has the right to use the signs to guide traffic to the Charlotte Coliseum, but NCDOT has the right to override these signs in case of an emergency. As of yet, there has not been a situation where this override was necessary. An NCDOT traffic operations center controls the Charlotte signs, and NCDOT is planning to install VMS units in Winston-Salem and Greensboro. The representative from North Carolina noted that NCDOT had found coordination with the state police to be particularly effective for the use of rural VMS units and that North Carolina does not have the "luxury" of a statewide emergency operations center such as Virginia's TEOC.

The New York DOT currently operates all permanent VMS units, which are located in the New York City area, out of the Long Island/INFORM effort, which runs 24 hours per day. The New York Thruway Authority is divided into four regions, each of which assumes responsibility for operating its own permanent HAR and VMS units, except for the New York region, which turns over control to TRANSCOM. The representative noted that the Authority is considering development of a central command center that would incorporate many operations functions, one of which would be operation of HAR and VMS devices. Unresolved is whether the regions would operate the devices during their normal 8-hour day.

The Maine DOT has no permanently mounted VMS or HAR units but is planning to install two VMS units in the coming year near the I-95/Route 1 interchange. No decision has yet been made about how these units will be controlled. Entities that would be affected include the state police, fire and rescue departments, and the Maine Turnpike Authority, which is also looking at future VMS installations. A representative from the Maine Turnpike Authority did not anticipate coordination with the DOT at this time.

The Texas DOT relies on each district to operate its own devices. Districts without 24-hour operations usually rely on persons who are on call to activate VMS units during off hours. (A representative suggested that in such situations the VMS might not be activated because incident responders would not have a central number they could call but instead would have to figure out which DOT entity was responsible for the particular VMS.) The Austin District has a unique arrangement where the police operate the VMS units during off hours. Providing training to the officers is a challenge since this is added to their regular duties, they work in shifts, and they have a relatively high turnover rate. Thus messages sometimes include locally specific nomenclature (e.g., "upper level closed"). A representative pointed out, however, that in his opinion this is better than communicating no real-time information at all. The Dallas area currently has the police contact a person on call during off hours to activate a VMS. The representative emphasized the need for the police to contact the VMS operator a second time once the incident is cleared from the roadway. Other districts have made their own arrangements: the El Paso District will rely on a combination of on-call persons, split shifts, and a courtesy patrol for VMS operation outside business hours, and the Laredo District, which operates a single VMS, uses an algorithm to activate the VMS automatically when traffic slows to a certain speed. (The VMS's primary purpose is to warn drivers to slow down at a spot where they will not have much time to realize traffic is backing up.) The district's representative noted that having on-call persons activate VMS units during off hours has worked very well, although the district is planning to have additional VMS and HAR units be controllable from the district (during an 8-hour day) and from a neighboring district that has a 24-hour operations center (at all other times).